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Radiological Habits Survey: Bradwell, 2007

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SUMMARY

This report presents the results of a survey conducted in 2007 to determine the habits and consumption patterns of people living, working and pursuing recreational activities in the vicinity of the Bradwell nuclear power station in Essex. The Nuclear Decommissioning Authority owns the site, and at the time of the survey, British Nuclear Group was responsible for managing the site. The station had twin Magnox reactors and ceased generating electricity in 2002, after 40 years of operation, and is now in an advanced stage of decommissioning. Magnox Electric Ltd is the site licence company. It is authorised under the Radioactive Substances Act, 1993, to discharge liquid wastes into the Blackwater Estuary and gaseous wastes via stacks to the local environment and is licensed for the purposes of operating certain activities prescribed under the Nuclear Installations Act, 1965. The site contains sources of direct radiation, although these are now considered to be minimal and not measurable as no fuel remains on site and the intermediate level waste skips are stored underground.

The following potential exposure pathways related to the site were investigated:

- The consumption of food from the terrestrial survey area
- The production, use and destination of local produce
- The consumption and use of groundwater and surface water in the terrestrial survey area
- Occupancy within 1 km of the licensed site boundary
- The consumption of food from the aquatic survey area
- Activities and occupancy over intertidal substrates
- The handling of fishing gear and sediment
- Activities and occupancy in and on water
- New or unusual practices such as the use of seaweed as a fertiliser or livestock feed and the transfer of contamination off-site by wildlife

Interviews were conducted with members of the public and data collected for 357 individuals are presented and discussed. High rates of consumption, occupancy and handling are

identified by using the 'cut off' method and 97.5th percentiles. These rates can be used in dose assessments. Additionally, profiles of integrated habits data are presented specifically for use in total dose assessments.

In the aquatic survey area, internal and external exposure pathways were investigated because of the potential effects from liquid discharges. Foods consumed from the aquatic survey area were fish, crustaceans, molluscs, wildfowl and marine plants/algae. For these foods groups, adult mean critical group consumption rates did not exceed the respective generic 97.5th percentile rates (where generic data exists). Critical group intertidal occupancy rates were calculated for people undertaking houseboat dwelling, oyster farming, boat and mooring maintenance, bait digging, wildfowling, water sport preparation, dog walking and walking. Critical group fishing gear and sediment handling rates were calculated for commercial fishermen, intertidal oyster farmers, bait diggers, people maintaining moorings and wildfowling. People were undertaking water-based activities such as commercial fishing, commercial and sport diving, ferrying, boat angling, canoeing, jet skiing, kite boarding and sailing. The use of seaweed as a fertiliser for vegetables or animal feed was not identified, although local seaweed was used for the packaging of live oysters for export to France.

The terrestrial survey covered an area up to 5 km from the site centre. In this survey area, internal exposure pathways were investigated because of the potential effects from gaseous discharges. Food production was identified at 22 farms (including beef cattle, lamb, young dairy cattle, chickens, chicken eggs and arable), a smallholding, one allotment site (two other allotment sites were also visited because they were only marginally outside the survey area) and private gardens. Honey production and consumption, and the consumption of wild/free foods and game, were identified in the survey area. For foods consumed from the terrestrial survey area, the adult mean critical group consumption rates exceeded the respective generic 97.5th percentile rates for green vegetables, root vegetables and honey. Other local foods consumed were other vegetables, potato, domestic fruit, cattle meat, sheep meat, poultry, eggs, wild/free foods, rabbits/hares and wild fungi. The consumption of milk, pig meat, venison, freshwater fish and cereals was not identified.

The use of groundwater was identified for crop irrigation and livestock consumption and one farm was using well water for their domestic supply.

Investigations into the off-site transfer of radioactive contamination by wildlife established that hares, partridges, pheasants and pigeons frequented the site. Information received was that rabbits had not been observed on site. Pigeons had been a nuisance in the past and nets had to be installed to prevent them entering buildings. Culling this species was carried out on an 'as required' basis. Members of the public who lived in the terrestrial survey area were consuming pigeons, partridges, pheasants, hares and rabbits that were shot within 5 km of the site.

The direct radiation survey covered an area out to 1 km from the site boundary. External pathways were investigated because of potential effects from ionising radiation emanating directly from the site and from exposure to gases discharged to the atmosphere from the site. The highest outdoor occupancy rate was for a resident who spent time relaxing and working in their garden, and the highest indoor occupancy rate was for a resident at Bradwell Waterside. Occupancy rates were also recorded for people undertaking recreational activities such as walking and angling.

Gamma dose rate measurements were taken at various locations in the aquatic survey area and both indoors and outdoors at properties in the direct radiation survey area. Background readings were taken outside the 5 km radius of the terrestrial survey area.

Comparisons are made with the results from the previous aquatic, terrestrial and direct radiation surveys.

The aquatic adult critical group mean consumption rates show significant decreases in the food groups fish, crustaceans and molluscs compared with those of the previous survey in 1999. The rate for fish decreased from 44 kg/y to 25 kg/y, the rate for crustaceans decreased from 3.1 kg/y to 1.1 kg/y and the rate for molluscs decreased from 6.5 kg/y to 2.9 kg/y. Adult critical group occupancy rates over intertidal substrates had also changed significantly. The

occupancy rate over mud had increased from 470 h/y to 830 h/y and the occupancy rate over sand and mud had decreased from 1200 h/y to 780 h/y.

There were significant changes in some of the mean adult critical group consumption rates for terrestrial food groups compared to the results of the previous survey of 1999. The mean consumption rate for honey had increased from 14 kg/y to 24 kg/y. Food groups with significant decreases in consumption rates were potato, 81 kg/y to 40 kg/y, domestic fruit, 130 kg/y to 38 kg/y, cattle meat, 38 kg/y to 7.9 kg/y, sheep meat, 26 kg/y to 17 kg/y, wild/free foods, 35 kg/y to 4.2 kg/y, and wild fungi, 4.0 kg/y to 0.7 kg/y.

Occupancy rates for individuals in the direct radiation survey area were similar to those recorded in the 1993 survey, with some residents again having very high annual rates. The major difference was the significantly lower gamma dose rates measured at the nearest dwellings to the perimeter fence now that the site was in an advanced stage of decommissioning.

Suggestions are provided for changes to environmental monitoring programmes on the basis of the information collected during the survey. These included adding a well water (used for household consumption) sample, a thornback ray sample and a pigeon sample.

1 INTRODUCTION

The public may be exposed to radiation as a result of the operations of the Bradwell site either from discharges of liquid or gaseous radioactive wastes into the local environment, or from radiation emanating directly from the site. This report provides information about activities carried out by members of the public under everyday circumstances, which may influence their radiation exposure. The study has been funded by the Environment Agency, the Food Standards Agency and the Health and Safety Executive in order to support their respective roles in protecting the public from the effects of radiation.

1.1 Regulatory framework

The Environment Agency regulates discharges of waste under the Radioactive Substances Act 1993 (RSA 93) (UK Parliament, 1993) as amended by: the Environment Act 1995 (EA 95) (UK Parliament, 1995a); by legislation implementing the European Union (EU) Basic Safety Standards (BSS) Directive 96/29/Euratom (CEC, 1996); and by the Energy Act 2004 (EA 04) (UK Parliament, 2004). The Directive takes into account Recommendations of the International Commission on Radiological Protection (ICRP), particularly ICRP 60 (ICRP, 1991). Authorisations under RSA 93 are issued by the Environment Agency after wide-ranging consultations that include the Food Standards Agency. As well as being a Statutory Consultee, the Food Standards Agency has responsibilities for ensuring that any radioactivity present in food does not compromise food safety and that authorised discharges of radioactivity do not result in unacceptable doses to consumers via the food chain. The Food Standards Agency also ensures that public radiation exposure via the food chain is within EU accepted limits. Consultation papers on Statutory Guidance to the Environment Agency on the regulation of radioactive waste discharges were issued by the Department of the Environment, Transport and the Regions (DETR) (now the Department for Environment, Food and Rural Affairs (Defra)) in 2000 (DETR, 2000a) and the Welsh Assembly in 2002 (The Welsh Assembly Government, 2002). Most recently, in 2006, Defra published a decision document for application to dispose of or accumulate radioactive wastes from or on eight

Magnox sites (including Bradwell) (Defra, 2006) stating it was decided not to change any of the Environment Agency's decisions. These documents include, *inter alia*, affirmation that protection of the critical groups of the public is the appropriate radiological protection methodology to use. This report provides information to support assessments of critical groups.

Installation and operation of certain prescribed activities can only take place on sites if they are licensed under the Nuclear Installations Act 1965 (as amended) (NIA 65) (UK Parliament, 1965). The Nuclear Installations Inspectorate of the Health and Safety Executive implements this legislation and is also responsible for regulating, under the Ionising Radiations Regulations (IRR 99) (UK Parliament, 1999), the restriction of exposure of the public to direct radiation from operations occurring on these sites.

1.2 Radiological protection framework

UK policy on the control of radiation exposure has long been based on the Recommendations of ICRP which embody the principles of justification of practices, optimisation of protection and dose limitation. Radiological protection of the public is based on the concept of a critical group of individuals. This group is defined as those people who, because of both their residence and habits, receive the highest radiation dose due to the operations of a site. It follows that, if the dose to this group is acceptable when compared to relevant dose limits and constraints, other members of the public will receive lower doses, and overall protection to the public is provided from the effects of radiation. The ICRP have recommended that the term 'representative person' be used in preference to the term 'critical group'. (ICRP, 2007) However, this recommendation has not yet been formally adopted in the UK and therefore we continue to use the term 'critical group' in this report.

Dose standards for the public are embodied in national policy (UK Parliament, 1995b), in guidance from the International Atomic Energy Agency (IAEA), in the Basic Safety Standards for Radiation Protection (IAEA, 1996) and in European Community legislation in the EU BSS

Directive 96/29/Euratom. The public dose standards were incorporated into UK law in IRR 99. In order to implement the Directive in England and Wales, the Environment Agency was issued with a direction by the DETR in 2000 (DETR, 2000b). This included the requirements that the Environment Agency ensure, wherever applicable,

- all public radiation exposures from radioactive waste disposal are kept As Low As Reasonably Achievable (ALARA)
- the sum of such exposures does not exceed the dose limit of 1 mSv a year

The principal limit of 1 mSv per year to the public, is also the recommendation made by the ICRP.

The Environment Agency shall have regard for maximum doses to individuals for use at the planning stage:

- 0.3 mSv a year from any source
- 0.5 mSv a year from the discharges from any single site

The Environment Agency is also required to ensure that the dose estimates are as realistic as possible for the population as a whole and for reference groups of the population. It is required to take all necessary steps to identify the reference groups of the population taking into account the effective pathways of transmission of radioactive substances. Guidance on the principles underlying prospective radiological assessment (i.e. assessments of potential future doses) has been provided by a group of UK Government Bodies (EA, SEPA, DoENI, NRPB and FSA, 2002). The National Dose Assessment Working Group (NDAWG) has also published principles underlying retrospective radiological assessment (i.e. assessment of doses already received from past discharges) (Allott, 2005) and possible methods of carrying out these assessments using data from combined habits surveys (Camplin *et al.*, 2005). NDAWG agreed that the optimal method for performing retrospective dose assessments would be to use habits profiles (profiling method). This approach is being adopted in Radioactivity in Food and the Environment (RIFE) publications, (e.g. EA, EHS, FSA and SEPA, 2007), as combined habits surveys are completed.

This report provides information that allows the habits of members of the public to be quantified so that the most exposed groups can be identified and doses to the groups can be assessed in a realistic way.

2 THE SURVEY

2.1 Site activity

The Bradwell site is located on the south side of the Blackwater Estuary, 3 km south of West Mersea on the north shore (see Figure 1). Bradwell ceased energy production in 2002, after 40 years of operation. Defuelling has now been completed and since then the station has been undergoing decommissioning. The Bradwell site discharges gaseous radioactive wastes via stacks to the atmosphere, liquid radioactive wastes via a discharge pipe into the Blackwater Estuary and contains sources of direct radiation. Details of the amounts of gaseous and liquid radioactive waste discharged in 2006 have been published (EA, EHS, FSA and SEPA, 2007). Whilst the habits survey fieldwork was being carried out, regular decommissioning activities were taking place at the site; removal of asbestos from the boilers being the biggest task at the time.

The Nuclear Decommissioning Authority (NDA) owns the Bradwell site and Magnox Electric Ltd is the licence company. At the time of the survey, British Nuclear Group (BNG) held the contract to manage the site. At the time of writing this report, Magnox Electric Ltd was the main management and operations contractor. Under RSA 93, Magnox Electric Ltd is authorised to discharge gaseous radioactive wastes via stacks to the atmosphere and liquid radioactive wastes via a pipeline into the Blackwater Estuary.

2.2 Survey objectives

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook the survey in 2007 on behalf of the Environment Agency, the Food Standards Agency, and the Health and Safety Executive. The aim of the survey was to obtain information on the habits of the public that might lead to their exposure to atmospheric discharges, liquid discharges and direct radiation from the Bradwell nuclear site. The survey provided comprehensive information to ensure that all potential exposure pathways were identified.

Specifically, investigations were conducted into the following:

- The consumption of food from the terrestrial survey area
- The production, use and destination of local produce
- The consumption and use of groundwater and surface water in the terrestrial survey area
- Occupancy within 1 km of the site perimeter
- The consumption of food from the aquatic survey area
- Activities and occupancy over intertidal substrates
- The handling of fishing gear and intertidal sediment
- Activities and occupancy in and on water
- New or unusual practices such as the use of seaweed as a fertiliser or livestock feed and the transfer of contamination off-site by wildlife

There were no additional site-specific investigations identified by the Environment Agency, the Food Standards Agency nor the Health and Safety Executive for the Bradwell survey.

2.3 Survey areas

Three survey areas were defined to encompass the dominant activities expected for aquatic, terrestrial and direct radiation pathways.

The aquatic survey area, shown in Figure 1, spanned the north and south shores of the River Blackwater estuarine areas from Maldon downstream to the east side of Mersea Island on the north shore and St Peter's Flat on the south shore. The area is relevant to the potential effects of liquid discharges from the site. The same area was used in the previous Bradwell aquatic habits survey conducted by Cefas, which was in 1999 (Tipple and Sherlock, 1999).

The terrestrial survey area, shown in Figure 2, was defined as the circle to a radius of 5 km from the centre of the Bradwell site (NGR TM 002 088) to encompass the main areas of potential deposition from gaseous discharges. The same area was used in the previous

Bradwell terrestrial habits survey conducted by Cefas, which was in 1999 (Parker and Taylor, 1999).

The direct radiation survey area, which is also shown in Figure 2, was defined as the area within 1 km of the site perimeter. In the previous direct radiation survey, conducted by Cefas in the Bradwell area in 1993 (Commercial in Confidence), a smaller survey area was defined. This included the Down Hall Beach Estate, Bradwell beach and sea wall and the power station's sports and social club.

2.4 Conduct of the survey

Prior to the fieldwork, discussions were held between a member of the Cefas survey team and representatives from the Bradwell site, the Environment Agency, the Food Standards Agency and the Health and Safety Executive. These discussions provided an outline of the main aims of the survey.

As part of the pre-survey preparation, people with a local knowledge of the survey area were contacted for information on any aspects relevant to the various exposure pathways. These included; the local council, beekeepers and wildfowling identified during the previous survey, commercial fishermen, a local Sea Fisheries Committee officer and a member of the local action group. These people provided information on allotments, beekeeping, wildfowling, commercial and non-commercial fishing and other activities in the aquatic survey area. Further information regarding the habits of people in the aquatic and terrestrial survey areas was obtained from internet searches and Ordnance Survey maps. A proposed programme for fieldwork was sent to the Environment Agency, the Food Standards Agency, and the Health and Safety Executive before the fieldwork commenced, for their comment.

The fieldwork component of the survey was carried out from 5th – 14th June 2007 by a survey team of four people, according to techniques described by Leonard *et al.* (1982). At the start of the fieldwork, on 5th June, a meeting was held between the survey team, and

representatives of the Bradwell site. This served to provide details about Bradwell site operations, including waste disposal, and information about potential pathways and activities in the area. Details obtained are as follows:

- Usual site activities were expected during the habits survey duration
- Information about potential pathways and activities in the area included; sources of direct radiation and activities undertaken by members of the public around the site perimeter and on the beach in front of the site

The site representatives were also asked about any wildlife studies and pest control measures in and immediately around the site. Animals are potential carriers for transporting radioactive materials off-site and are also potential food items for some individuals (see Section 5.2).

During the fieldwork, individuals who were identified in the pre-survey preparation as having the potential to be exposed to radioactivity from the site were contacted and interviewed. These included commercial fishermen, boat owners, anglers, wildfowlers, boat dwellers, a commercial diver, farmers, a beekeeper and people living and/or working close to the site. Interviews were used to establish individuals' consumption rates of locally grown terrestrial foods and locally caught freshwater food, their handling rates of fishing gear, their occupancy rates relevant to external exposure and occupancy rates in and on water. Any general information of possible use to the survey was also obtained. Using the information obtained in the interviews, a list of occupations and activities was built up to produce a picture of potential exposure pathways.

For practical and resource reasons, the survey did not involve the whole population in the vicinity of the Bradwell site. Individuals or groups were targeted in order to identify the most potentially exposed. However, it is possible that even within a subset or group there may have been people not interviewed during the survey. Therefore, a further protocol has been adopted to aid interpretation and to address this issue. Where possible, a percentage has been determined for the number of interviewed individuals as a function of the estimated total

number of potential individuals in each group. The results are summarised in Table 1; the 'groups' are described and quantified. For certain groups, such as anglers, it can be virtually impossible to calculate the total number of people who undertake the activity in the survey area because it is difficult to quantify visitors from outside the area or occasional visitors during the year. Overall, the number of potential interviewees in the terrestrial survey area was estimated to be 8000; information was obtained for a significantly smaller number than this. In particular, it should be noted that the survey did not include site employees, or contractors while they were at work on the site. This is because dose criteria applicable to these people whilst at work and the dose assessment methods are different to those for members of the public. However, any consumption data, and activities and occupancy rates for these employees while outside work, are included in the results if employees were encountered during the survey.

For each of the three survey areas, the survey targeted pathways primarily relevant to that survey area. Where possible, people were also asked about habits relating to the other two survey areas. For example, people in the terrestrial survey were initially questioned because it was known that they grew significant quantities of terrestrial foodstuffs. However, they were also asked about habits that might lead to exposure to liquid discharges or direct radiation. During interviews with, for example, representatives from wildfowling and water sport clubs, it was not possible to collect data for all pathways (such as consumption of local foods) for each person. In these cases, data were limited to occupancy rates relating to these activities. In Annexes 1 and 2, these individuals only have data for the pathway of primary interest.

Forty person-days were spent investigating the survey areas and interviewing individuals who were relevant to the survey. Observations for 357 individuals were recorded. During the survey, gamma dose rate measurements were taken to aid assessment of external exposure pathways.

3 METHODS FOR DATA ANALYSIS

3.1 Data recording

Data collected during the fieldwork were recorded in logbooks. On return to the laboratory, the data were examined and any notably high rates were double-checked, where possible, with/by a follow-up phone call. In rare cases where follow-up phone calls were not possible (e.g. interviewees who wished to remain anonymous), the data were accepted at face value. The raw data were entered into a habits survey database where each individual for whom information was obtained was given a unique identifier (the observation number) to assist in maintaining data quality.

During the interviews, people could not always provide consumption rates in kilograms per year. 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. The database converted these data into consumption rates (kg/y) using a variety of conversion factors. These factors included produce weights (Hessayon, 1990 and 1997; Good Housekeeping, 1994), edible fraction data researched by Cefas, and information supplied by the Meat and Livestock Commission.

All consumption and occupancy data in the text of this report are rounded to two significant figures to reflect the authors' judgement on the accuracy of the methods used. In the tables and annexes, the consumption rate data are usually presented to one decimal place. Occasionally, this rounding process causes the row totals or mean rates to appear slightly erroneous (± 0.1). Consumption rates less than 0.05 kg/y are presented to two decimal places in order to avoid the value of 0.0 kg/y. External exposure data are quoted as integers.

To ensure the quality of the data collected during the survey fieldwork and presented in the report, the following procedures have been employed:

- Experienced scientific staff were used for fieldwork and data assessment. They had been trained in the techniques of interviewing and obtaining data for all pathways that were relevant to the survey being conducted. Where individuals offered information during interview that was unusual, they were questioned further in order to double-check the validity of their claims
- Where possible, interviewees were contacted again to confirm the results of the initial interview if, when final consumption or occupancy rates were calculated, observations were found to be high in relation to our experience of other surveys. Local factors were taken into account in these cases
- Data were manipulated in a database using a consistent set of conversion factors
- Data were stored in a purpose built database in order to minimise transcription and other errors
- Draft reports were formally reviewed by a senior Cefas radiological scientist
- Final reports were only issued when the Environment Agency, the Food Standards Agency and the Health and Safety Executive were entirely satisfied with the format and content of the draft

For the purpose of data analysis, foodstuffs were aggregated into food groups as identified in Table 2. Specific food types relevant to this survey are presented in the subsequent tables. The data are structured into groups 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 crustacean species are grouped as 'crustaceans'. For external exposure over intertidal sediments, occupancy over a common substrate (e.g. salt marsh) 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 to that group.

In addition to grouping of activities, data are structured into age groups because different dose coefficients (i.e. the factors which convert intakes of radioactivity into dose) can apply to different ages. The age groups and their relevant age ranges are based on the recommendations in ICRP 72 (ICRP, 1996), and are listed below:

Age group	Age range in group
3-month-old	Under 1-year-old
1-year-old	1-year-old
5-year-old	2-year-old to 6-year-old
10-year-old	7-year-old to 11-year-old
15-year-old	12-year-old to 16-year-old
Adult	17-year-old and over

For direct radiation pathways, the data are grouped into distance zones from the site perimeter as a coarse indication of the potential dose rate distribution due to this source of exposure. The bands used were: 0 – 0.25 km, >0.25 – 0.5 km and >0.5 – 1 km. These distance bands are also useful when assessing exposure to gaseous discharges.

3.2 Data analysis

The main outputs of the study are the statements of individuals' consumption, handling and occupancy rates given in Annexes 1 and 2. These can be used in radiological assessments of the effects of the operations at the Bradwell site – taking into account the concentrations and/or dose rate distributions in space and time relevant to the assessments.

Annex 3, where relevant, contains qualitative and estimated data for pathways where it was not possible to obtain quantifiable data from interviews. This includes activities that were revealed during the survey e.g. activities which were taking place at a different time of year to the survey. Annex 3 is included in habits survey reports so that the information can be used in dose assessments, thereby ensuring that all potential pathways have been covered in the

assessments that would otherwise be missed. In the case of this Bradwell habits survey, no activities were identified for which quantifiable data could not be obtained.

The habits data have been analysed to indicate high rates of consumption, occupancy and handling, prior to a formal assessment being undertaken. Three approaches have been used:

Firstly, the 'cut-off' method described by Hunt *et al.* (1982) was used. With the 'cut-off' method, the appropriate high rate was calculated by taking the arithmetic mean of the maximum observed rate and all observed rates within a factor of 3 of the maximum value (termed the lower threshold value and this differs from the methodology used for external pathways at the time of the 1999 aquatic survey when the factor used was 1.5). 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. For ease of presentation in this report, the term critical group rate is used to represent the data derived by the 'cut-off' method. A separate critical group rate was calculated for each food group, intertidal substrate and handling pathway identified in the survey. In certain cases, using the 'cut-off' method could result in only one person being in the critical group. In these cases, expert judgement was used to decide whether the critical group should remain as one individual or whether others should be included. If others were included, the second highest rate was divided by three to give a new cut-off value and all observations above this were included in the critical group. When the second highest rate has been used, this is explained in the table notes.

Secondly, 97.5th percentile rates were calculated using the Excel mathematical function for calculating percentiles. This method accords with precedents used in risk assessment of the safety of food consumption. Mean and 97.5th percentile rates based on national statistics have been derived by the Ministry of Agriculture, Fisheries and Food (MAFF) (now part of Defra) and the Food Standards Agency (Byrom *et al.*, 1995 and FSA, 2002), and these are referred to as generic rates in this report.

Thirdly, profiles have been produced that give a complete view of the habits of the individual that might lead to exposure to all the discharges and radiation from the site. The profiles are based on values calculated by the 'cut off' method. The profiled data can be used to assess total dose integrated across all pathways of exposure.

For consumption and external pathways, critical group rates for children have been calculated from the survey data. However, because few child consumers were identified, the rates should be viewed with caution. For assessment purposes, an alternative approach may be taken which involves scaling the critical group rates for adults by ratios. These ratios are given in Annex 4 and have been calculated using generic 97.5th percentile consumption rates.

Selection of critical group rates and 97.5th percentile rates for occupancy is not made for the direct radiation pathway. Such an analysis is of limited value without a detailed knowledge of the spatial extent of dose rates due to direct radiation.

4 AQUATIC RADIATION PATHWAYS

4.1 Aquatic survey area

The aquatic survey area, shown in Figure 1, extended from Maldon downstream to the eastern end of Mersea Island on the north shore and St Peter's Flat on the south shore. It encompassed all intertidal areas, including the muddy backwater creeks and salt marshes.

Overview of survey area

For the most part, the Blackwater Estuary substrate was mud, which was bordered by large areas of salt marsh at several locations, particularly where the many creeks enter the main estuary. Because of the muddy substrate in the extensive, relatively shallow water areas, the estuary made an ideal breeding ground for oysters, both European (*Ostrea edulis*) and Pacific (*Crassostrea gigas*) species. Three large oyster companies operated in the estuary and produced large, high quality yields of both species which were sought after by both the UK and European markets. Some were exported further afield to China. The salt marsh areas were used for grazing livestock in the spring and summer periods and by wildfowling associations in the autumn and winter periods. Houseboats also used the creeks and salt marsh areas as permanent moorings, particularly at West Mersea and Tollesbury.

In addition to oyster rearing, the estuary was used extensively for water sports such as boating, sailing and jet skiing. Commercial fishing, which included trawling and gill netting for fish species and dredging for oysters also took place.

North side of the estuary

Maldon to Tollesbury

The substrate along this section of foreshore was mainly mud. Several boats were berthed in the river at Maldon harbour including two or three commercial fishing boats. Upstream of the town bridge, a few boats served as part or full-time residences. North west of Maldon is Heybridge where the Blackwater Sailing Club was based, which had approximately 1000 members including juniors. East of Heybridge is the village of Heybridge Basin, where a working boatyard was located and several small privately owned yachts and boats were moored in the river. These settled onto the mud at low water. A small yacht club, having about 60 members, also used the mooring facilities here. Although winkles were prolific at this location, nobody was seen collecting them during the survey. This was not the case in the 1999 survey when one commercial collector worked at this location. West of Heybridge Basin is Goldhanger Creek which was an extensive shallow water, muddy area used for oyster rearing by one of the larger oyster companies working in the estuary. Two islands are located approximately in the middle of the estuary, Northey and Osea Islands. The former was owned by the National Trust and members of the public were permitted to visit occasionally to bird watch. They were not allowed onto the intertidal areas, but were restricted to the non-tidal grassed sea defence embankment. Osea Island was private with no public access.

With the exception of oyster farming and small boating activities, no other intertidal activities were noted along this section of shoreline.

Tollesbury to Mersea Island

The coastal part of the village of Tollesbury contained several working boatyards and marine chandlers. Tollesbury Marina provided floating berths for approximately 250 craft, 80% of these were yachts and 20% were cruising boats. Some belonged to members of the Tollesbury Sailing Club, which had a membership of approximately 300 adults and juniors. To

the east of Tollesbury Village were extensive salt marsh areas that were intersected by three large channels and several creeks. The channels, North Channel, South Channel and Tollesbury Fleet, were used by another large oyster company for rearing mature native and Pacific oysters from seed oysters purchased from outside the survey area.

Most of the salt marsh areas, owned by two farms, were used for grazing cattle (spring and summer) and sheep (all year round). One of these farms was owned by the Essex Wildlife Trust, which had increased the intertidal area further by breaching the estuary sea wall, thus providing more wetland for wading birds. The trust harvested samphire (*Salicornia europaea*) commercially from some of their salt marsh areas to provide additional income to maintain the farm. The other farm was owned by the National Trust.

Houseboats used the Tollesbury salt marsh creeks as permanent intertidal moorings and at the time of the survey ten were present which provided either full-time or part-time accommodation.

Two salt marsh areas, Abbot Hall Saltings and Copthall Saltings, were used by the Colchester and Mersea Island Wildfowling Associations during the shooting season, which was from 1st September until 20th February.

Mersea Island

East of the Tollesbury salt marsh areas is Mersea Island, accessible only by road over a man-made causeway which frequently flooded during large high tides. The Island has a small town and a village, West Mersea and East Mersea, respectively. East Mersea was a quiet village and mostly residential. Access to the shore here was mainly by private tracks. West Mersea in contrast was full of activity, being the main mooring location for the commercial fishing boats and private large yachts. Situated along the seafront were two sailing clubs, two boatyards, a large floating pontoon used by the West Mersea fishermen and yacht owners for loading and off-loading their catches and fishing/boating equipment. There were also a

lifeboat station, two large oyster companies which both had locally caught seafood shops and restaurants, a large public car park and an extensive salt marsh area where in excess of a dozen houseboats were permanently berthed. West Mersea also had an Outdoor Pursuit Centre, which provided kayaking instruction to parties of youngsters from schools and colleges. The town was very popular with tourists and weekend visitors who used the beach facilities at the eastern end of the town and the seafood restaurants. At peak times both restaurants frequently had queues of people waiting for tables to be vacated.

The mud and sand intertidal areas in front of the boatyards were frequently used by boat owners to carry out maintenance on their craft. A commercial diver was also working on the off-shore moorings and yachts, securing and cleaning the submerged parts of the craft, respectively.

South side of the estuary

Maldon to Maylandsea

This section of the estuary again had muddy intertidal substrates with areas of salt marsh separating them from the non-tidal mainland. Public access was restricted, with the exception of a track leading to the causeway to Northey Island. All other accesses were private farm tracks. With the exception of sailing and boating, around Northey and Osea Islands and walkers on the seawall, no other activities were noted.

Maylandsea to Bradwell Waterside

The predominant substrate along this section of the shore was mud and there were a few small areas of salt marsh separating the mud from the non-tidal shore. Several creeks flowed into the River Blackwater but the only one of any size was Lawling Creek, which entered the estuary south of Osea Island. The main access points for vehicles were at Maylandsea, Ramsey Island and Bradwell Waterside. A footpath ran along the top of the embankment for

the entire stretch of coast but was not frequently used except close to the vehicle access points.

There was a boatyard and marina at Maylandsea with approximately 40 floating pontoon berths and another 40 offshore moorings for yachts and powered pleasure craft. Most of these dried out at low tide so that the boats rested on mud. Maylandsea also had a sailing club where approximately eighty dinghies were parked on the shore. The upper shore in front of the dinghy park was shingle and there was a concrete slipway for launching dinghies.

From the village of Steeple a private track led down to another sailing club. There was a large car park that was only accessible to members. The club had 500 members and catered for dinghy, yacht and power craft owners. There was a wide concrete slipway for launching boats. The upper shore around the slipway was shingle and the lower shore was mud. It was difficult for people other than club members to gain access to the shore in this area owing to the limited parking opportunities.

At Ramsey Island there was a 1 km stretch of sand and gravel along the upper foreshore. Either side of this the shore reverted to mud. The Stone Watersports Club and Stone Sailing Club were located here. Dinghies from the sailing club were hand launched from the shingle beach and the larger power craft from the water sports club were tractor launched. The water sports club had 200 members and the activities included jet skiing, water-skiing, boat angling and kite-surfing. The sailing club had 470 members ranging in age from 7 years upwards.

From St Lawrence Bay eastwards there were rocks from an old embankment scattered in the mud of the middle shore and many of these were covered with bladder wrack. One individual was identified who collected peeler crabs for angling bait in this area. At Bradwell Waterside the substrate was mud with small areas of salt marsh. The small Pewet Island is on the other side of Bradwell Creek. A marina provided 300 berths for power craft and yachts. Angling charter boats operated from here. There was an outdoor activities centre, offering boating and other water sports, with a capacity for 40 individuals between the ages of 9 and 21 years

old. Some angling and walking took place in the area and occasional wildfowling was reported. Most of the walkers stayed on the path running along the top of the embankment above the intertidal area.

Bradwell Waterside to St Peter's Flat

There was a free car park to the east of the Bradwell site and a nature trail and other footpaths leading down to the shore from the estuary embankment footpath. From the Bradwell site eastwards to Sales Point, a distance of about 4 km, the upper shore was sand and shells. The lower shore was mud that was exposed at low tide. The area was popular with anglers, walkers, beachcombers, and bird watchers and children were observed swimming in the area. Evidence, in the form of discarded litter, suggested that barbeques and picnics frequently took place along the upper shore.

From Sales Point southwards there was an extensive area of salt marsh and the mud of St Peter's Flat extended seawards from it. Car parking was available at the Chapel of St Peter on the Wall and the Othona Roman Fort. Wildfowling took place on the salt marsh and bait digging was reported to occur on the mud flats.

4.2 Commercial fisheries

The main commercial fishery in the estuary was the thriving oyster industry. Three companies reared them on a large scale, buying in seed oysters from outside the area to supplement the natural spawning in the estuary. Conditions in the estuary were ideal for rapid oyster growth and small seed oysters could be grown to marketable size in five to six months. Seed oysters were obtained from Plymouth, Portsmouth, Isle of Wight and Poole. In addition to oyster farming, dredging by fishing boats and hand collection was undertaken by commercial fishermen for the abundant wild oysters in permitted areas of the estuary. In addition to oysters, Manila clams (*Tapes philippinarum*) were caught in small numbers which were also wild stock, surviving from experimental seeding and fishing work conducted by one of the

oyster companies several years earlier. Even smaller quantities of cockles (*Cerastoderma edule*) and whelks (*Buccinum undatum*) were caught by the boats that were dredge fishing.

Trawling and gill netting for fish species was also carried out by several boats working in the estuary for either part of the year or full-time. The most abundant fish species in the estuary during the summer months were Dover sole (*Solea solea*), bass (*Dicentrarchus labrax*), grey mullet (*Chelon labrosus*) and thornback rays (*Raja clavata*). During the winter the predominant species was cod (*Gadus morhua*). Small quantities of plaice (*Pleuronectes platessa*), flounder (*Platichthys flesus*), herring (*Clupea harengus*) and brill (*Scophthalmus rhombus*) were also caught.

Lobster (*Homarus gammarus*) and crabs (*Cancer pagurus*) were caught in small quantities as a by-catch in gill and trawl nets. The crabs were of poor quality and usually discarded, but the lobsters were sold to local hotels, restaurants and retailers, and local individuals.

4.3 Angling

Angling was a popular sport in the area with both shore and boat angling taking place. The majority of boat angling, however, was found to occur outside the survey area. A keen local angler informed the survey team that the preferred shore angling locations were Bradwell beach and West Mersea foreshore, as these were relatively clean sandy locations. The main species caught were thornback rays and bass in summer and cod in winter.

Only one commercial bait digger was noted in the survey area. He also collected peeler crabs for bait. He sold all his bait directly to private angling boat owners.

4.4 Wildfowling

Six wildfowling clubs were identified that were shooting over salt marsh areas in the Blackwater Estuary. Members of four of these clubs were available for interview. The main

species being shot were mallard (*Anas platyrhynchos*), teal (*Anas crecca*) and wigeon (*Anas penelope*). Other duck species were shot in lesser numbers together with occasional greylag geese (*Anser anser*) and Canada geese (*Branta canadensis*).

4.5 Other Pathways

Several people were consuming two species of marine plants that grew prolifically on the salt marsh areas. These were samphire (*Salicornia europaea*) and leaf beet (*Beta vulgaris*). Samphire was also harvested commercially by the Essex Wildlife Trust and sold to one of the seafood restaurants at West Mersea. No one was identified as either consuming seaweed or using it for animal feed or fertiliser.

The harvesting of sea salt was identified in the area. A company produced a few hundred tonnes of sea salt a year and the product was distributed worldwide. The salt is harvested from Goldhanger Creek and Fullbridge, near Maldon. Water is collected on spring tides and stored into tanks, the salt is then evaporated in saltpans and salt crystals are harvested by hand using long handled rakes.

4.6 Wholesalers and retailers

The three oyster companies based at West Mersea and Maldon were the main producers and exporters of the two species of oyster. The two companies in West Maldon also bought local fish species and lobsters for retail through their seafood shops and restaurants. Larger quantities of fish were sold to wholesalers based in Lowestoft and Colchester. One of the West Maldon oyster companies also bought locally harvested samphire to sell via its restaurant trade.

4.7 Food consumption data

Consumption data for local aquatic foodstuffs are presented in Tables 3 to 7 for adults and in Tables 8 to 10 for children. The tables include the mean consumption rates of the critical groups together with the observed 97.5th percentile rates calculated as described in Section 3.2. For purposes of comparison, the data are summarised in Table 11 for adults and Tables 12 to 14 for children (15-year-old, 10-year-old and 5-year-old age groups, respectively). No children in the 1-year-old and 3-month-old age groups were noted to be consuming aquatic foods. The summary tables also include mean rates 97.5th percentile rates based on national data (referred to as 'generic' data in this report). No generic data are available for the 5-year-old age group.

Adults' consumption rates

Adults were found consuming foods from the following five food groups: fish, crustaceans, molluscs, wildfowl and marine plants/algae. The people consuming the greatest quantities of food from the aquatic survey area were commercial fishermen, oyster company owners, anglers, wildfowlers and families of these people.

The predominant species of fish consumed by adults were thornback ray, cod, bass and Dover sole with smaller quantities of brill, herring, plaice, flounder and eels (*Anguilla anguilla*). A critical group of 16 individuals was identified with a maximum consumption rate of 41 kg/y and a mean consumption rate of 25 kg/y. The observed 97.5th percentile rate based on 59 observations was 39 kg/y. This compares with the adult generic mean and 97.5th percentile consumption rates for fish of 15 kg/y and 40 kg/y, respectively. The percentage breakdown of species eaten by the critical group was 30% cod, 30% thornback ray, 15% bass, 15% Dover sole and 5% herring and 5% plaice plus brill. These percentages, rounded to the nearest 5%, are based on the total amount of fish consumed by this critical group and exclude observations for 'mixed fish'.

Two species of crustaceans were consumed by adults - crabs and lobsters. A critical group of eight individuals was identified with a maximum consumption rate of 2.0 kg/y and a mean consumption rate of 1.1 kg/y. The observed 97.5th percentile rate based on 10 observations was 1.8 kg/y. This compares with the adult generic mean and 97.5th percentile consumption rates for crustaceans of 3.5 kg/y and 10 kg/y, respectively. The critical group consumed 55% crabs and 45% lobsters. These percentages are again rounded up to the nearest 5%.

The species of molluscs consumed by adults were Pacific and European oysters with smaller amounts of Manila clams, cockles, mussels (*Mytilus edulis*), and whelks. A critical group of 12 individuals was identified with a maximum consumption rate of 6.0 kg/y and a mean consumption rate of 2.9 kg/y. The observed 97.5th percentile rate based on 26 observations was 4.8 kg/y. This compares with the adult generic mean and 97.5th percentile consumption rates for molluscs of 3.5 kg/y and 10 kg/y, respectively. The critical group consumed 80% Pacific oysters, 10% European oysters, 10% cockles and 5% Manila clams. These percentages are again rounded up to the nearest 5%.

The species of wildfowl consumed by adults were mallard, teal, wigeon, greylag geese and Canadian geese. A critical group of five individuals was identified with a maximum consumption rate of 44 kg/y and a mean consumption rate of 27 kg/y. The observed 97.5th percentile rate based on 22 observations was 44 kg/y. No generic data are available for this food group. The percentage breakdown of species, rounded up to the nearest 5%, eaten by the critical group was 70% mixed ducks and 30% geese.

The species of marine plants/algae consumed by adults were samphire and leaf beet. A critical group of seven individuals was identified with a maximum consumption rate of 2.3 kg/y and a mean consumption rate of 1.4 kg/y. The observed 97.5th percentile rate based on 19 observations was 2.1 kg/y. No generic data are available for this food group. The percentage breakdown of species, rounded up to the nearest 5%, eaten by the critical group was 70% samphire and 30% leaf beet.

Children's consumption rates

15-year-old age group

Children in the 15-year-old age group were noted to be consuming only fish (of the five food groups). No consumption was identified for the following four food groups: crustaceans, molluscs, wildfowl and marine plants/algae.

For fish, a critical group of two individuals was identified with a maximum consumption rate of 4.3 kg/y and a mean consumption rate of 4.3 kg/y. The observed 97.5th percentile rate based on two observations was 4.3 kg/y. This compares with the generic mean and 97.5th percentile consumption rates for fish of 6.5 kg/y and 20 kg/y, respectively.

10-year-old age group

Children in the 10-year-old age group were noted to be consuming only fish (of the five food groups). No consumption was identified for the following four food groups: crustaceans, molluscs, wildfowl and marine plants/algae.

For fish, a critical group of one individual was identified who consumed 12 kg/y. The observed 97.5th percentile rate based on two observations was 12 kg/y. This compares with the generic mean and 97.5th percentile consumption rates for fish of 6.0 kg/y and 20 kg/y, respectively.

5-year-old age group

Children in the 5-year-old age group were noted to be consuming fish, crustaceans and molluscs (of the five food groups). No consumption was identified for the remaining two food groups: wildfowl and marine plants/algae.

For fish, a critical group of one individual was identified who was consuming 12 kg/y. The observed 97.5th percentile rate based on four observations was 11 kg/y.

For crustaceans, a critical group of two individuals was identified with a maximum consumption rate of 1.0 kg/y and a mean consumption rate of 1.0 kg/y. The observed 97.5th percentile rate based on two observations was 1.0 kg/y.

For molluscs, a critical group of two individuals was identified with a maximum consumption rate of 0.4 kg/y and a mean consumption rate of 0.4 kg/y. The observed 97.5th percentile rate based on two observations was 0.4 kg/y.

4.8 Intertidal occupancy

Adults' occupancy rates

Intertidal occupancy rates for adults are presented in Table 15. The table includes data on occupancy over the following six different types of substrate: mud; mud and sand; rocks; salt marsh; sand; sand and stones. Occupancy rates for houseboat dwelling are also included in the table. Individuals in the critical groups are shown in bold.

The maximum occupancy rate recorded over mud was 1300 h/y for an individual maintaining his boat. Two other individuals had occupancy rates within a factor of three of this; a commercial bait digger and a person maintaining boat moorings and his boat. This provides a critical group mean occupancy rate for this group of 830 h/y.

The maximum occupancy rate recorded over mud and sand was 780 h/y for four individuals oyster farming. No other individuals had occupancy rates within a factor of three, therefore the critical group mean occupancy rate for this group is 780 h/y.

The only occupancy rate recorded over rock was 310 h/y for an individual collecting peeler crabs commercially for angling bait.

The maximum occupancy rate recorded over salt marsh was 750 h/y for two wildfowlers. Another wildfowler had an occupancy rate within a factor of three of this. This provides a critical group mean occupancy rate for this group of 600 h/y.

The maximum occupancy rate recorded over sand was 480 h/y for two individuals carrying out water sports preparation. Twenty other people also preparing for water sports had occupancy rates within a factor of three of this. This provides a critical group mean occupancy rate for this group of 230 h/y.

The maximum occupancy rate recorded over sand and stone was 170 h/y for two dog walkers. Two other individuals walking had occupancy rates within a factor of three of this, which provides a critical group mean occupancy rate for this group of 120 h/y.

The maximum occupancy rate recorded for an occupant of a houseboat was 7900 h/y. Eleven other people who lived on houseboats had occupancy rates within a factor of three of this. This provides a critical group mean occupancy rate for this group of 6200 h/y. The occupancy rates only account for time living on boats while the tide was out and the boats were grounded on mud.

Children's occupancy rates

Occupancy rates for children are presented in Table 16. Only one child observation of occupancy over substrate was obtained during the survey. This was for a child in the 15-year-old age group of 8 h/y angling over sand and stones.

Four children in the 10-year-old age group were living on houseboats for some or all of the year. The maximum rate was 7000 h/y for two of them. One other child in this age group had

an occupancy rate within a factor of three of this. This provides a critical group mean occupancy rate for this group of 6800 h/y.

One child in the 5-year-old age group was living on a houseboat for some of the year. His occupancy rate was 2600 h/y.

Gamma dose rate measurements

Representative gamma dose rate measurements at 1 m above the substrate were taken over mud, salt marsh and sand. These measurements (shown in Table 17) ranged from 0.055 to 0.077 $\mu\text{Gy/h}$ over mud, 0.080 to 0.086 $\mu\text{Gy/h}$ over salt marsh, and the one measurement over sand was 0.058 $\mu\text{Gy/h}$. These values are consistent with those reported in RIFE (EA, EHS, FSA and SEPA, 2007). Natural levels of around 0.05 $\mu\text{Gy/h}$ over sand and around 0.07 $\mu\text{Gy/h}$ over mud and salt marsh are expected. A value of 0.06 $\mu\text{Gy/h}$ is expected for all other substrate types.

4.9 Handling of sediment, fishing gear and nets

Handling sediment, while bait digging or mollusc collecting, or handling commercial fishing gear which has become entrained with fine sediment particles, can potentially give rise to skin exposure from beta radiation. Doses to the skin need consideration as there is a separate dose limit for skin for members of the public. There is also a contribution to effective dose due to skin exposure (ICRP, 1991).

Handling of angling equipment was not considered to be a significant pathway. Therefore, as in previous surveys, data for this pathway were not collected.

Fishing gear can also be a source of whole body gamma exposure due to occupancy in the vicinity of the gear. However, this pathway is minor compared with the same exposure

received during occupancy over intertidal areas and it has therefore been omitted from the report.

Adults' handling

Table 18 shows the rates adults that spent handling fishing gear and intertidal sediment, as recorded during the survey.

The maximum fishing gear handling rate recorded was 2000 h/y for a commercial fishermen. Ten other commercial fishermen had fishing gear handling rates that came within a factor of three of this. This gives critical group mean handling rate for this group of 1100 h/y.

The maximum sediment handling rate recorded was 940 h/y for a commercial bait digger/peeler crab collector. Ten other individuals, who were oyster farming, repairing moorings and wildfowling, had handling rates within a factor of three of this giving a critical group mean handling rate of 650 h/y.

Children's handling

No children were identified during the survey that had handling rates for either sediment or commercial fishing gear.

4.10 Water based activities

Activities taking place in or on the water can potentially 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 enable dose assessment, relevant data have been collected. No manipulation of the data (for example, calculating critical group mean rates) has been carried out.

Occupancy rates for activities taking place in or on water in the survey area are shown in Table 19 for adults and Table 20 for children. For the purposes of this report, activities where there is a high likelihood of the individual's face submerging under the water have been classified as activities 'in water', as they are more likely to lead to ingestion of water. All other activities have been classified as activities 'on water'. Generic data for some activities, such as wind surfing, kite boarding and sailing were gained through an interview with club representatives.

Adults' activities in the water

Activities taking place in water included kite surfing, wind surfing, kayaking, diving, water skiing, jet skiing and swimming. The maximum rate was 400 h/y for 10 members of a kite surfing club.

Adults' activities on the water

Activities taking place on the water around Bradwell included houseboat dwelling, sailing, boating, working on boats on the estuary, commercial fishing and boat angling. The highest occupancy rate was 5200 h/y for an individual who was living on a houseboat; this represents the time the houseboat was afloat.

Children's activities in the water

Two children in the 10-year-old age group were recorded spending time in water. Both were swimming and the maximum rate was 40 h/y.

One child in the 5-year-old age group was recorded spending time in water. He was swimming for 31 h/y.

Children's activities on the water

Only one child was recorded spending time on water. He was in the 15-year-old age group and spent 120 h/y boat angling.

5 TERRESTRIAL RADIATION PATHWAYS

5.1 Terrestrial survey area

The terrestrial survey area covered all land within 5 km of the site centre (NGR TM 002 088) as shown in Figure 2.

The land around the Bradwell site was predominantly agricultural, although a considerable portion of the terrestrial area was reduced by the estuary and adjoining unfarmable salt marshes. Within the survey area, the villages of Bradwell Waterside, Bradwell on Sea and a portion of Tillingham are located to the south of the site. The towns of West Mersea and Tollesbury are located to the north of the site on the far side of the Blackwater Estuary.

Twenty two farms were identified in the Bradwell survey area. Of these:

- One produced beef cattle
- Two produced beef cattle and sheep
- One produced sheep
- One produced chicken eggs and arable crops
- One produced chicken eggs and fruit and vegetables
- Sixteen produced arable crops

Beef cattle and lambs were sold to the nearest abattoir in Burnham. Chicken eggs were sold from one farm directly to the public. Sixteen farms produced crops, which included potatoes, peas, lucerne, wheat, barley, oil seed rape, linseed, grass for hay and sugar beet. The crops were either kept for animal feed or sold to a crop merchant and a national grain merchant outside the survey area.

Farmers and their families were consuming beef, lamb and eggs from their own farms.

One allotment site, at Bradwell on Sea, was located in the terrestrial survey area, and two others, marginally outside the survey area, at Tillingham and Tollesbury, were visited to increase the number of observations. The allotment sites were well maintained and people were growing a range of vegetables and fruit. Several private gardens with a large range of fruit and vegetables were also noted and some people kept chickens in their gardens for eggs.

One beekeeper was identified in the survey area who owned and maintained five hives, all kept in their garden at Tillingham, inside the terrestrial survey area. The beekeeper reported that an average honey yield per hive was 90 kg/y. Although some honey was sold from their doorstep, the majority was sold through local shops.

The consumption of wild foods included blackberries, sloes, bullus plums, plums, greengages, hazelnuts and mushrooms. Game from within the survey area was consumed; this included pheasant, pigeon, partridge, woodcock, rabbit and hare.

One household was using spring fed well water as their domestic supply, but no one was found drinking borehole water. Livestock were identified drinking borehole and surface water at several farms.

No freshwater fisheries containing trout were identified in the terrestrial area. Several dykes, ditches and streams were noted that could contain coarse fish (such as eels), however, angling was not observed by the survey team. One farm had ponds stocked with carp for sport angling only, none of which were consumed.

5.2 Unusual pathways

Transfer of radioactive contamination from the site into the surrounding area by wildlife was investigated. Representatives from the Bradwell site were asked about wildlife that could potentially act as carriers for the transfer of radioactivity off site. Hares, pheasants, partridges

and pigeons were observed on site. The latter were considered by the site operators to be a problem and were periodically culled when they became numerous. Members of the public who lived in the survey area were consuming hares, pheasants, partridges and pigeons that were shot within the terrestrial survey area.

5.3 Retailers

Several retailers located inside the survey area were interviewed in order to find out whether they were selling produce grown/reared from within the survey area. They included a butcher, four village shops, a deli and a smallholding outlet. One of the shops and the deli were selling honey supplied by the local beekeeper and another village shop was selling fruit and vegetables supplied by one of the farmers in the survey area. The smallholding sold locally produced jam, preserves, fruit, vegetables, eggs and chickens to the public from its premises. The butcher and a shop owner selling organically reared beef and lamb reported that all their produce was supplied from outside the survey area.

5.4 Food consumption data

Consumption data for locally produced foodstuffs potentially affected by gaseous discharges are presented in Tables 21 to 33 for adults and Tables 34 to 44 for children. These tables include the mean consumption rates of the critical groups together with the observed 97.5th percentile rates calculated as described in Section 3.2. For purposes of comparison, the data are summarised in Table 11 for adults and in Tables 12 to 14 for children (15-year-olds, 10-year-olds and 5-year-olds, respectively). No children in the 1-year-old or 3-month-old age groups were noted to be consuming locally produced foods potentially affected by gaseous discharges.

In order to provide information relevant to surveillance and assessments studies, the consumption rate data collected during the survey were analysed to indicate which food types most commonly contributed to each food group. The data are summarised in Table 45.

Those food types shown in bold and labelled with an asterisk were sampled as part of the 2006 Food Standards Agency monitoring programme (EA, EHS, FSA and SEPA, 2007).

Adults' consumption rates

Consumption of locally produced foods was identified in the following 13 food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, cattle meat, sheep meat, poultry, eggs, wild/free foods, rabbits/hares, honey and wild fungi. No consumption of milk, pig meat, venison, freshwater fish and local cereals was identified.

Critical group mean consumption rates were found to be greater than the generic 97.5th percentile consumption rates for green vegetables, root vegetables and honey. A further five critical group mean rates exceeded the generic mean consumption rates. These were for other vegetables, domestic fruit, sheep meat, poultry and eggs. Three observed 97.5th percentile consumption rates exceeded the generic 97.5th percentile consumption rates. These were for other vegetables, root vegetables and honey.

Children's consumption rates

15-year-old age group

Eight children in this age group were identified to be eating locally produced food. Consumption was identified in the following 11 food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, cattle meat, sheep meat, poultry, eggs, wild/free foods and wild fungi. No consumption of milk, pig meat, rabbits/hares, honey, venison, freshwater fish and local cereals was identified. Critical group mean consumption rates did not exceed the generic 97.5th percentile consumption rates for any food group. Two critical group mean consumption rates exceeded the generic mean consumption rates. These were for root vegetables and eggs. No observed 97.5th percentile consumption rates were greater than the generic 97.5th percentile consumption rates.

10-year-old age group

Three children in this age group were identified to be eating locally produced food. Consumption was identified in the following five food groups: domestic fruit, cattle meat, sheep meat, wild/free foods and wild fungi. No consumption of green vegetables, other vegetables, root vegetables, potato, milk, pig meat, poultry, eggs, rabbits/hares, honey, venison, freshwater fish and local cereals was identified. No critical group mean consumption rates exceeded the generic 97.5th percentile or generic mean consumption rates. No observed 97.5th percentile consumption rates were greater than the generic 97.5th percentile consumption rates.

5-year-old age group

One child in this age group was identified to be eating locally produced food. Consumption was identified in the following two food groups: potato and eggs. No consumption of green vegetables, other vegetables, root vegetables, domestic fruit, milk, cattle meat, sheep meat, pig meat, poultry, wild/free foods, rabbits/hares, honey, wild fungi, venison, freshwater fish and local cereals was identified. No generic 97.5th percentile or generic mean consumption rates have been determined for this age group so no comparisons with the corresponding observed rates are possible.

6 DIRECT RADIATION PATHWAYS

6.1 Direct radiation survey area

The direct radiation survey area is shown in Figure 2. It covers all land within 1 km of the Bradwell licensed site boundary. The direct radiation survey also overlaps with direct exposure to gaseous releases from the site. The occupancy data collected from the direct radiation survey area is also applicable to direct exposure arising from gaseous releases from the site.

To the north, north-east and north-west of the site, the survey area is marine (the River Blackwater) and includes the intertidal foreshore. There was easy access to the beach within the direct radiation survey area; there was a public car park just to the east of the site with a footpath running alongside the eastern perimeter fence. There was also a public footpath running along the western side of the Bradwell site which led down to the beach, and a public footpath running parallel to the beach along the sea wall. This beach was very popular with shore anglers and walkers.

The area immediately to the east of the site was farmland and there were no businesses or residential properties in this part of the direct radiation survey area, other than barns (converted from old aircraft hangars).

To the south and south-east of the site were the remnants of RAF Bradwell Bay airfield's runways (closed in 1946); there were three businesses, three residential properties and a playing field in this part of the direct radiation survey area, interspersed within arable farmland.

To the south-west and west of the site were the bulk of the residential properties, with the western edge of the direct radiation survey area encompassing the village of Bradwell Waterside (see Figure 2.). Within the village itself there was one public house, an outdoor

training centre (a residential centre offering courses in sailing, canoeing etc.), a group of old people's homes and a caravan park, as well as residential properties themselves.

6.2 Residential activities

The direct radiation survey area included a small village (Bradwell Waterside) with several residences dotted around the Bradwell site. There was a terrace of residential care homes for older people in Bradwell Waterside.

6.3 Leisure activities

Leisure activities observed in the direct radiation survey area included angling, bird watching, dog walking, walking, sailing and canoeing.

6.4 Commercial activities

There were a chicken farm, a book distribution warehouse, a performance car engineering works, a public house and an outdoor activity centre within the direct radiation survey area. The fields around the site were farmed for arable crops. The commercial activities of the employees and contractors of the Bradwell site, while at work, were not included in the direct radiation survey.

6.5 Occupancy rates

Table 46 presents indoor, outdoor and total occupancy data for adults and children. An analysis of the data by distance zones and occupancy rates is shown in Table 47.

0 - 0.25 km from the site perimeter fence

Occupancy data were collected for 10 individuals in the 0 - 0.25 km zone. Two were retired residents and the rest were engaged in recreational activities such as angling and dog walking. One of the residents had the highest total occupancy rate of 8600 h/y. He also had both the highest indoor and outdoor occupancy rates of 7300 h/y and 1300 h/y, respectively.

>0.25 – 0.5 km from the site perimeter fence

Occupancy data were collected for three individuals in the >0.25 - 0.5 km zone. Two were residents and the other was a farmer spending time in fields adjacent to the site. One of the residents had the highest total occupancy rate of 7400 h/y. He also had both the highest indoor and outdoor occupancy rates of 6700 h/y and 740 h/y, respectively.

>0.5 – 1.0 km from the site perimeter fence

Occupancy data were collected for 69 people in the >0.5 - 1.0 km zone. The majority of observations were for residents. Other observations were people working in the area, such as at the Bradwell Outdoor Centre and the performance car engineering works. A resident had the highest total occupancy rate of 8600 h/y. The highest indoor rate was 8500 h/y for this resident. The highest outdoor rate was 1600 h/y for a different resident spending leisure time in her garden.

6.6 Gamma dose rate measurements

Table 48 presents gamma dose rate measurements for the Bradwell direct radiation survey. Representative gamma dose rate measurements were taken at a height of 1 m both inside and outside residences and businesses and at outdoor background locations outside the direct radiation survey area. Outdoor measurements were taken approximately 5 to 10 metres from the nearest buildings, and the background locations were in field of rough

grassland. It should be noted that the measurements taken at residences and businesses have not been adjusted for natural background dose rates.

In the survey area, the six outdoor measurements taken over grass ranged from 0.063 to 0.079 $\mu\text{Gy/h}$. The three outdoor measurements taken over concrete ranged from 0.049 to 0.084 $\mu\text{Gy/h}$. The 12 measurements taken inside houses and a business ranged from 0.047 to 0.099 $\mu\text{Gy/h}$.

Outside the survey area, background readings over grass ranged from 0.068 to 0.075 $\mu\text{Gy/h}$. At the time of the survey, only two outdoor measurements within the survey area were above the maximum of these background measurements; one over grass and the other over concrete.

Comprehensive studies of background radiation have been carried out on a national scale by the Radiation Protection Division of the Health Protection Agency (previously the National Radiological Protection Board), the most recent of these being a review conducted in 2005 (Watson *et al*, 2005). The results from this review could be used for comparison with the data collected during the survey.

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 Table 49. Each of the 30 combinations shown 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 Table 49 do not correlate directly with observation numbers in Annex 1. Other individuals from Annex 1 have combinations that are not listed in Table 49 because they have fewer pathways and a dose assessment for them would be adequately covered by one of the 30 listed combinations.

Qualitative and estimated data shown in Annex 3, if any, have not been included in Table 49. This is because data in Annex 3 are estimated rates for pathways that were reported during the survey, but not quantified by interviewees.

Combinations of pathways at critical group rates may be achieved by considering the data in Annexes 1 and 2. Although critical group rates are not given in the annexes, the rates for individuals making up the groups are shown emboldened. Possible combinations of pathways and their associated critical group rates are therefore apparent.

7.1 Use of the data for assessing total dose

The Environment Agency and the Food Standards Agency have considered ways of using habits data to calculate total dose retrospectively. The adopted approach is to use the adult consumption and occupancy data collected in each habits survey to create a matrix with a series of habits profiles for each site. The relevant matrix for the Bradwell adults' profiled habits data is shown in Annex 5. The National Dose Assessment Working Group (NDAWG) has considered this approach to assessing retrospective total doses (Camplin *et al*, 2005) and has agreed that using habits profiles is an appropriate approach. Retrospective total doses around Bradwell will in future be made using these profiles and reported in the Radioactivity in Food and the Environment Reports (e.g. EA, EHS, FSA and SEPA, 2007). Data from Annex 3 are not included in Annex 5.

7.2 Use of the data for foetal dose assessment

Dose assessment of the prenatal age group was introduced routinely for the first time in the Radioactivity in Food and the Environment Report in 2005 (EA, EHS, FSA and SEPA, 2006), following the publication of recommendations by the Radiation Protection Division of the Health Protection Agency (National Radiological Protection Board, 2005). The adopted approach is to use consumption and occupancy data for women of childbearing age. Therefore, to assist in the assessment of foetal dose, consumption and occupancy data collected during the Bradwell habits survey for females of childbearing age are presented in Annex 6. The Office of National Statistics classifies women to be of childbearing age if they are between 15 – 44 years old (www.statistics.gov.uk); this age range has been used in Annex 6. It was not possible to collect ages for all female observations during the habits survey, however, these females with unknown ages have been included in Annex 6 as they are potentially women of childbearing age.

8 CONCLUSIONS AND SUGGESTIONS

8.1 Survey findings

The survey investigated the three potential sources of public radiation exposure from the Bradwell site, which were:

- Discharges of liquid radioactive waste to the Blackwater Estuary
- Discharges of gaseous radioactive waste to the atmosphere
- Emissions of direct radiation

Data were collected for 357 individuals including commercial fishermen, anglers, water sports enthusiasts, farmers, allotment holders and people spending time within 1 km of the site. These people were targeted because their habits and where they live may cause them to be exposed to radioactivity from the site. However, it should be noted that the most exposed people can only be defined with the outcome of a dose assessment.

All consumption rates recorded are only for foods produced or caught from within the aquatic and terrestrial survey areas as defined in Section 2.3.

The adult mean critical group rates (as defined in Section 3.2) for the separate aquatic consumption pathways for foods potentially affected by liquid discharges were:

- 25 kg/y for fish
- 1.1 kg/y for crustaceans
- 2.9 kg/y for molluscs
- 27 kg/y for wildfowl
- 1.4 kg/y for marine plants/algae

The predominant foods consumed by the respective critical groups for these food groups were thornback ray, cod, bass, Dover sole, crabs, lobster, Pacific oysters, European oysters, ducks, geese, samphire and leaf beet.

The consumption of seaweed by humans or animals and the use of seaweed as fertiliser were not identified. No other unusual pathways were identified.

The adult mean critical group occupancy rates over the separate intertidal substrates were:

- 830 h/y for mud
- 780 h/y for mud and sand
- 310 h/y for rock
- 600 h/y for salt marsh
- 230 h/y for sand
- 120 h/y for sand and stones
- 6200 h/y for living on houseboats while over mud

The adult mean critical group rate for handling fishing gear was 1100 h/y and for handling sediment was 650 h/y.

The adult maximum occupancy rate for time spent in water was 400 h/y and the adult maximum occupancy rate for time spent on water was 5200 h/y.

The adult mean critical group rates for the separate terrestrial consumption pathways for foods potentially affected by gaseous discharges were:

- 59 kg/y for green vegetables
- 47 kg/y for other vegetables
- 46 kg/y for root vegetables
- 40 kg/y for potato
- 38 kg/y for domestic fruit
- 7.9 kg/y for cattle meat
- 17 kg/y for sheep meat
- 14 kg/y for poultry
- 15 kg/y for eggs
- 4.2 kg/y for wild/free foods

- 4.7 kg/y for rabbits/hares
- 24 kg/y for honey
- 0.70 kg/y for wild fungi

No consumption of milk, pig meat, venison, freshwater fish and cereals was identified. Consumption of foodstuffs by children was also recorded. Combinations of food groups (both aquatic and terrestrial) consumed at critical group rates, together with external pathway exposures, may be derived from the data for individuals in Annexes 1 and 2. Rates for individuals making up the critical groups are presented in bold type.

One household was using spring fed well water as their domestic supply, but no one was found drinking borehole water. Livestock were identified drinking borehole and surface water at several farms.

No freshwater fisheries containing trout were identified in the terrestrial area. Several dykes, ditches and streams were noted that could contain coarse fish (such as eels), however, no individuals were observed angling in them. One farm had ponds stocked with carp for sport angling only, none of which were consumed.

Investigations into the off-site transfer of radioactive contamination by wildlife established that hares, partridges, pheasants and pigeons were found on site. Rabbits were not observed on the Bradwell site. In the past, pigeons were considered a nuisance and nets were installed to prevent them entering buildings. Culling this species was carried out on an 'as required' basis. Members of the public who lived in the terrestrial survey area were consuming pigeons, pheasants, partridges, hares and rabbits that were shot within 5 km of the site.

For occupancy by members of the public within 1 km of the Bradwell site area, the highest rates were:

- For the 0 - 0.25 km zone; 8600 h/y total occupancy, 7300 h/y indoors and 1300 h/y outdoors

- For the >0.25 - 0.5 km zone; 7400 h/y total occupancy, 6700 h/y indoors and 740 h/y outdoors
- For the >0.5 - 1.0 km zone; 8600 h/y total occupancy, 8500 h/y indoors and 1600 h/y outdoors

In the 0 - 0.25 km and >0.25 - 0.5 km zones, the highest total, indoor and outdoor occupancy rates were for one individual resident in each case. In the >0.5 - 1.0 km zone, one resident had the highest total and indoor occupancy rates and a different resident had the highest outdoor occupancy rate.

8.2 Comparisons with previous surveys

The results from this 2007 survey can be compared with results from the last aquatic and terrestrial habits surveys, which were both undertaken in 1999, and the direct radiation survey undertaken in 1993. The aquatic and terrestrial survey areas in the 2007 survey were the same as those in the previous surveys and the 2007 direct radiation survey area encompassed a slightly larger area than that of 1993.

Aquatic survey

Internal pathways

Consumption rates had significantly decreased in 2007 in three food groups; fish, crustaceans and molluscs and increased slightly in the remaining food group marine plants/algae. A comparison of the maximum consumption rates, critical group mean rates and number of individuals in each food group for 2001 and 2007 are shown in Table A.

Table A. Comparison between 1999 and 2007 aquatic internal exposure pathways at Bradwell

	1999			2007		
	Number in group	Maximum rate kg/y	Critical group mean kg/y	Number in critical group	Maximum rate kg/y	Critical group mean kg/y
Fish	23	83.2	43.5	16	41.4	25.0
Crustaceans	6	4.4	3.1	8	2.0	1.1
Molluscs	15	54.8	6.5	12	6.0	2.9
Wildfowl	*	*	*	5	43.9	26.5
Marine plants/algae	12	0.9	0.8	7	2.3	1.4

* Comparison of wildfowl consumption rates cannot be made because in the 1999 survey consumption rates for this food group were included in the poultry food group and cannot now be differentiated.

The main species of fish consumed by the critical group in 1999 were cod, bass, herring, thornback ray, Dover sole and sprat, and in 2007 were cod, bass, thornback ray and Dover sole. The two species of crustaceans consumed by the critical group in 1999 and 2007 were lobsters and crabs. The main species of molluscs consumed by the critical group in 1999 were mussels, Pacific oysters, winkles and whelks, and in 2007 were Pacific oysters, European oysters, Manila clams and cockles. The two species of marine plants consumed by the critical group in 1999 and in 2007 were samphire and leaf beet.

External pathways

For intertidal occupancy, the six substrates listed in Section 4.8 were identified during the 2007 survey, but only two of these – mud, and mud and sand – were identified in the 1999

survey. Therefore, only these substrates together with houseboat dwelling over mud can be compared.

For external pathways, it should be noted that the methodology for determining the critical group has changed since the 1999 survey (see Section 3.2) so care is needed when comparing results. In addition, houseboat dwelling was not considered as a separate pathway, but included in the occupancy over mud pathway. In the table, the critical group rates for the 1999 survey have been recalculated using the current methodology. Houseboat dwelling and occupancy over mud have also been recalculated as separate pathways. A comparison of the 1999 and 2007 maximum rates, critical group mean rates and number of individuals in each group for intertidal occupancy and handling fishing gear and sediment in 2001 and 2007 are shown in Table B.

Table B. Comparison between 1999 and 2007 aquatic external exposure pathways at Bradwell

Intertidal occupancy and handling	1999			2007		
	Number in group	Maximum rate h/y	Critical group mean h/y	Number in critical group	Maximum rate h/y	Critical group mean h/y
Mud	2	468	468	3	1300	827
Mud and sand	3	1185	1185	4	780	780
Houseboat dwelling	18	7665	5138	12	7924	6187
Fishing gear	8	1287	967	11	1950	1149
Sediment	5	1560	1153	11	936	645

The intertidal occupancy activities undertaken by the individuals in the critical groups in 2001 were: oyster farm workers over mud; oyster farming over mud and sand; and houseboat dwelling. The activities undertaken by the individuals in the critical groups in 2007 were: boat maintenance and bait digging over mud; oyster farming over mud and sand; and houseboat dwelling. The activity in the critical group for handling sediment in 1999 was the commercial dredging for oysters. In 2007 the sediment handling activities were oyster farming, wildfowling, fixing moorings and commercial bait digging.

A comparison of occupancy rates in and on water cannot be made because this pathway was not investigated in the 1999 survey.

Terrestrial survey

For terrestrial food groups the data in the 1999 survey were not originally used to calculate critical group rates. Therefore, for the purpose of comparison these rates have been calculated from the original data. The adult critical group mean consumption rates for terrestrial food groups from the 1999 and 2007 surveys are shown in Table C below.

Table C. Comparison between 1999 and 2007 adult critical group mean consumption rates (kg/y or l/y) for terrestrial food groups at Bradwell

Food group	1999	2007
Green vegetables	56.8	58.8
Other vegetables	51.0	47.4
Root vegetables	44.7	46.2
Potato	81.1	39.7
Domestic fruit	129.6	37.6
Cattle meat	37.8	7.9
Sheep meat	26.4	17.0
Poultry	*	14.2
Eggs	18.6	14.9
Wild/free foods	35.0	4.2
Rabbits/hares	6.0	4.7
Honey	13.6	23.6
Wild fungi	4.0	0.7

** The critical group mean consumption rate for poultry in the 1999 terrestrial survey was 56 kg/y. However, a comparison of poultry consumption rates cannot be made because wildfowl were included in the poultry group in the 1999 survey, whereas in 2007 it formed a separate food group. It has not been possible to differentiate between poultry and wildfowl in the 1999 data.*

Consumption rates had increased in 2007 in the following three food groups: green vegetables root vegetables and honey. Consumption rates had decreased in 2007 in the following nine food groups: other vegetables, potato, domestic fruit, cattle meat, sheep meat, eggs, wild/free foods, rabbits/hares, and wild fungi. There was a large increase in the honey consumption rate and there were large reductions in potato, domestic fruit, cattle meat, sheep meat, wild/free foods, and wild fungi consumption rates.

Direct radiation survey

Several direct radiation survey comparisons can be made between the 1993 survey and the 2007 survey, despite the survey area being slightly larger in 2007 than that in 1993.

The highest indoor plus outdoor occupancy rate in 1993 was 8300 h/y, all of which was spent indoors. The 2007 survey identified a maximum indoor plus outdoor occupancy rate of 8600 h/y for two retired residents, one of whom also had the highest indoor rate of 8500 h/y.

The highest outdoor occupancy rates recorded in the 1993 survey were for two residents spending 3700 h/y in their garden. The highest outdoor occupancy rate recorded in the 2007 survey was 1600 h/y for a resident working in their garden.

The main outdoor recreational activities observed during both surveys were angling and dog walking on the beach in front of the station. However, the outdoor occupancy times recorded were insignificant compared to those of the residents in both cases.

Due to the Bradwell site's advanced stage of decommissioning, the 2007 gamma dose measurements were significantly lower than those of the 1993 survey, when the station was operational. During the 1993 survey, the highest indoor and outdoor gamma dose rate measurements were 0.159 and 0.169 $\mu\text{Gy/h}$, respectively. These were measured at the residence closest to the perimeter fence. The indoor and outdoor gamma dose rate measurements taken during the 2007 survey at the same property were 0.068 and 0.079 $\mu\text{Gy/h}$, respectively.

8.3 Suggestions for environmental monitoring

The 2006 monitoring programmes operated by the Environment Agency and the Food Standards Agency included the following samples and measurements (EA, EHS, FSA and SEPA, 2007):

Aquatic surveillance

- Sole from Bradwell
- Mullet and bass from the pipeline
- Lobsters from West Mersea
- Native oysters from Tollesbury N. Channel
- Pacific oysters from Goldhanger Creek
- Winkles from the pipeline and Heybridge Basin
- Seaweed from Bradwell
- Leaf beet and samphire from Tollesbury
- Sediment from the pipeline, Waterside, West Mersea beach huts, West Mersea, Maldon and N. side Blackwater Estuary
- Seawater from Bradwell

Gamma dose rate measurements

- Sand and shingle at Bradwell Beach
- Mud and salt marsh at beach opposite power station N. side of estuary
- Salt marsh at beach opposite power station N. side of estuary
- Mud at Waterside
- Mud and salt marsh at Waterside
- Mud at Maldon
- Mud and salt marsh at Maldon
- Mud and sand at West Mersea beach huts
- Sand and shingle at West Mersea beach huts
- Mud and shingle at West Mersea

Terrestrial surveillance

- Milk
- Apples
- Blackberries
- Cabbage
- Carrots
- Lucerne
- Potatoes
- Rabbit
- Wheat
- Freshwater from public supply and coastal ditch

The following are suggestions for changes to the current environmental monitoring programmes. It should be noted that the suggestions are based on the findings of this survey. They are not the outcome of any form of assessment. It is suggested that samples currently monitored, which are not listed below, remain unchanged in the monitoring programme.

Environment Agency monitoring

- An annual water sample from the spring fed well which is being used as a domestic supply

Food Standards Agency monitoring

- An annual sample of thornback ray from the Blackwater Estuary could replace the annual mullet sample as no consumption of the latter species was identified
- An annual sample of pigeons as they are common on site and shot and consumed in the terrestrial survey area

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Figure 1. The Bradwell aquatic survey area



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Figure 2. The Bradwell terrestrial (outer ring) and direct radiation (inner ring) survey area

- 1** Bradwell allotments
- 2** Tollesbury allotments
- 3** Tillingham allotments

Table 1. Survey coverage

Group	Criteria	Estimate of complete coverage	Number for whom positive data were obtained	Coverage for positive observations	Notes
SUMMARY OF ALL PATHWAYS					
All potential people in Bradwell aquatic, terrestrial and direct radiation survey areas	Number of people resident in terrestrial survey area (excluding those resident in the direct radiation survey area) (See (B) terrestrial pathways)	8000 ^a	80 ^b	1%	The survey targeted individuals who were potentially the most exposed (See Section 2.4), mostly producers of local food (farmers and allotment holders). The number for whom positive data were obtained includes 11 people who only consumed terrestrial food
	Number of people resident in the direct radiation survey area (See (C) direct radiation pathways)	80	41	50%	
	Number of people employed but not resident in the direct radiation survey area (See (C) direct radiation pathways)	32	32	100%	Excluding employees and contractors of Magnox Electric Ltd. and British Energy Generation Ltd., and people living in the direct radiation survey area
	Number of people doing leisure pursuits but not resident in the direct radiation survey area (See (C) direct radiation pathways)	U	7	U	Angling, walking etc.
	Number of people affected by liquid discharges (See (A) aquatic pathways)	U	197 ^b	U	
	Total for aquatic, terrestrial and direct radiation survey areas	U	357 ^b	U	In the Summary of All Pathways section each interviewee has only been counted once. This is in the section where their predominant activities took place
(A) AQUATIC PATHWAYS					
Commercial fishermen	Number of commercial fishermen actively fishing in survey area	30	19	63%	
Charter boat skippers	Number seen or heard of during survey	6	1	20%	
Boat anglers and hobby fishermen	Number seen or heard of during survey	U	8	U	
Shore anglers and other beach users	Number seen in action or spoken to during survey	U	73	U	
Watersports enthusiasts, yachtsmen, and ferrymen	Members of clubs in survey area and people seen in action or spoken to during survey period	U	119	U	Interviews with water sport club officials provided generic data for 40 people
Houseboats	Number of people living on houseboats in the area	50	30	60%	Estimate of 25 occupied houseboats, occupants of 15 houseboats were interviewed
Wildfowling	Number of participating club members	200	8	4%	Six wildfowling clubs were active in the Blackwater Estuary; Colchester, Mersea, Tillingham, Sergie Hundred, Blackwater and Tollesbury Wildfowling Clubs

(B) TERRESTRIAL PATHWAYS^c					
Farms	Number of farmers and their family members consuming food from the survey area	40	40	100%	Estimate of 22 working farms in the area, of which all 22 farmers were interviewed
Allotments	Number of allotment holder and their family members consuming food from the survey area	150	21	14%	Three allotment sites visited, 7 allotment holders were interviewed
Bee keepers	Number of people consuming honey in survey area	U	5	U	Estimate of beekeepers in the area, who was interviewed
(C) DIRECT RADIATION PATHWAYS					
Occupancy of area	Number with occupancies > 100 hours (excluding site employees)	U	64	U	Number of anglers etc fishing during seasonal times eg October to March for cod is unknown
Residences	Number of residents in the survey area	80	41	50%	
Employees	Number of people employed in the survey area >100 hours	32	32	100%	
BREAKDOWN OF AGE GROUPS					
Adults	Individuals over 17	U	330	U	
15-year-old	> 12.0-year-old - 17.0-year-old	U	13	U	
10-year-old	> 7.0-year-old - 12.0-year-old	U	8	U	
5-year-old	> 2.0-year-old - 7.0-year-old	U	6	U	
1-year-old	> 1.0-year-old - 2.0-year-old	U	0	U	
3-months-old	0 - 1.0-year-old	U	0	U	

Notes

^a Data from www.statistics.gov.uk were used to estimate this figure for people resident in the 5 km survey area.

^b The number of people for whom positive data was obtained, for pathways (A) and (B), will not equal the relevant totals in the summary of all pathways. This is because some individuals, for example someone who fishes from a boat and the shore and digs their own bait, will be counted three times within the pathway, whereas others, such as the families of fishermen, will not be counted at all.

^c 7 shops were visited during the survey.

U - Unknown

Table 2. 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, goat's 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
Fish (freshwater)	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, queens, scallops, razor shell, whelks, winkles

Notes

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

† Including offal

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

Observation number	Bass	Brill	Cod	Dover sole	Eel	Flounder	Herring	Mixed fish	Plaice	Thornback ray	Total
203-204	10.2		31.1								41.4
93			8.8	8.8					8.8	8.8	35.4
95-96	11.8		11.8							11.8	35.4
135		7.9		7.9						7.9	23.8
101				5.9			5.9		5.9	5.9	23.6
150-151				11.8						11.8	23.6
97, 100	5.9						5.9			5.9	17.7
102				4.4			4.4		4.4	4.4	17.7
125-126			8.2							8.2	16.3
75-76								15.6			15.6
304-305				5.9						5.9	11.8
306				5.0						5.0	10.0
77-78	2.9		2.9							2.9	8.8
159-162				4.4			4.4				8.8
157-158			4.1	4.1							8.2
79-80	2.2		2.2							2.2	6.6
9-10	2.0			2.0						2.0	6.1
87				1.9		1.3			1.9		5.1
355-356	2.6		1.2							1.2	5.0
33	4.3				0.6						4.9
88-89				1.9		0.8			1.9		4.5
5-8	2.0		2.0								4.1
82-86				2.7							2.7
217-218			1.8								1.8
335-336				1.4							1.4
106-107				1.4							1.4
114, 116	0.7		0.7								1.4
24-26	0.3									0.3	0.7
27-28	0.2										0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for fish based on the 16 highest adult consumers is 25.0 kg/y

The observed 97.5th percentile rate based on 59 observations is 38.7 kg/y

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

Observation number	Crab	Lobster	Total
87	0.7	1.3	2.0
89		1.3	1.3
9	0.4	0.6	1.1
10	0.4	0.6	1.1
5	0.8		0.8
6	0.8		0.8
7	0.8		0.8
8	0.8		0.8
134		0.6	0.6
135		0.6	0.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for crustaceans based on the 8 highest adult consumers is 1.1 kg/y

The observed 97.5th percentile rate based on 10 observations is 1.8 kg/y

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

Observation number	Manila clam	Cockle	Mussel	European oyster	Pacific oyster	Whelk	Total
304		2.0			4.0		6.0
100				1.9	2.2		4.1
350					4.0		4.0
101				1.0	2.5		3.5
108	1.0			0.5	0.9		2.4
5					2.2		2.2
6					2.2		2.2
7					2.2		2.2
8					2.2		2.2
150					2.2		2.2
151					2.2		2.2
109	0.1	0.7		0.5	0.9		2.1
333					2.0		2.0
334					2.0		2.0
93					1.7		1.7
102				0.4	1.0		1.4
335					1.0		1.0
336					1.0		1.0
307			1.0				1.0
308			1.0				1.0
87						0.8	0.8
89						0.8	0.8
95					0.4		0.4
96					0.4		0.4
119				0.3			0.3
355				0.2			0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for molluscs based on the 12 highest adult consumers is 2.9 kg/y

The observed 97.5th percentile rate based on 26 observations is 4.8 kg/y

Table 6. Adults' consumption rates of wildfowl in the Bradwell area (kg/y)

Observation number	Duck	Goose	Mallard	Teal	Wigeon	Total
147-148	32.9	11.1				43.9
24-26	7.5	7.3				14.8
129-130	11.3					11.3
355-357	6.0					6.0
244			5.4			5.4
245			5.4			5.4
352		0.2	3.0	1.1	0.6	4.9
351		0.2	3.0	1.1	0.6	4.9
354			2.7	1.0		3.7
11	2.7					2.7
12	2.7					2.7
353		0.2	0.8	0.3	0.1	1.4
259			0.2	0.1	0.2	0.5
260			0.2	0.1	0.2	0.5
38	0.2					0.2
39	0.2					0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for wildfowl based on the 5 highest adult consumers is 26.5 kg/y

The observed 97.5th percentile rate based on 22 observations is 43.9 kg/y

Table 7. Adults' consumption rates of marine plants/algae in the Bradwell area (kg/y)

Observation number	Samphire	Sea beet	Total
321	1.8	0.5	2.3
259	1.0	1.0	2.0
260	1.0	1.0	2.0
110	0.9		0.9
147	0.9		0.9
148	0.9		0.9
290	0.5	0.5	0.9
307-308	0.5		0.5
101-102	0.5		0.5
257-258	0.5		0.5
304	0.5		0.5
109	0.2		0.2
310-311	0.2		0.2
11	0.1		0.1
12	0.1		0.1

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for marine plants/algae based on the 7 highest adult consumers is 1.4 kg/y

The observed 97.5th percentile rate based on 19 observations is 2.1 kg/y

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

15-year-old age group

Observation number	Age	Bass
34	15	4.3
35	15	4.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for fish based on the 2 highest 15-year-old age group consumers is 4.3 kg/y

The observed 97.5th percentile rate based on 2 observations is 4.3 kg/y

10-year-old age group

Observation number	Age	Bass	Cod	Dover sole	Thornback ray	Total
152	7			5.9	5.9	11.8
115	8	0.7	0.7			1.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for fish based on the highest 10-year-old age group consumer is 11.8 kg/y

The observed 97.5th percentile rate based on 2 observations is 11.5 kg/y

5-year-old age group

Observation number	Age	Bass	Cod	Dover sole	Flounder	Plaice	Thornback ray	Total
153	4			5.9			5.9	11.8
91	5			0.9	0.7	0.9		2.5
90	3			0.9	0.7	0.9		2.5
117	2	0.3	0.3					0.7

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for fish based on the highest 5-year-old age group consumer is 11.8 kg/y

The observed 97.5th percentile rate based on 4 observations is 11.1 kg/y

Table 9. Children's consumption rates of crustaceans in the Bradwell area (kg/y)

5-year-old age group

Observation number	Age	Crab	Lobster	Total
91	5	0.3	0.7	1.0
90	3	0.3	0.7	1.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for crustaceans based on the 2 highest 5-year-old age group consumers is 1.0 kg/y

The observed 97.5th percentile rate based on 2 observations is 1.0 kg/y

Table 10. Children's consumption rates of molluscs in the Bradwell area (kg/y)

5-year-old age group

Observation number	Age	Whelk
91	5	0.4
90	3	0.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate for molluscs based on the 2 highest 5-year-old age group consumers is 0.4 kg/y

The observed 97.5th percentile rate based on 2 observations is 0.4 kg/y

Table 11. Summary of adults' consumption rates in the Bradwell area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum higher rate consumption	Observed minimum higher rate consumption	Observed critical group mean consumption rate	Observed 97.5 th percentile consumption rate	Generic mean consumption rate	Generic 97.5 th percentile consumption rate
Fish	59	16	41.4	15.6	25.0	38.7	15.0	40.0
Crustaceans	10	8	2.0	0.8	1.1	1.8	3.5	10.0
Molluscs	26	12	6.0	2.1	2.9	4.8	3.5	10.0
Wildfowl	22	5	43.9	14.8	26.5	43.9	ND	ND
Marine plants/algae	19	7	2.3	0.9	1.4	2.1	ND	ND
Green vegetables	41	3	98.3	39.1	58.8	39.1	15.0	45.0
Other vegetables	52	19	72.0	28.6	47.4	71.3	20.0	50.0
Root vegetables	42	10	83.9	29.3	46.2	50.1	10.0	40.0
Potato	40	20	67.7	22.8	39.7	60.5	50.0	120.0
Domestic fruit	57	7	45.2	26.3	37.6	45.2	20.0	75.0
Milk	NC	NC	NC	NC	NC	NC	95.0	240.0
Cattle meat	2	2	7.9	7.9	7.9	7.9	15.0	45.0
Pig meat	NC	NC	NC	NC	NC	NC	15.0	40.0
Sheep meat	4	2	17.0	17.0	17.0	17.0	8.0	25.0
Poultry	33	9	20.8	9.6	14.2	20.8	10.0	30.0
Eggs	20	10	23.7	8.9	14.9	23.7	8.5	25.0
Wild/free foods	16	5	5.5	2.0	4.2	5.5	7.0	25.0
Rabbits/hares	14	5	6.0	2.7	4.7	6.0	6.0	15.0
Honey	5	1	23.6	23.6	23.6	21.3	2.5	9.5
Wild fungi	6	4	0.8	0.6	0.7	0.8	3.0	10.0
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. Summary of 15-year-old children's consumption rates in the Bradwell area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum higher rate consumption	Observed minimum higher rate consumption	Observed critical group mean consumption rate	Observed 97.5 th percentile consumption rate	Generic mean consumption rate	Generic 97.5 th percentile consumption rate
Fish	2	2	4.3	4.3	4.3	4.3	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	NC	NC	NC	NC	NC	NC	ND	ND
Marine plants/algae	NC	NC	NC	NC	NC	NC	ND	ND
Green vegetables	1	1	3.0	3.0	3.0	NA	9.0	25.0
Other vegetables	3	3	7.6	6.8	7.3	7.6	10.0	30.0
Root vegetables	3	3	8.8	5.4	7.7	8.8	7.5	20.0
Potato	3	1	22.8	22.8	22.8	21.8	60.0	130.0
Domestic fruit	4	3	4.6	4.3	4.5	4.6	15.0	50.0
Milk	NC	NC	NC	NC	NC	NC	110.0	260.0
Cattle meat	1	1	7.9	7.9	7.9	NA	15.0	35.0
Pig meat	NC	NC	NC	NC	NC	NC	10.0	30.0
Sheep meat	1	1	3.4	3.4	3.4	NA	5.5	15.0
Poultry	1	1	0.2	0.2	0.2	NA	6.5	20.0
Eggs	2	2	7.9	7.9	7.9	7.9	7.0	25.0
Wild/free foods	1	1	1.4	1.4	1.4	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	1	1	0.2	0.2	0.2	NA	2.0	5.5
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

NA = not applicable

Table 13. Summary of 10-year-old children's consumption rates in the Bradwell area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum higher rate consumption	Observed minimum higher rate consumption	Observed critical group mean consumption rate	Observed 97.5 th percentile consumption rate	Generic mean consumption rate	Generic 97.5 th percentile consumption rate
Fish	2	1	11.8	11.8	11.8	11.5	6.0	20.0
Crustaceans	NC	NC	NC	NC	NC	NC	2.5	7.0
Molluscs	NC	NC	NC	NC	NC	NC	2.5	7.0
Wildfowl	NC	NC	NC	NC	NC	NC	ND	ND
Marine plants/algae	NC	NC	NC	NC	NC	NC	ND	ND
Green vegetables	NC	NC	NC	NC	NC	NC	6.0	20.0
Other vegetables	NC	NC	NC	NC	NC	NC	8.0	25.0
Root vegetables	NC	NC	NC	NC	NC	NC	6.0	20.0
Potato	NC	NC	NC	NC	NC	NC	45.0	85.0
Domestic fruit	1	1	4.3	4.3	4.3	NA	15.0	50.0
Milk	NC	NC	NC	NC	NC	NC	110.0	240.0
Cattle meat	2	2	2.0	2.0	2.0	2.0	15.0	30.0
Pig meat	NC	NC	NC	NC	NC	NC	8.5	25.0
Sheep meat	2	2	0.9	0.9	0.9	0.9	4.0	10.0
Poultry	NC	NC	NC	NC	NC	NC	5.5	15.0
Eggs	NC	NC	NC	NC	NC	NC	6.5	20.0
Wild/free foods	2	2	0.4	0.4	0.4	0.4	3.0	11.0
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	2.0	7.5
Wild fungi	2	2	0.1	0.1	0.1	0.1	1.5	4.5
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

NA = not applicable

Table 14. Summary of 5-year-old children's consumption rates in the Bradwell area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum higher rate consumption	Observed minimum higher rate consumption	Observed critical group mean consumption rate	Observed 97.5 th percentile consumption rate	Generic mean consumption rate	Generic 97.5 th percentile consumption rate
Fish	4	1	11.8	11.8	11.8	11.1	ND	ND
Crustaceans	2	2	1.0	1.0	1.0	1.0	ND	ND
Molluscs	2	2	0.4	0.4	0.4	0.4	ND	ND
Wildfowl	NC	NC	NC	NC	NC	NC	ND	ND
Marine plants/algae	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	1	1	5.4	5.4	5.4	NA	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	NC	NC	NC	NC	NC	NC	ND	ND
Poultry	NC	NC	NC	NC	NC	NC	ND	ND
Eggs	1	1	1.8	1.8	1.8	NA	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

Notes

ND = not determined

NC = not consumed

NA = not applicable

Table 15. Adults' intertidal occupancy rates in the Bradwell area (h/y)

Observation number	Location	Activity	House boat	Mud	Mud and sand	Rocks	Salt marsh	Sand	Sand and stones
111	West Mersea	Boat dwelling	7924						
128	West Mersea	Boat dwelling	7128						
122	West Mersea	Boat dwelling	6924						
123	West Mersea	Boat dwelling	6924						
119	West Mersea	Boat dwelling	6908						
125	West Mersea	Boat dwelling	6816						
126	West Mersea	Boat dwelling	6813						
127	West Mersea	Boat dwelling	6648						
109	West Mersea	Boat dwelling	5380						
120	West Mersea	Boat dwelling	4380						
121	West Mersea	Boat dwelling	4380						
118	West Mersea	Boat dwelling	4015						
116	West Mersea	Boat dwelling	2614						
284	Tollesbury Saltings	Boat dwelling	2580						
114	West Mersea	Boat dwelling	2192						
308	Tollesbury Saltings	Boat dwelling	2124						
307	Tollesbury Saltings	Boat dwelling	1894						
311	Tollesbury Saltings	Boat dwelling	1376						
310	Tollesbury Saltings	Boat dwelling	1278						
65	West Mersea	Boat dwelling	624						
110	West Mersea	Boat maintenance		1300					
203	Sales Point to Tip Head	Bait digging		624					
	St. Lawrence Bay	Collecting crabs				312			
306	West Mersea	Boat and moorings maintenance		556					
108	Blackwater Estuary	Oyster farming		312					
	West Mersea	Boat maintenance			30				
97	West Mersea	Oyster farming		234					
98	West Mersea	Oyster farming		234					
99	West Mersea	Oyster farming		234					
309	Tollesbury Saltings	Fixing moorings		200					

Table 15. Adults' intertidal occupancy rates in the Bradwell area (h/y)

Observation number	Location	Activity	House boat	Mud	Mud and sand	Rocks	Salt marsh	Sand	Sand and stones
209-210	Cockle Spit	Walking							72
29-30	Bradwell Beach Point A	Dog walking							38
27-28	Bradwell Beach Point B	Angling							14
33	Bradwell Beach Point C	Angling							8

Notes

- Emboldened observations are the critical group members
- The critical group intertidal occupancy rate for houseboat dwelling based on 12 observations is 6187 h/y
- The observed 97.5th percentile rate based on 20 observations for houseboat is 7546 h/y
- The critical group intertidal occupancy rate over mud based on 3 observations is 827 h/y
- The observed 97.5th percentile rate based on 20 observations for mud is 979 h/y
- The critical group intertidal occupancy rate over mud and sand based on 4 observations is 780 h/y
- The observed 97.5th percentile rate based on 16 observations for mud and sand is 780 h/y
- The critical group intertidal occupancy rate over rock based on 1 observation is 312 h/y
- The observed 97.5th percentile rate is not applicable for 1 observation
- The critical group intertidal occupancy rate over salt marsh based on 3 observations is 596 h/y
- The observed 97.5th percentile rate based on 11 observations for salt marsh is 750 h/y
- The critical group intertidal occupancy rate over sand based on 22 observations is 225 h/y
- The observed 97.5th percentile rate based on 27 observations for sand is 480 h/y
- The critical group intertidal occupancy rate over sand and stones based on 4 observations is 121 h/y
- The observed 97.5th percentile rate based on 9 observations for sand and stones is 170 h/y

Table 16. Children's intertidal occupancy rates in the Bradwell area (h/y)

15-year-old age group

Observation number	Age	Location	Activity	Sand and stones
34	15	Bradwell beach	Angling	8

Notes

Emboldened observations are the critical group members

The critical group intertidal occupancy rate over sand and stones based on the only observation in the 15-year-old age group is 8 h/y

The observed 97.5th percentile is not applicable for 1 observation

10-year-old age group

Observation number	Age	Location	Activity	House boat
113	9	West Mersea	Boat dwelling	6962
112	7	West Mersea	Boat dwelling	6962
124	11	West Mersea	Boat dwelling	6572
115	8	West Mersea	Boat dwelling	2192

Notes

Emboldened observations are the critical group members

The critical group intertidal occupancy rate for houseboat dwelling based on three observations in the 10-year-old age group is 6832 h/y

The observed 97.5th percentile rate based on 4 observations for houseboat dwelling is 6962 h/y

5-year-old age group

Observation number	Age	Location	Activity	House boat
117	2	West Mersea	Boat dwelling	2614

Notes

Emboldened observations are the critical group members

The critical group intertidal occupancy rate for houseboat dwelling based on the only observation in the 5-year-old age group is 2614 h/y

The observed 97.5th percentile is not applicable for 1 observation

Table 17. Gamma dose rate measurements over intertidal substrates in the Bradwell area ($\mu\text{Gy/h}$)

Location	NGR	Substrate	Gamma dose rate at 1 metre ^a
West Mersea house boat area	TM 023 123	Salt marsh	0.080
West Mersea boatyard	TM 018 122	Mud	0.062
Tollesbury Saltings	TL 967 108	Salt marsh	0.086
Tollesbury Saltings	TL 967 108	Mud	0.077
Sales Point (bait digging area)	TM 030 090	Mud	0.060
Bradwell Waterside slipway	TL 994 079	Mud	0.055
Beach opposite Bradwell power station	TM 002 091	Sand	0.058
Maylandsea Bay Sailing Club	TL 904 025	Mud	0.056
St. Lawrence Bay Watersports Club	TL 952 063	Mud	0.061

^a These measurements have not been adjusted for natural background dose rates.

Table 18. Adults' handling rates of fishing gear and sediment in the Bradwell area (h/y)

Observation number	Location	Activity	Fishing gear	Sediment
9	Blackwater Estuary	Gear handling	1950	
150	Blackwater Estuary	Gear handling	1638	
134	Blackwater Estuary	Gear handling	1512	
108	Blackwater Estuary	Gear handling	1456	
	Blackwater Estuary	Oyster farming		312
306	Tollesbury Channel	Gear handling	1200	
	West Mersea	Fixing moorings		460
304	Salcott Channel	Gear handling	960	
75	West Mersea	Gear handling	902	
	West Mersea	Oyster farming		130
87	Blackwater Estuary	Gear handling	792	
92	Blackwater Estuary	Gear handling	792	
93	Blackwater Estuary	Gear handling	720	
94	Blackwater Estuary	Gear handling	720	
159	Blackwater Estuary	Gear handling	464	
97-99	Blackwater Estuary	Gear handling	397	
	West Mersea	Oyster farming		234
77	Blackwater Estuary	Gear handling	300	
78	Blackwater Estuary	Gear handling	300	
82	Blackwater Estuary	Gear handling	200	
83	Blackwater Estuary	Gear handling	200	
95	Blackwater Estuary	Gear handling	43	
81	Blackwater Estuary	Gear handling	40	
203	Sales Point to Tip Head, St. Lawrence Bay	Bait digging, collecting crabs		936
346	Goldhanger	Oyster farming		780
347	Goldhanger	Oyster farming		780
348	Goldhanger	Oyster farming		780
349	Goldhanger	Oyster farming		780
147	Mersea to Saltcot Marshes	Wildfowling		750
149	Mersea to Saltcot Marshes	Wildfowling		750
24	Sales Point area, Tollesbury Marsh, Bradwell Creek	Wildfowling		384
26	Sales Point area, Tollesbury Marsh, Bradwell Creek	Wildfowling		384

Table 18. Adults' handling rates of fishing gear and sediment in the Bradwell area (h/y)

Observation number	Location	Activity	Fishing gear	Sediment
12	Sales Point area, Tollesbury Marsh, Bradwell Creek	Wildfowling		288
309	Tollesbury Saltings	Fixing moorings		200
291	Tollesbury Saltings	Fixing moorings		120
292	Tollesbury Saltings	Fixing moorings		120
129	Copt Hall Marsh	Wildfowling		94
351	Orplands Farm Managed Retreat	Wildfowling		90
355	Copt Hall Marsh, Mersea Island	Wildfowling, bait digging		80
157	West Mersea	Bait digging		65
170	Bradwell Outdoor Centre	Fixing moorings		36
171	Bradwell Outdoor Centre	Fixing moorings		36

Notes

Emboldened observations are the critical group members

The critical group gear handling rate based on 11 observations is 1149 h/y

The observed 97.5th percentile rate based on 21 observations for fishing gear is 1794 h/y

The critical group sediment handling rate based on 11 observations is 645 h/y

The observed 97.5th percentile rate based on 25 observations for sediment is 842 h/y

Table 19. Adults' occupancy rates in and on water in the Bradwell area (h/y)

Observation number	Location	Activity	In water	On water
261-270	Blackwater Estuary	Kite surfing	400	
271-280	Blackwater Estuary	Wind surfing	300	
120-121	West Mersea	Kayaking, sailing	260	260
281	Blackwater Estuary	Wind surfing	240	
282	Blackwater Estuary	Wind surfing, kite surfing	240	
147	West Mersea	Diving	208	
66-74	West Mersea	Kayaking	159	
219-121	Stone Watersports Club	Water skiing	96	
131-133	West Mersea	Jet skiing	60	
114, 116	West Mersea	Swimming	31	
122-123	West Mersea	Swimming	20	
259-260	West Mersea	Swimming	12	
	West Mersea	Sailing		30
257-258	Bradwell Beach	Swimming	10	
	Blackwater Estuary	Sailing		60
136-146	Blackwater Estuary	Diving	4	
	Blackwater Estuary	Boating		14
284	Tollesbury Saltings	Boat dwelling		5151
308	Tollesbury Saltings	Boat dwelling		4248
307	Tollesbury Saltings	Boat dwelling		3788
134	Blackwater Estuary	Working on the river, trawling		3092
311	Tollesbury Saltings	Boat dwelling		2753
75	West Mersea	Ferrying, dredging, trawling		2614
310	Tollesbury Saltings	Boat dwelling		2557
304	Salcott Channel, Blackwater Estuary	Trawling, working on the river		2520
9	Blackwater Estuary	Trammel netting		1800
306	Blackwater Estuary, Tollesbury Channel	Sailing, trawling		1800
150	Blackwater Estuary	Dredging		1638
108	Blackwater Estuary	Dredging		1456
87, 92	Blackwater Estuary	Trawling		1320
157	Blackwater Estuary	Boat angling		1235
159	Blackwater Estuary	Trawling		774
93-94	Blackwater Estuary	Dredging		720
333-334	Blackwater Estuary	Sailing		600
171-175	Blackwater Estuary	Sailing		576
77-78	Blackwater Estuary	Trawling		500
294-303	Blackwater Estuary	Sailing		480
97-99	Blackwater Estuary	Dredging		397
309	Blackwater Estuary	Sailing		384
82-83	Blackwater Estuary	Trawling		330
293	Blackwater Estuary	Sailing		320
5	Blackwater Estuary	Boat angling		300
176-179	Blackwater Estuary	Sailing		300
285-289	Blackwater Estuary	Sailing, dredging		225
316	Blackwater Estuary	Sailing		200
320, 323	Blackwater Estuary	Sailing		200
31-32	Blackwater Estuary	Sailing		164
106	Blackwater Estuary	Trawling		163
312-313	Blackwater Estuary	Sailing		160
324	Blackwater Estuary	Sailing		150
355	Blackwater Estuary	Boat angling		120
222-223	Blackwater Estuary	Boat angling		132
33	Blackwater Estuary	Boat angling		120
314-319	Blackwater Estuary	Sailing		120
327-332	Blackwater Estuary	Working on the river		110
170	Blackwater Estuary	Sailing		104
235	Blackwater Estuary	Sailing		100
95	Blackwater Estuary	Trawling		87
321-322	Blackwater Estuary	Sailing		84
81	Blackwater Estuary	Trawling		50
11-12	Blackwater Estuary	Sailing		44
156	Blackwater Estuary	Boat angling		42

Table 20. Children's occupancy rates in and on water in the Bradwell area (h/y)

Observation number	Age	Location	Activity	In water	On water
15-year-old age group					
34	15	Blackwater Estuary	Boat angling		120
10-year-old age group					
124	11	West Mersea	Swimming	40	
115	8	West Mersea	Swimming	31	
5-year-old age group					
117	2	West Mersea	Swimming	31	

Table 21. Adults' consumption rates of green vegetables in the Bradwell area (kg/y)

Observation number	Artichoke	Asparagus	Broccoli	Brussel sprout	Cabbage	Cauliflower	Chard	Courgettes	Cucumber	Lettuce	Marrow	Spinach	Total
64			42.6	25.9		7.1		7.7		8.4		6.5	98.3
1-2			9.8	9.8	9.8	9.8							39.1
3-4			7.3	7.3	7.3	7.3							29.3
325-326	5.4				4.0	4.1	4.0			1.8	2.0	4.0	25.3
24-26					14.7				1.8	1.6			18.1
257-258		1.6			4.6	2.8				6.8		1.3	17.0
344-345					6.4				4.8	3.2			14.3
337-338	2.7	1.4	1.4	0.9	1.1	0.7		2.8		2.0			12.9
52-53								7.4		4.0			11.4
46-47				8.2						3.0			11.2
154-155								7.4		1.5		1.7	10.6
167-169									8.5				8.5
225-228				2.5		0.9			3.8	0.9			8.1
48-51			1.4	1.4	3.2								5.9
186								5.5					5.5
171								5.5					5.5
55				3.0									3.0
54				3.0									3.0
304										0.9			0.9
305										0.9			0.9
44		0.5											0.5
45		0.5											0.5

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of green vegetables based on the 3 highest adult consumers is 58.8 kg/y

The observed 97.5th percentile rate based on 41 observations is 39.1 kg/y

Table 22. Adults' consumption rates of other vegetables in the Bradwell area (kg/y)

Observation number	Aubergine	Broad bean	French bean	Pea	Pepper	Runner bean	Squash	Sweetcorn	Tomato	Total
326		14.5	14.5		2.0	14.5	2.0	2.8	21.8	72.0
325		14.5	14.5		2.0	14.5	2.0	2.8	21.8	72.0
64		17.3				51.7	0.3			69.3
52		9.1				54.4			5.4	68.9
53		9.1				54.4			5.4	68.9
167		5.5		2.3		32.6			24.0	64.4
168		5.5		2.3		32.6			24.0	64.4
169		5.5		2.3		32.6			24.0	64.4
1		9.8				9.8		9.8	9.8	39.1
2		9.8				9.8		9.8	9.8	39.1
224									36.0	36.0
258	7.7	1.7	1.4	3.4	3.7	5.1			9.5	32.4
257	7.7	1.7	1.4	3.4	3.7	5.1			9.5	32.4
46		4.1	6.5	8.1		12.2				30.9
47		4.1	6.5	8.1		12.2				30.9
3		7.3				7.3		7.3	7.3	29.3
4		7.3				7.3		7.3	7.3	29.3
154			1.8		2.0	20.4			4.5	28.6
155			1.8		2.0	20.4			4.5	28.6
344		4.8		4.7		9.5				19.0
345		4.8		4.7		9.5				19.0
171	2.0					4.8			3.6	10.4
186	2.0					4.8			3.6	10.4
58-62						3.9		1.6	2.1	7.6
239									7.2	7.2
54						6.8				6.8
55						6.8				6.8
24-26		1.2	1.2			1.2			1.2	4.8
209									4.5	4.5
210									4.5	4.5
304									3.8	3.8
305									3.8	3.8
225-228				0.4			0.1		3.2	3.7
48-51		1.1				1.1		1.2		3.4
337			1.4				0.2	1.4		2.9
338			1.4				0.2	1.4		2.9
11						0.9			0.5	1.4
12						0.9			0.5	1.4
44-45						0.9				0.9

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of other vegetables

based on the 19 highest adult consumers is 47.4 kg/y

The observed 97.5th percentile rate based on 52 observations is 71.3 kg/y

Table 23. Adults' consumption rates of root vegetables in the Bradwell area (kg/y)

Observation number	Jerusalem artichoke	Beetroot	Carrot	Celeriac	Celery	Garlic	Leek	Onion	Parsnip	Radish	Shallot	Spring onion	Swede	Turnip	Total
64			34.2			1.7	17.1	13.9	13.7	3.4					83.9
24		15.7	15.7					15.7	2.0	1.0					50.1
25		15.7	15.7					15.7	2.0	1.0					50.1
26		15.7	15.7					15.7	2.0	1.0					50.1
325			8.0				7.2	18.1	8.0					4.0	45.3
326			8.0				7.2	18.1	8.0					4.0	45.3
1			9.8	9.8				9.8	9.8						39.1
2			9.8	9.8				9.8	9.8						39.1
3			7.3	7.3				7.3	7.3						29.3
4			7.3	7.3				7.3	7.3						29.3
257		6.2	6.8		4.1		6.8		1.4						25.1
258		6.2	6.8		4.1		6.8		1.4						25.1
344		8.6	4.7					5.7							19.0
345		8.6	4.7					5.7							19.0
52		12.3	4.5									2.0			18.8
53		12.3	4.5									2.0			18.8
337	2.7	4.6		1.0				6.8	2.4						17.5
338	2.7	4.6		1.0				6.8	2.4						17.5
46-47		7.4						6.5				1.8			15.7
154-155		2.9						4.7				1.3			8.9
58-62		4.7	1.3					2.6				0.3			8.8
48-51		2.3	1.1					1.1	1.1				0.6		6.2
54-55			2.3				1.5				1.6				5.4
225-228		0.5	0.4				0.9	1.0	0.4						3.2
304		2.5													2.5
305		2.5													2.5
167-169			1.4												1.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of root vegetables based on the 10 highest adult consumers is 46.2 kg/y

The observed 97.5th percentile rate based on 42 observations is 50.1 kg/y

Table 24. Adults' consumption rates of potato in the Bradwell area (kg/y)

Observation number	Potato
64	67.7
48	60.3
49	60.3
50	60.3
51	60.3
1	47.2
2	47.2
3	35.4
4	35.4
344	35.0
345	35.0
24	33.9
25	33.9
26	33.9
46	28.3
47	28.3
163	23.4
164	23.4
54	22.8
55	22.8
167	16.4
168	16.4
169	16.4
52	13.7
53	13.7
257	13.7
258	13.7
44	12.7
45	12.7
154	11.8
155	11.8
225	4.9
226	4.9
227	4.9
228	4.9
58	2.0
59	2.0
60	2.0
61	2.0
62	2.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato based on the 20 highest adult consumers is 39.7 kg/y

The observed 97.5th percentile rate based on 40 observations is 60.5 kg/y

Table 25. Adults' consumption rates of domestic fruit in the Bradwell area (kg/y)

Obs. no.	Apple	Apricot	Black-berry	Black-currant	Cherry	Dam-son	Goose-berry	Grape	Green-gages	Peach	Pear	Plum	Pumpkin	Quince	Rasp-berry	Red-currant	Rhubarb	Straw-berry	Walnut	White-currant	Total
24-26	23.6	3.0			0.9						15.7	1.4							0.6		45.2
325	3.3			0.8	2.0		2.0		3.3	6.4	3.3	3.3	6.0	1.0	2.3	0.8		2.7		0.8	37.6
326	3.3			0.8	2.0		2.0		3.3	6.4	3.3	3.3	6.0	1.0	2.3	0.8		2.7		0.8	37.6
257	22.7					1.4													2.3		26.3
258	22.7					1.4													2.3		26.3
337-338	6.8			2.1											2.5	1.7					13.2
167-169																	3.1	6.8			9.9
333-334	5.0										4.5								0.1		9.6
187-188	5.5		3.5																		9.0
154-155								1.1							4.4		2.3				7.8
344-345																		7.5			7.5
1-2							2.0								2.0			2.0			6.0
48-51			0.5	0.5			2.3								0.8	1.1				0.1	5.2
225																	1.6	3.1			4.6
226																	1.6	3.1			4.6
227																	1.6	3.1			4.6
228																	1.6	3.1			4.6
58-62				0.03							3.9						0.7				4.6
3-4							1.5								1.5			1.5			4.5
231-232	3.8																	0.5			4.3
64																	3.2				3.2
171, 186																		2.4			2.4
203-204			2.0																		2.0
209																		1.0			1.0
210																		1.0			1.0
40-43																		0.3			0.3
16-22			0.3																		0.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the 7 highest adult consumers is 37.6 kg/y

The observed 97.5th percentile rate based on 57 observations is 45.2 kg/y

Table 26. Adults' consumption rates of cattle meat in the Bradwell area (kg/y)

Observation number	Beef
339	7.9
340	7.9

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of cattle meat based on the 2 highest adult consumers is 7.9 kg/y

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

Table 27. Adults' consumption rates of sheep meat in the Bradwell area (kg/y)

Observation number	Lamb/mutton
237	17.0
238	17.0
339	3.4
340	3.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of sheep meat based on the 2 highest adult consumers is 17.0 kg/y

The observed 97.5th percentile rate based on 4 observations is 17.0 kg/y

Table 28. Adults' consumption rates of poultry in the Bradwell area (kg/y)

Observation number	Chicken	Duck	Partridge	Pheasant	Pigeon	Woodcock	Total
24-26	4.3		0.6	7.5	7.7	0.8	20.8
197	15.0						15.0
333		5.4		5.4			10.8
244-245			1.8	2.7	6.0		10.5
325-326	9.0	0.6					9.6
257-258				1.4	1.4		2.7
11-12					2.1		2.1
259-260				1.1			1.1
351-352				0.3	0.8		1.1
38-39				0.7			0.7
353				0.3	0.2		0.5
187-188				0.5			0.5
209				0.5			0.5
210				0.5			0.5
16-22				0.2			0.2
40-41				0.2			0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of poultry based on the 9 highest adult consumers is 14.2 kg/y

The observed 97.5th percentile rate based on 33 observations is 20.8 kg/y

Table 29. Adults' consumption rates of eggs in the Bradwell area (kg/y)

Observation number	Chicken egg
167-169	23.7
325-326	12.3
24-26	11.9
1-2	8.9
240-241	7.9
163-164	7.6
3-4	6.7
36-37	4.4
337-338	4.1

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of eggs based on the 10 highest adult consumers is 14.9 kg/y

The observed 97.5th percentile rate based on 20 observations is 23.7 kg/y

Table 30. Adults' consumption rates of wild/free foods in the Bradwell area (kg/y)

Observation number	Blackberry	Bullus plum	Greengage	Hazel nuts	Plums	Sloe	Total
187-188						5.5	5.5
257-258	1.4	1.4		0.5		0.9	4.1
333						2.0	2.0
339-340	0.3		0.5		0.6		1.4
203-204						1.1	1.1
259-260	1.1						1.1
325-326		1.0					1.0
24-26	0.3			0.3			0.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wild/free foods based on the 5 highest adult consumers is 4.2 kg/y

The observed 97.5th percentile rate based on 16 observations is 5.5 kg/y

Table 31. Adults' consumption rates of rabbits/hares in the Bradwell area (kg/y)

Observation number	Hare	Rabbit	Total
24-26		6.0	6.0
244-245		2.7	2.7
351-352		1.5	1.5
257-258		1.4	1.4
259-260	0.8		0.8
209-210		0.5	0.5
353		0.4	0.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of rabbits/hares based on the 5 highest adult consumers is 4.7 kg/y

The observed 97.5th percentile rate based on 14 observations is 6.0 kg/y

Table 32. Adults' consumption rates of honey in the Bradwell area (kg/y)

Observation number	Honey
13	23.6
44	0.9
45	0.9
11	0.5
12	0.5

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of honey based on the highest adult consumer is 23.6 kg/y

The observed 97.5th percentile rate based on 5 observations is 21.3 kg/y

Table 33. Adults' consumption rates of wild fungi in the Bradwell area (kg/y)

Observation number	Mushrooms
257	0.8
258	0.8
259	0.6
260	0.6
339	0.2
340	0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wild fungi based on the 4 highest adult consumers is 0.7 kg/y

The observed 97.5th percentile rate based on 6 observations is 0.8 kg/y

Table 34. Children's consumption rates of green vegetables in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Brussel sprout
56	16	3.0

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of green vegetables based on the only 15-year-old age group consumer is 3.0 kg/y
 The observed 97.5th percentile rate is not applicable for 1 observation

Table 35. Children's consumption rates of other vegetables in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Runner bean	Sweetcorn	Tomato	Total
63	16	3.9	1.6	2.1	7.6
57	15	3.9	1.6	2.1	7.6
56	16	6.8			6.8

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of other vegetables based on the 3 highest 15-year-old age group consumers is 7.3 kg/y
 The observed 97.5th percentile rate based on 3 observations is 7.6 kg/y

Table 36. Children's consumption rates of root vegetables in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Beetroot	Carrot	Leek	Onion	Shallot	Spring onion	Total
63	16	4.7	1.3		2.6		0.3	8.8
57	15	4.7	1.3		2.6		0.3	8.8
56	16		2.3	1.5		1.6		5.4

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of root vegetables based on the 3 highest 15-year-old age group consumers is 7.7 kg/y
 The observed 97.5th percentile rate based on 3 observations is 8.8 kg/y

Table 37. Children's consumption rates of potato in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Potato
56	16	22.8
63	16	4.0
57	15	4.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato based on the highest 15-year-old age group consumer is 22.8 kg/y

The observed 97.5th percentile rate based on 3 observations is 21.8 kg/y

5-year-old age group

Observation number	Age	Potato
165	3	5.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato based on the only 5-year-old age group consumer is 5.4 kg/y

The observed 97.5th percentile rate is not applicable for 1 observation

Table 38. Children's consumption rates of domestic fruit in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Apple	Blackberry	Blackcurrant	Plum	Rhubarb	Strawberry	Total
63	16			0.03	3.9	0.7		4.6
57	15			0.03	3.9	0.7		4.6
233	12	3.8					0.5	4.3
23	13		0.3					0.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the 3 highest 15-year-old age group consumers is 4.5 kg/y

The observed 97.5th percentile rate based on 4 observations is 4.6 kg/y

10-year-old age group

Observation number	Age	Apple	Strawberry	Total
234	9	3.8	0.5	4.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the only 10-year-old age group consumer is 4.3 kg/y

The observed 97.5th percentile rate is not applicable for 1 observation

Table 39. Children's consumption rates of cattle meat in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Beef
341	16	7.9

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of cattle meat based on the only 15 year old age group consumer is 7.9 kg/y
The observed 97.5th percentile rate is not applicable for 1 observation

10-year-old age group

Observation number	Age	Beef
342	11	2.0
343	11	2.0

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of cattle meat based on the 2 highest 10-year-old age group consumers is 2.0 kg/y
The observed 97.5th percentile rate based on 2 observations is 2.0 kg/y

Table 40. Children's consumption rates of sheep meat in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Lamb/mutton
341	16	3.4

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of sheep meat based on the only 15-year-old age group consumer is 3.4 kg/y
The observed 97.5th percentile rate is not applicable for 1 observation

10-year-old age group

Observation number	Age	Lamb/mutton
342	11	0.9
343	11	0.9

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of sheep meat based on the 2 highest 10-year-old age group consumers is 0.9 kg/y
The observed 97.5th percentile rate based on 2 observations is 0.9 kg/y

Table 41. Children's consumption rates of poultry in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Pheasant
23	13	0.2

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of poultry based on the only 15-year-old age group consumer is 0.2 kg/y
The observed 97.5th percentile rate is not applicable for 1 observation

Table 42. Children's consumption rates of eggs in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Chicken egg
242	16	7.9
243	13	7.9

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of eggs based on the 2 highest 15-year-old age group consumers is 7.9 kg/y
The observed 97.5th percentile rate based on 2 observations is 7.9 kg/y

5-year-old age group

Observation number	Age	Chicken egg
165	3	1.8

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of eggs based on the only 5 year old-age-group consumer is 1.8 kg/y
The observed 97.5th percentile rate is not applicable for 1 observation

Table 43. Children's consumption rates of wild/free foods in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Blackberry	Greengage	Plums	Total
341	16	0.3	0.5	0.6	1.4

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 1.4 kg/y
The observed 97.5th percentile rate is not applicable for 1 observation

10-year-old age group

Observation number	Age	Blackberry	Greengage	Plums	Total
342	11	0.1	0.1	0.1	0.4
343	11	0.1	0.1	0.1	0.4

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of wild/free foods based on the 2 highest 10-year-old age group consumers is 0.4 kg/y
The observed 97.5th percentile rate based on 2 observations is 0.4 kg/y

Table 44. Children's consumption rates of wild fungi in the Bradwell area (kg/y)

15-year-old age group

Observation number	Age	Mushrooms
341	16	0.2

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of wild fungi based on the only 15-year-old age group consumer is 0.2 kg/y
The observed 97.5th percentile rate is not applicable for 1 observation

10-year-old age group

Observation number	Age	Mushrooms
342	11	0.1
343	11	0.1

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of wild fungi based on the 2 highest 10-year-old age group consumers is 0.1 kg/y
The observed 97.5th percentile rate based on 2 observations is 0.1 kg/y

Table 45. Percentage contribution each food type makes to its terrestrial food group for adults

Domestic fruit		Root vegetables		Wild/free foods	
*Apple 33.2 %		Onion 26.4 %		Sloe 52.8 %	
Strawberry 14.0 %		Beetroot 22.5 %		*Blackberry 20.3 %	
Pear 10.8 %		*Carrot 22.3 %		Bullus plum 14.6 %	
Plum 7.9 %		Parsnip 11.0 %		Hazel nuts 5.6 %	
Raspberry 5.8 %		Leek 6.8 %		Plums 3.5 %	
Rhubarb 5.3 %		Celeriac 4.8 %		Greengage 3.2 %	
Gooseberry 4.0 %		Spring onion 1.5 %			
Blackberry 3.0 %		Celery 1.1 %		Poultry	
Peach 2.6 %		Turnip 1.1 %		Chicken 30.9 %	
Pumpkin 2.4 %		Radish 0.8 %		Pheasant 29.9 %	
Redcurrant 1.9 %		Artichoke 0.7 %		Pigeon 29.4 %	
Apricot 1.8 %		Shallot 0.4 %		Duck 4.4 %	
Blackcurrant 1.6 %		Swede 0.3 %		Partridge 3.6 %	
Cherry 1.4 %		Garlic 0.2 %		Woodcock 1.6 %	
Walnuts 1.3 %					
Greengage 1.3 %		Green vegetables		Other vegetables	
Damson 0.5 %		*Cabbage 20.7 %		Runner bean 43.2 %	
Grape 0.5 %		Brussel sprout 16.7 %		Tomato 26.0 %	
Quince 0.4 %		Broccoli 14.3 %		Broad bean 13.3 %	
Whitecurrant 0.4 %		Lettuce 10.6 %		Sweetcorn 5.1 %	
		Cauliflower 10.1 %		French bean 5.0 %	
Rabbits/hares		Cucumber 9.4 %		Pea 3.7 %	
*Rabbit 95.0 %		Courgette 9.0 %		Aubergine 1.8 %	
Hare 5.0 %		Spinach 3.4 %		Pepper 1.4 %	
		Artichoke 2.7 %		Squash 0.4 %	
Eggs		Chard 1.3 %			
Chicken egg 100.0 %		Asparagus 1.1 %		Potato	
		Marrow 0.7 %		Potato 100.0 %	
Cattle meat		Wild fungi			
Beef 100.0 %		Mushroom 100.0 %		Sheep meat	
				Lamb 100.0 %	

Notes

Food types astrisked and emboldened were monitored by FSA in 2006 (EA, EHS, FSA and SEPA, 2007). Other foods monitored were milk, lucerne and wheat.

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

Table 46. Occupancy rates in the Bradwell direct radiation survey area for adults and children (h/y)

Observation Number	Sex	Age (years)	Indoor occupancy	Outdoor occupancy	Total occupancy
0 to 0.25 km zone					
187	M	71	7268	1300	8568
188	F	68	4122	520	4642
14	M	53		170	170
15	F	53		170	170
29	M	50		38	38
30	F	49		38	38
27	M	37		14	14
28	M	38		14	14
33	M	50		8	8
34	M	15		8	8
>0.25 to 0.5 km zone					
189	M	56	6685	743	7428
190	F	56	6053	673	6726
166	M	34		25	25
>0.5 to 1 km zone					
249	F	65	8506	86	8592
224	F	66	8124	234	8358
239	F	61	6941	1365	8306
228	F	32	7916	80	7996
205	F	47	7194	598	7792
229	F	50	5986	1638	7624
250	M	12	7437	75	7512
251	M	13	7437	75	7512
232	F	49	6880	365	7245
230	M	49	6795	312	7107
252	F	29	6962	70	7033
225	F	53	6809	139	6948
231	M	49	6304	365	6669
240	M	49	6582	66	6648
211	M	46	5697	858	6555
254	F	5	6456	65	6521
246	M	35	6447	65	6512
206	M	47	5708	702	6410
248	M	65	5710	634	6344
255	M	44	5867	442	6309
256	F	48	6049	260	6309
243	M	13	6209	63	6272
12	M	71	6105	46	6151
209	F	42	5869	250	6119
210	F	38	5869	250	6119
207	M	18	6044	52	6096
212	F	44	5613	429	6042
11	F	57	5884	144	6028
241	F	46	5853	59	5912
242	F	16	5843	59	5902
233	F	12	5510	365	5875
216	F	21	5815	59	5874
234	M	9	5342	365	5707
215	F	19	5588	56	5644
227	M	34	5576	56	5632
214	M	21	5380	54	5434

Table 46. Occupancy rates in the Bradwell direct radiation survey area for adults and children (h/y)

Observation Number	Sex	Age (years)	Indoor occupancy	Outdoor occupancy	Total occupancy
253	M	37	4946	50	4996
247	F	30	4902	50	4952
226	M	56	4871	49	4920
213	M	23	4687	47	4734
208	F	22	4172	104	4276
198	M	53	2784	96	2880
199	M	27	2784	96	2880
200	M	22	2784	96	2880
201	M	16	2064	96	2160
197	M	44	1872	208	2080
191	M	U	1440	360	1800
192	M	U	1440	360	1800
193	M	U	1440	360	1800
194	M	U	1440	360	1800
195	M	U	1440	360	1800
196	M	U	1440	360	1800
170	M	47	888	888	1776
171	M	37	178	1598	1776
172	M	U	178	1598	1776
173	M	U	178	1598	1776
174	M	U	178	1598	1776
175	M	U	178	1598	1776
180	F	42	1776		1776
183	F	45	1776		1776
184	F	35	1776		1776
202	M	53	1104	96	1200
181	F	50	1008		1008
182	F	20	1008		1008
176	M	U	93	833	925
177	M	U	93	833	925
178	M	U	93	833	925
179	F	U	93	833	925
185	M	60		416	416

Notes

U = Unknown

Table 47. Analysis of occupancy rates in the Bradwell direct radiation survey area

0 to 0.25 km zone	
Number of hours	Number of observations
8000 to 8760	1
7000 to 8000	0
6000 to 7000	0
5000 to 6000	0
4000 to 5000	1
3000 to 4000	0
2000 to 3000	0
1000 to 2000	0
0 to 1000	8
0 to 8760	10

>0.25 to 0.5 km zone	
Number of hours	Number of observations
8000 to 8760	0
7000 to 8000	1
6000 to 7000	1
5000 to 6000	0
4000 to 5000	0
3000 to 4000	0
2000 to 3000	0
1000 to 2000	0
0 to 1000	1
0 to 8760	3

>0.5 to 1 km zone	
Number of hours	Number of observations
8000 to 8760	3
7000 to 8000	8
6000 to 7000	17
5000 to 6000	8
4000 to 5000	5
3000 to 4000	0
2000 to 3000	5
1000 to 2000	18
0 to 1000	5
0 to 8760	69

Table 48. Gamma dose rate measurements for the Bradwell direct radiation survey ($\mu\text{Gy/h}$)

Location	Outdoor substrate	Gamma dose rate at 1 metre ^a	Indoor substrate	Gamma dose rate at 1 metre ^a
Properties				
House 1	Grass	0.079	Wood	0.068
House 2	Grass	0.063	Unknown	NM
Farm 1	Concrete	0.049	Unknown	NM
Business 1	Unknown	NM	Concrete	0.047
House 3	Unknown	NM	Concrete	0.091
House 4	Concrete	0.084	Concrete	0.088
House 5	Unknown	NM	Concrete	0.079
House 6	Concrete	0.065	Concrete	0.059
House 7	Unknown	NM	Concrete	0.089
House 8	Unknown	NM	Concrete	0.093
House 9	Unknown	NM	Concrete	0.099
House 10	Grass	0.066	Concrete	0.099
House 11	Grass	0.066	Unknown	NM
House 12	Grass	0.071	Unknown	NM
House 13	Unknown	NM	Concrete	0.077
House 14	Grass	0.064	Wood	0.098

Backgrounds				
	Distance from site boundary (km)	NGR	Substrate	Gamma dose rate at 1 metre
Background 1	5.70	TL 982 035	Grass	0.069
Background 2	6.00	TM 031 036	Grass	0.075
Background 3	7.60	TL 955 147	Grass	0.068

Notes

NM = Not measured

^a These measurements have not been adjusted for natural background dose rates.

Table 49. Combinations of adult pathways for use in dose assessments in the Bradwell 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	Intertidal occupancy over houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over mud	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and shells	Intertidal occupancy over sand and stones	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the licensed site boundary	Outdoor occupancy within 1 km of the licensed site boundary	
1	*				*	*	*	*	*	*			*	*	*	*						*												
2	*	*																									*							
3			*		*		*						*				*										*		*			*	*	
4	*																										*					*	*	
5						*	*		*								*															*	*	
6			*	*															*												*	*	*	
7																				*											*	*	*	
8	*																						*					*	*		*	*	*	
9	*		*	*		*	*	*															*					*	*		*	*	*	
10			*																	*			*						*	*		*	*	
11				*																			*						*	*		*	*	
12	*																		*				*						*	*		*	*	
13																				*									*	*		*	*	
14		*																									*	*		*	*		*	*
15					*																						*	*	*	*		*	*	*
16	*					*	*			*										*			*					*	*	*	*	*	*	*
17										*			*		*								*	*				*	*	*	*	*	*	*
18										*			*		*								*	*				*	*	*	*	*	*	*
19	*									*			*		*								*	*				*	*	*	*	*	*	*
20						*	*		*	*		*	*		*	*							*	*		*	*	*	*	*	*	*	*	*
21	*																								*	*					*	*	*	*
22						*	*	*	*	*		*	*		*	*										*	*			*	*	*	*	*
23						*	*	*	*	*		*	*		*	*														*	*	*	*	*
24										*	*	*	*		*	*		*												*	*	*	*	*
25						*	*	*	*	*		*	*		*	*		*											*	*	*	*	*	*
26			*	*	*	*	*	*	*	*		*	*		*	*		*										*	*	*	*	*	*	*
27			*	*	*	*	*	*	*	*		*	*		*	*		*										*	*	*	*	*	*	*
28										*		*	*		*	*		*						*				*	*	*	*	*	*	*
29		*							*	*		*	*		*	*		*					*					*	*	*	*	*	*	*
30															*	*		*				*						*	*	*	*	*	*	*

Notes

The food groups and external exposure pathways marked with an asterisk are combined for the corresponding combination number. For example, combination number 1 represents an individual (or individuals) from Annex 1 who had positive data in the following pathways: fish, wildfowl, green vegetables, other vegetables, root vegetables, potato, domestic fruit, poultry, eggs, wild/free foods, rabbits/hares, intertidal occupancy over mud, intertidal occupancy over salt marsh and handling sediment.

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Bradwell area

Observation number	Sex	Age (years)	Fish	Crustaceans	Molluscs	Marine plants/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	Intertidal occupancy over houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the licensed site boundary	Outdoor occupancy within 1 km of the licensed site boundary	
1	F	26						39.1	39.1	39.1	47.2	6.0				8.9																		
2	M	54						39.1	39.1	39.1	47.2	6.0				8.9																		
3	F	50						29.3	29.3	29.3	35.4	4.5				6.7																		
4	M	83						29.3	29.3	29.3	35.4	4.5				6.7																		
5	M	58	4.1	0.8	2.2																											300		
6	F	58	4.1	0.8	2.2																													
7	F	30	4.1	0.8	2.2																													
8	F	35	4.1	0.8	2.2																													
9	M	62	6.1	1.1																								1950				1800		
10	F	60	6.1	1.1																														
11	F	57				0.1	2.7		1.4						2.1				0.5												44	5884	144	
12	M	71				0.1	2.7		1.4						2.1				0.5								288		288		44	6105	46	
13	F	64																	23.6															
14	M	53																								170								170
15	F	53																							170									170
16	M	51										0.3			0.2																			
17	F	50										0.3			0.2																			
18	F	26										0.3			0.2																			
19	F	25										0.3			0.2																			
20	F	23										0.3			0.2																			
21	F	21										0.3			0.2																			
22	F	18										0.3			0.2																			
24	M	61	0.7				14.8	18.1	4.8	50.1	33.9	45.2			20.8	11.9	0.6	6.0							192		192		384					
25	F	57	0.7				14.8	18.1	4.8	50.1	33.9	45.2			20.8	11.9	0.6	6.0																
26	M	29	0.7				14.8	18.1	4.8	50.1	33.9	45.2			20.8	11.9	0.6	6.0						192			192		384					
27	M	37	0.2																								14							14
28	M	38	0.2																								14							14
29	M	50																									38							38
30	F	49																									38							38
31	M	36																														164		

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Bradwell area

Observation number	Sex	Age (years)	Fish	Crustaceans	Molluscs	Marine plants/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	Intertidal occupancy over houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the licensed site boundary	Outdoor occupancy within 1 km of the licensed site boundary	
67	M	U																				68										159		
68	M	U																					68										159	
69	M	U																					68										159	
70	M	U																					68										159	
71	M	U																					68										159	
72	F	U																					68										159	
73	F	U																					68										159	
74	F	U																					68										159	
75	M	35	15.6																				130					902	130		2614			
76	F	34	15.6																															
77	M	64	8.8																									300			500			
78	M	36	8.8																									300			500			
79	F	63	6.6																															
80	F	34	6.6																															
81	M	52																											40		50			
82	M	50	2.7																										200		330			
83	M	45	2.7																										200		330			
84	F	49	2.7																															
85	F	45	2.7																															
86	M	18	2.7																															
87	M	36	5.1	2.0	0.8																							792			1320			
88	F	34	4.5																															
89	M	71	4.5	1.3	0.8																													
92	M	U																											792		1320			
93	M	57	35.4		1.7																								720		720			
94	M	59																											720		720			
95	M	52	35.4		0.4																								43		87			
96	F	52	35.4		0.4																													
97	M	45	17.7																				234						397	234	397			
98	M	U																					234						397	234	397			

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Bradwell area

Observation number	Sex	Age (years)	Fish	Crustaceans	Molluscs	Marine plants/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	Intertidal occupancy over houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the licensed site boundary	Outdoor occupancy within 1 km of the licensed site boundary		
167	F	63						8.5	64.4	1.4	16.4	9.9				23.7																			
168	M	64						8.5	64.4	1.4	16.4	9.9				23.7																			
169	M	36						8.5	64.4	1.4	16.4	9.9				23.7																			
170	M	47																					36						36		104	888	888		
171	M	37						5.5	10.4			2.4										36						36		576	178	1598			
172	M	U																													576	178	1598		
173	M	U																													576	178	1598		
174	M	U																													576	178	1598		
175	M	U																													576	178	1598		
176	M	U																													300	93	833		
177	M	U																													300	93	833		
178	M	U																													300	93	833		
179	F	U																													300	93	833		
180	F	42																															1776		
181	F	50																															1008		
182	F	20																																1008	
183	F	45																																1776	
184	F	35																																1776	
185	M	60																																	416
186	F	27						5.5	10.4			2.4																							
187	M	71										9.0			0.5	5.5																	7268	1300	
188	F	68										9.0			0.5	5.5																	4122	520	
189	M	56																															6685	743	
190	F	56																															6053	673	
191	M	U																															1440	360	
192	M	U																															1440	360	
193	M	U																															1440	360	
194	M	U																															1440	360	
195	M	U																															1440	360	
196	M	U																															1440	360	

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Bradwell area

Observation number	Sex	Age (years)	Fish	Crustaceans	Molluscs	Marine plants/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	Intertidal occupancy over houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the licensed site boundary	Outdoor occupancy within 1 km of the licensed site boundary	
228	F	32						8.1	3.7	3.2	4.9	4.6																				7916	80	
229	F	50																															5986	1638
230	M	49																														6795	312	
231	M	49										4.3																				6304	365	
232	F	49										4.3																				6880	365	
235	M	31																					2								100			
236	M	63																					2											
237	M	61												17.0																				
238	F	60												17.0																				
239	F	61						7.2																								6941	1365	
240	M	49														7.9																6582	66	
241	F	46													7.9																	5853	59	
244	M	43					5.4								10.5		2.7																	
245	M	19					5.4								10.5		2.7																	
246	M	35																														6447	65	
247	F	30																														4902	50	
248	M	65																														5710	634	
249	F	65																														8506	86	
252	F	29																														6962	70	
253	M	37																														4946	50	
255	M	44																														5867	442	
256	F	48																														6049	260	
257	M	68				0.5		17.0	32.4	25.1	13.7	26.3			2.7	4.1	1.4			0.8											10	60		
258	F	68				0.5		17.0	32.4	25.1	13.7	26.3			2.7	4.1	1.4			0.8											10	60		
259	F	67				2.0	0.5								1.1	1.1	0.8			0.6											12	30		
260	M	65				2.0	0.5								1.1	1.1	0.8			0.6											12	30		
261	M	U																								200					400			
262	M	U																								200					400			
263	M	U																								200					400			
264	M	U																								200					400			

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Bradwell area

Observation number	Sex	Age (years)	Fish	Crustaceans	Molluscs	Marine plants/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	Intertidal occupancy over houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the licensed site boundary	Outdoor occupancy within 1 km of the licensed site boundary		
325	M	45						25.3	72.0	45.3		37.6			9.6	12.3	1.0																		
326	F	U						25.3	72.0	45.3		37.6			9.6	12.3	1.0																		
327	M	U																															110		
328	M	U																														110			
329	M	U																														110			
330	M	U																														110			
331	M	U																														110			
332	M	U																														110			
333	M	U			2.0							9.6			10.8		2.0															600			
334	F	U			2.0							9.6																				600			
335	M	U	1.4		1.0																														
336	F	U	1.4		1.0																														
337	F	U						12.9	2.9	17.5		13.2				4.1																			
338	M	U						12.9	2.9	17.5		13.2				4.1																			
339	M	57												7.9	3.4		1.4				0.2														
340	F	47												7.9	3.4		1.4				0.2														
344	M	85						14.3	19.0	19.0	35.0	7.5																							
345	M	53						14.3	19.0	19.0	35.0	7.5																							
346	M	U																								780						780			
347	M	U																								780						780			
348	M	U																								780						780			
349	M	U																								780						780			
350	M	U			4.0																														
351	M	55					4.9								1.1		1.5						90						90						
352	F	52					4.9								1.1		1.5																		
353	M	27					1.4								0.5		0.4																		
354	M	U					3.7																												
355	M	62	5.0		0.2		6.0																		30			50		80		120			
356	F	62	5.0				6.0																												
357	M	U					6.0																												

Notes

Emboldened observations are included in the critical groups.

U = Unknown

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

Observation number	Sex	Age (years)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Wild fungi	Intertidal occupancy over houseboat	Intertidal occupancy over sand and stones	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the licensed site boundary	Outdoor occupancy within 1 km of the licensed site boundary
15-year-old age group																						
56	M	16				3.0	6.8	5.4	22.8													
63	F	16					7.6	8.8	4.0	4.6												
201	M	16																			2064	96
242	F	16												7.9							5843	59
341	F	16									7.9	3.4			1.4	0.2						
34	M	15	4.3															8		120		8
35	M	15	4.3																			
57	M	15					7.6	8.8	4.0	4.6												
23	M	13								0.3			0.2									
243	M	13												7.9							6209	63
251	M	13																			7437	75
233	F	12								4.3											5510	365
250	M	12																			7437	75
10-year-old age group																						
124	F	11															6572		40			
342	F	11									2.0	0.9			0.4	0.1						
343	F	11									2.0	0.9			0.4	0.1						
113	M	9															6962					
234	M	9							4.3												5342	365
115	M	8	1.4																	2192	31	
112	M	7															6962					
152	F	7	11.8																			
5-year-old age group																						
91	M	5	2.5	1.0	0.4																	
254	F	5																			6456	65
153	F	4	11.8																			
90	F	3	2.5	1.0	0.4																	
165	F	3							5.4					1.8								
117	M	2	0.7														2614		31			

Notes

Emboldened observations are included in the critical groups.

Annex 3. Qualitative and estimated data for use in dose assessment

Details of activity	Exposure pathways involved	Estimated rate
None identified	None identified	Not applicable

Annex 4. Ratios for determining child consumption and occupancy rates for dose assessments

Group	Ratio child/adult ^a	
	1-year-old	10-year-old
Fish ^b	0.050	0.200
Crustaceans ^b	0.050	0.250
Molluscs ^b	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 ^c	0.110	0.490
Game ^d	0.140	0.500
Honey	0.789	0.789
Wild fungi	0.150	0.450
Freshwater fish ^b	0.050	0.250
Direct radiation	1.000	1.000
External exposure	0.030	0.500
Plume	1.000	1.000

Notes

^a The age groups suggested for assessment in this table are those relating to dose coefficients representing 1 to 2-year-olds (labelled 1-year-old) and 7 to 12-year-olds (labelled 10-year-old). Excepting notes ^b and ^c, consumption ratios were derived from Byrom *et al.*, (1995) for 1-year-old (6 to 12 months) and 10-year-old children (10 to 11 years).

^b Ratios were derived from Smith and Jones, (2003) which presented data for infants and children.

^c Ratios were derived from FSA data for wild fruit and nuts for infants and 10-yr-old children.

^d Game includes rabbits/hares and venison.

Annex 5. Summary of adults' profiled consumption data (kg/y or l/y) and occupancy data (h/y) in the Bradwell area

Profile Name	Number of individuals	Pathway Name																								
		Crustacea	Direct ^a	Eggs	Fish - Sea	Fruit - Domestic	Fruit and nuts - Wild	Gamma ext - Sediment ^b	Honey	Marine Plants and Algae	Meat - Cow	Meat - Game ^c	Meat - Poultry	Meat - Sheep	Mollusca	Mushrooms	Occupancy IN water	Occupancy ON water	Plume (IN; 0-0.25km) ^d	Plume (MID; >0.25-0.5km) ^d	Plume (OUT; >0.5-1 km) ^d	Vegetables - Green	Vegetables - Other Domestic	Vegetables - Potatoes	Vegetables - Root	
Crustacean consumers	8	1.1			4.8									1.3			430									
Occupants for direct radiation	72		1	0.2	0.1	0.7	0.2	10			0.1	0.3					60	190	200	3560	0.5	1.1	0.3	0.2		
Egg consumers	10			14.9	0.2	25.2	0.4	80			6.2	8.1									20.9	43	24.5	30.8		
Sea fish consumers	16				25	0.3	0.1	490	0.1					1			340									
Domestic fruit consumers	7			8.6	0.3	37.6	1.7	110	0.1		9.3	12.4			0.2		20				19.9	31.9	18.4	39.3		
Wild fruit and nut consumers	5		0.4			16.1	4.2		0.2		0.5	3.4		0.4	0.3		140	2640			6.8	13	5.5	10		
Occupants for exposure - Sediment	12				2.7			3090								50	40									
Honey consumers	1							24																		
Marine plants and algae consumers	7					0.3	290		1.4		13	0.3			0.2	30	20									
Cattle meat consumers	2					1.4				7.9					0.2											
Game meat consumers	5			7.1	0.4	27.1	0.4	300	0.4		30	12.5				40					10.9	2.9	20.3	26.9		
Poultry meat consumers	9		0.1	6.7	0.2	24.5	0.6	90			8.7	14.2					70				230	11.7	17.6	11.3	25	
Sheep meat consumers	2												17													
Mollusc consumers	12	0.3			9.7			250	0.1					2.9			490				0.1	0.3		0.2		
Mushroom consumers	4					13.2	2.6		1.2		1.3	1.9			0.7	10	50				8.5	16.2	6.8	12.5		
Occupancy in water	25							400			1.8					340	20									
Occupants on water	10	0.2			4.4			540	0.2					0.8			3030				0.1	0.4		0.2		
Occupants for plume pathways (inner area)	2		1			9	5.5					0.5						6610								
Occupants for plume pathways (middle area)	2		1																7080							
Occupants for plume pathways (outer area)	36		1	0.4		0.8		10			0.2	0.1									6110	0.9	1.9	0.5	0.4	
Green vegetable consumers	3			5.9		5.1															58.8	49.2	54	54		
Other domestic vegetable consumers	19		0.1	6.7		10.4	0.5				0.1	1.3			0.1	10				440	21.7	47.4	21.9	23.8		
Potato consumers	20			4.1	0.1	9.8	0.1	40			3.1	3.1									18.5	17.4	39.7	23		
Root vegetable consumers	10			9.1	0.2	23.5	0.4	80			6.2	8.1									34	36.5	33.4	44.6		

Notes

^a Direct radiation is expressed as a proportion of the group who are present within 1 km of the site

^b Gamma ext - sediment includes occupancy over; mud; mud & sand; salt marsh; sand; and sand & stones

^c Game meat includes rabbits/hares and wildfowl

^d Plume times are the sums of individuals' indoor and outdoor times

Annex 6. Female consumption (kg/y or l/y) and occupancy rates (h/y) in the Bradwell area, for use in foetal dose assessments

Observation number	Sex	Age (years)	Fish	Crustaceans	Molluscs	Marine plants/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	Intertidal occupancy over houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the licensed site boundary	Outdoor occupancy within 1 km of the licensed site boundary		
135	F	38	23.8	0.6																															
151	F	36	23.6		2.2																														
161	F	22	8.8																																
163	F	32									23.4					7.6																			
179	F	U																													300	93	833		
180	F	42																															1776		
182	F	20																															1008		
184	F	35																															1776		
186	F	27						5.5	10.4			2.4																							
208	F	22																															4172	104	
209	F	42							4.5			1.0			0.5			0.5								72						5869	250		
210	F	38							4.5			1.0			0.5			0.5								72						5869	250		
212	F	44																															5613	429	
215	F	19																															5588	56	
216	F	21																															5815	59	
228	F	32						8.1	3.7	3.2	4.9	4.6																					7916	80	
242	F	16														7.9																	5843	59	
247	F	30																															4902	50	
252	F	29																																6962	70
305	F	U	11.8					0.9	3.8	2.5																									
308	F	U			1.0	0.5															2124												4248		
311	F	U				0.2															1376												2753		
326	F	U						25.3	72.0	45.3		37.6			9.6	12.3	1.0																		
334	F	U			2.0							9.6																					600		
336	F	U	1.4		1.0																														
337	F	U						12.9	2.9	17.5		13.2				4.1																			
341	F	16											7.9	3.4			1.4			0.2															

Notes

U = Unknown

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