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I. INTRODUCTION

The detection in Scandinavia on Monday April 28th 1986 of increased radiation levels was the first indication of the occurrence of a major reactor accident somewhere, possibly in the USSR. Later that day, the USSR authorities confirmed that a severe accident had occurred at the Chernobyl nuclear power plant near Kiev two days earlier on April 26th but provided little detailed information. Conflicting reports were circulated during the next few days. As very little information was available about the nature and magnitude of the catastrophe, it took some time for response systems, both at national and international levels, to become operative and effective.

Whilst an assessment of the prevailing meteorological data and the pattern of contamination over Europe indicated that Ireland would not be immediately affected by the radioactive cloud from Chernobyl, the Irish air monitoring stations at Dublin and Valentia, Co. Kerry and the Nuclear Energy Board's Laboratory were placed on the alert.

The occurrence of radioactive contamination was detected in Ireland during the period May 2-4, 1986. Whilst the radioactive contamination of the air was lower than that reported for European countries, heavy rainfall occurring during the period resulted in quantities of airborne radioactivity being deposited on the ground. As a consequence the Board initiated a major environmental monitoring programme to determine the level and distribution of the deposition, the contamination of foodstuffs and the potential radiation exposure of members of the Irish public.

The contamination levels of foodstuffs being imported into Ireland were monitored and an extensive programme was undertaken to certify foodstuffs being exported.

People returning from contaminated areas in Eastern Europe were monitored at Irish hospitals and monitoring of ships and aircraft was also carried out.

The measurements were performed at the Board's Environmental Radiation Laboratory (National Radiation Monitoring Service) and at the research laboratories in the Physics Departments of the Irish universities of Trinity College Dublin, University College Dublin and University College Galway. Their advice, close co-operation and assistance with the analysis of environmental samples enabled an extensive programme to be put into operation immediately. Considerable assistance was also received from many national organisations, notably the Civil Defence, the Meteorological Service, the Department of Energy, the Department of Agriculture and many commercial organisations through the provision of environmental and foodstuff samples.

This report reviews the results of the measurements made during the first six months after the Chernobyl accident to determine the extent of the resultant environmental contamination. Estimates are presented of the individual and collective doses received by the Irish public during the first six months and the first year after the accident. Studies are continuing to provide estimates of the doses which will be received in subsequent years.

2. CHERNOBYL REACTOR AND THE ACCIDENT

Reactor No. 4 of the Chernobyl nuclear power station was a 1000 MW(e), 3200 MW(th) graphite moderated pressure tube type reactor with a direct cycle to two 500 MW(e) turbogenerators. Four of these reactors have been operating at Chernobyl and a further two are under construction. Fifteen of this type of reactor are operating in the USSR.

The accident occurred on April 26, 1986, while a test was being carried out on a turbogenerator at the time of a scheduled shutdown of the reactor. This test was designed to check the ability of one of the turbogenerators to supply the reactors power requirements should a power failure ever occur [1]. The reactor was operating at low power, 200 MW(th), at the time of the accident. Subsequent investigations showed that the accident was caused by design deficiencies and a series of human errors whereby safety systems were switched off, operation rules ignored and the reactor brought to an unstable condition. A rapid power excursion was followed by explosions which destroyed the reactor and its building. The destruction of the reactor was followed by burning of the graphite and fires started in several parts of the damaged building. These were extinguished by fire units from neighbouring towns after three and a half hours but radioactive fission products continued to be released from the reactor in substantial amounts.

The continued release of fission products was associated with the continued burning of the graphite moderator which was kept at a high temperature by the heat generated by the fission products. Large amounts of boron, dolomite, sand, clay and lead were dropped on the reactor until eventually the smouldering graphite was quenched [2]. The releases to the environment were stopped on May 5, about nine days after the accident.

It has been estimated that about 100% of the reactor core's inventory of noble gases escaped from the plant together with about 2×10^{18} Bq or about 3-4% of the core inventory of other radionuclides[2]. Estimates of the core inventories at the time of the accident and of the total releases are given in Table 1. The releases comprised about 10-20% of the caesium, iodine and tellurium inventories and about 3-6% of the remaining radionuclides. These estimates have an error of ±50%. Further studies are in progress within the USSR to characterise the physical and chemical nature of the releases.

Due to the high temperature of the release a substantial plume rise occured bringing the released materials to heights of several hundred and possibly a thousand to fifteen hundred metres. The releases were prolonged and they varied in rate and radionuclide composition.

The most significant radionuclides contained in the releases were iodine-131, caesium-134 and caesium-137 but many others were detected as airborne particulates or as deposition on the ground in the many countries affected by contamination from the Chernobyl cloud. These other radionuclides included ruthenium-103, ruthenium-106, barium-140, lanthanum-140 and tellurium-132. Actinides were detected but at very low levels.

3. RADIATION EXPOSURE PATHWAYS AND ACTION LEVELS

The most important pathways by which the exposure of man can result as a consequence of atmospheric contamination and ground deposition are:

1. External exposure from the radioactive cloud,

2. External exposure from radioactive substances deposited on the ground,

3. Internal exposure as a result of the inhalation of radioactive substances during the passage of the radioactive cloud and

4. Internal exposure as result of the ingestion of contaminated foodstuffs.

After the initial alert by the Swedish authorities, monitoring for radioactive contamination was increased by all European countries. Early attention was focussed on monitoring radiation dose rates and the concentration of various radionuclides in the air and on the ground. Once it became evident that external or inhalation exposure was not likely to be of major significance, monitoring of potential food pathways became of greatest importance. The radionuclide of immediate importance was iodine-131. It has a relatively short physical half-life of about 8 days and milk from animals grazing contaminated pastures was clearly the most likely source of human exposure. Other foods such as green vegetables and fruits were also identified as possible exposure sources. As the levels of iodine-131 decreased, the longer lived isotopes of caesium became of increasing importance in such foods as milk, milk products and meat. The potential pathways to human exposure are outlined in Figure 1.

There were inconsistent opinions among European countries on the intervention level at which protective measures, such as the restrictions on the movement and consumption of foodstuffs, should be taken to minimise doses to members of the public as recommended by the International Commission on Radiological Protection [3]. Some suggested an intervention contamination level in foodstuffs of 2000 Bq kg^{-1}. Others suggested that the intervention levels should be considerably higher to be consistent with the recommended radiation dose limits for members of the public [3, 4]. Most countries including Ireland adopted a level of 1,000 Bq kg^{-1} as the level at which the introduction of control measures would be considered.

Within the European Community, several measures were rapidly adopted in relation to the importation of foodstuffs from third countries. On May 7 the Commission adopted a decision suspending until 31 May the importation of bovine animals, swine and fresh meats from seven countries with territories within 1000 km of the site of the accident [5]. The Member States of the Community adopted a Statement on May 12 by which they undertook not to apply to agricultural products and foodstuffs coming from other Member States maximum permitted levels which were more restrictive than those applied in the case of national production.

Finally the Council adopted a Regulation on May 30 whereby the suspension of imports from seven countries imposed on May 12 was replaced by controls on imports on the basis of maximum permitted levels [6]. This Regulation states that the radioactivity due to caesium-134 and -137 must not exceed 370 Bq kg^{-1} for milk and food preparations for infants and 600 Bq kg^{-1} for other foodstuffs. Member States were also required to check compliance with these levels.

As a consequence the Nuclear Energy Board is notified of imports of foodstuffs to Ireland. Samples are taken at invervals and the contamination levels measured to ensure that imports comply with the requirements of the EEC Regulation and that members of the Irish public are not subjected to unwarranted radiation exposures. Checks are also carried out on samples collected at retail outlets. The results of some of the measurements made are given in Appendix 9.

In addition many countries outside the European Community require certification that foodstuffs imported into their countries comply with national or international standards. On request the Nuclear Energy Board as the competent national authority tests and certifies that foods exported from Ireland comply with the requirements laid down by the EEC Regulation or with the requirements of the importing country. This has necessitated the testing of a substantial number of Irish exports to many countries of the world.

4. AIRBORNE PARTICULATE RADIOACTIVITY

Airborne particulate samples are routinely collected as part of the Board's normal environmental monitoring programme at two locations, Glasnevin, Dublin and Valentia, Co. Kerry. The samples are obtained at ground level by drawing air through filter papers with a low volume pump. Sampling is normally undertaken continuously at Valentia and was extended to a similar basis at Glasnevin when news of the Chernobyl accident and its radioactive cloud became available. The samples were tested as soon as possible for their total beta and radioiodine activities and later more detailed analyses were undertaken.

The first indication that the radioactive cloud had reached Ireland came from an air filter sample collected at Glasnevin during the period from 1000 hours on Friday May 2 to 1000 hours on Saturday May 3 when a significant increase in airborne radioactivity was detected. By 1000 hours on the following day, Sunday May 4, the radioactivity levels had fallen to about one-third those of the previous day. Very little contamination was detected on air filters collected after this period and the airborne contamination levels reverted rapidly to their pre-Chernobyl levels. This rapid decrease combined with meteorological data, which showed a reversal in the direction of the airstream over Ireland, indicated that significant contamination had been limited to the period of May 2-5 with the major contamination most likely to have occurred on Saturday May 3, 1986.

The long-lived radionuclide analyses of the air filter samples collected at Glasnevin, Dublin during the period of May 1 to July 29 are given in Appendix 1 and the caesium-137 and -134 concentrations of the samples from Glasnevin are given in Table 2 for the period of May 1-10. The total beta concentrations for Glasnevin and Valentia are given in Appendix 2 and the total beta analyses for the period of May 2-10 in Table 3. No allowance has been made for sampling losses.

The principal radionuclides detected were iodine-131, caesium-137, caesium-134, ruthenium-103, ruthenium-106, tellurium-132/iodine-132 and barium-140/lanthanum-140. Traces of other radionuclides were also detected. The sharp increase in airborne activity followed by a rapid decrease is demonstrated in Figure 2. The caesium-137 concentrations at Glasnevin peaked on May 3 at 42 mBq m^{-3}, the caesium-134 at 21 mBq m^{-3} and the ruthenium-103 at 67 mBq m^{-3}. The most significant short-lived radionuclide was iodine-131 and its peak particulate activity measured at Glasnevin on May 3 was 195 mBq m^{-3}. The corresponding levels of tellurium-132/iodine-132 and barium-140/lanthanum-140 were 217 and 39 mBq m^{-3} respectively. As indicated by Table 3, the airborne contamination levels at Valentia were considerably lower than those recorded at Glasnevin. There was a further slight increase on the following Thursday, May 8, but this was followed by a decrease.

The prevailing weather conditions during the passage of the Chernobyl cloud over Ireland were characterised by extremely heavy showers of rain which varied considerably at local and regional level. The distribution of rainfall which occurred during the periods of 1000 hours Saturday May 3 to 1000 hours Sunday May 4 and for the similar period of May 4 to May 5 are shown in Figures 3 and 4. The marked regional differences in rainfall are clearly evident in these figures which were provided by the Meteorological Service [7]. It was expected as a consequence of this heavy and variable rainfall that there would be significant contamination and that it would vary considerably from location to location due to the localised nature of the heavy showers of rain.

The air filters collected at Glasnevin during the period of May 2-3 were analysed at University College Dublin for plutonium nuclides and compared with the results of the analysis of a similar sample collected at Belfield, Dublin. These results given in Table 4 showed that the plutonium airborne radioactivity at Dublin was very low, being of the order of 0.001 mBq m^{-3} [8]. It may be noted from Table 1 that the amount of plutonium released from Chernobyl was reported to have been very small.

5. RAINFALL DEPOSITION AND DRINKING WATERS

The heavy rainfall which occurred across the country during the passage of the Chernobyl cloud across Ireland resulted in airborne activity being deposited on the ground. Samples of rainwater collected during the period of May 1-5 by the Meteorological Service at six locations distributed around the country showed elevated levels of activity but considerable variation was, as shown by the results given in Table 5, observed from location to location. These results suggest that the level of deposition was dependent on the relationship between the passage of the Chernobyl cloud and the time and nature of the rainfall. The results indicate ground deposition levels varying from about 3000 to 16000 Bq m^{-2} of iodine-131.

Detailed testing is being continued at Trinity College, Dublin to determine the extent of the ground contamination due to the caesium isotopes but early results indicated a mean total caseium deposition level of about 5000 Bq m^{-2}[9]. The pre-Chernobyl levels due to fallout from the atmospheric testing of nuclear weapons in the nineteen fifties and early sixties were of the order of about 500-600 Bq m^{-2}.

Immediate attention was given to the possible contamination of drinking water supplies and subsequent exposure of members of the public through the drinking of water. Samples were taken from various water supply systems across the country including reservoirs. In general no detectable, (less than 1 Bq l^{-1}), increases above background, were found apart from two or three reservoirs where traces of contamination, less than 5 Bq l^{-1}, were detected.

6. MONITORING OF MILK AND MILK PRODUCTS

The radionuclide of most immediate importance after the deposition was iodine-131 as it is readily concentrated in milk. This provides a rapid route by which radioactive material deposited on the ground can be incorporated into the food chain and ingested by man. In the body radioiodine is highly concentrated in the thyroid and irradiates principally that organ. Iodine-131 has a physical half-life of about 8 days i.e. 50% of the iodine present decays in this time and hence its irradiation does not persist for any great length of time. It is, however, of major significance in the short term.

The other radionuclides of particular importance from this accident were caesium-137 and -134. These are also concentrated in the milk pathway and on ingestion are distributed throughout the body. Caesium-137 has a long physical half-life of about 30 years and is therefore the dominating long term contaminant. Its deposition over agricultural areas is likely to cause contamination which will persist in decreasing quantities for many years.

The sampling and testing of milk was commenced as soon as the airborne contamination was detected with the first samples being collected early on Sunday May 4 from the Dublin dairies. These proved to be free of contamination as the milk had been obtained from farms before deposition occurred. Contamination was detected in later samples when levels of 67 Bq l^{-1} iodine-131 and 136 Bq l^{-1} total caesium were detected. The testing programme was extended to a network of sampling locations around the country. Initially the samples were taken daily at individual farms from a single herd but when the contamination levels decreased samples were taken from bulked supplies at dairies and creameries. Once the contamination pattern had been established the frequency of testing was reduced, firstly to weekly testing from the end of May and monthly from July onwards.

The results of the measurements showed that the levels of contamination of milk varied considerably between the different parts of the country. The highest were found in the south midlands and in the north-west with the iodine-131 peaks occurring slightly ahead of the radiocaesium peaks. These peaks lasted for only one day and then decreased rapidly. The highest iodine-131 level of 441 Bq l^{-1} was detected on May 5 and the highest caesium-137 level of 340 Bq l^{-1} on May 6. The caesium 134 levels were approximately half those of caesium-137. Table 6 gives a summary of the contamination levels in milk whilst Appendix 3 presents the detailed results. The iodine-131 level had decreased significantly by the middle of May and was undetectable by the end of the month. Caesium contamination on the other hand, persisted for a longer period, with the mean caesium-137 level dropping to 14 Bq l^{-1} in June, 9 during July, 4 during August and 2 during September and October.

The Irish dairy industry produces a wide range of products for both the home and export markets. Besides the better known commodities such as butter and cheese, there is also extensive production of both full-fat and skim milk powders, lactose, whey powder and casein. Lactose and milk powders are used extensively in the food processing industry and are also major components in the production of infant and baby foods. Casein is used in cheese manufacture while the whey powders are primarily used for animal foodstuffs although in a demineralised form they are used in the manufacture of baby foods. The manufacture of these products involves the separation of milk into its various components as illustrated in Figure 5.

Measurements on milk products indicated that most of the caesium contamination is transferred to the skim milk portion at separation and, hence, butter showed relatively low levels of caesium. Cheeses and milk powder products showed higher levels of contamination. It is interesting to note that the manufactured products such as casein, lactose and demineralised whey powder were almost free of caesium contamination. The manufacturing processes for these products involve high pressure washing, precipitation and demineralisation and these processes were probably responsible for the removal of caesium from the final products. The contamination levels of milk powders were of particular interest as these powders are major components in the production of baby foods. Baby food manufacturers were advised to avoid the use of the higher contaminated powders and tests were carried out in cooperation with them to ensure minimum contamination.

The results of the monitoring of dried milk powders are summarised in Table 7 and detailed in Appendix 4. Table 7 gives the mean caesium-137, caesium-134 and total caesium contamination levels for a number of periods from May to October. The pattern of contamination was similar to that found in milk, the highest levels being obtained in the south midlands, the peak contamination levels occurring shortly after the deposition and the contamination levels decreasing during the monitoring period. As decay of iodine-131 would occur before the milk products are used, the caesium isotopes were of primary concern. The mean caesium-137 contamination levels in dried milk powders, i.e. the averages of a number of measurements made of samples from various locations around the country were found to be 684 Bq kg^{-1} on May 5-6, 974 Bq kg^{-1} on May 7-12, 512 Bq kg^{-1} on May 13-19 and about 389 Bq kg^{-1} during the remainder of May. These decreases continued during the subsequent months. The caesium-134 contamination levels were about half those of caesium-137. The highest level of contamination was detected in a sample of May 8 from the south midlands. It has a caesium-137 contamination level of 2586 Bq kg^{-1} and a caesium-134 level of 1361 Bq kg^{-1} to give a total caesium contamination level of 3947 Bq kg^{-1}. Such a powder would on reconstitution produce a contamination level of about 375-390 Bq l^{-1} of total caesium.

A selection of the results of the measurements of the radioactivity concentrations of the various other milk products is given in Table 8. It will be seen that contamination levels in butter, cheeses, caesin, lactose and demineralised whey powders were quite low but the rennet mother liquor (RML) and whey powders were considerably higher. The results given in Table 8 for the rennet mother liquor powders represent the maximum contamination levels detected. The highest total caesium activity shown in Appendix 4 was 9651 Bq kg^{-1} and, in common with other milk products, the contamination level fell rapidly from this value.

7. MONITORING OF VEGETABLES

Following deposition of radionuclides on vegetables and soil, the vegetables likely to show the highest levels of contamination in the short term are those which are leafy and surface grown out-of-doors as distinct from root vegetables and those grown indoors. Analyses were immediately carried out on a range of these types of vegetables sampled from different parts of the country. The species checked included broccoli, cabbage, cauliflower, lettuce, leeks, rhubarb, scallions and spinach. It was in fact very difficult to obtain samples as it appeared that relatively small quantities were available for harvesting. Prior to analysis no removal of outer leaves from cabbages or lettuces was undertaken nor were leeks, scallions or rhubarb skinned.

The first samples showed detectable amounts of expected contamination radionuclides with iodine-131, caesium-137, caesium-134, and ruthenium-103 being the principal contaminants. Iodine-132, tellurium-132, molybdenum-99, cobalt-60, barium-140 and lanthanum-140 were also present in trace amounts. At a later date testing was extended to potatoes and root vegetables.

The monitoring results are summarised in Table 9 and detailed in Appendix 5. The highest contamination was found on vegetables with high surface areas such as lettuce and cabbage. The highest levels found on lettuce were, 140 Bq kg^{-1} iodine-131 on a sample from Donegal, 166 Bq kg^{-1} caesium-137 and 111 Bq kg^{-1} ruthenium-103 on a sample from Wicklow. The lettuce samples from different parts of the country tested during the period of May 6-15 had mean contamination levels of 78 Bq kg^{-1} caesium-137, 42 Bq kg^{-1} caesium-134 and 68 Bq kg^{-1} ruthenium-103. It was particularly difficult to locate lettuce being grown out-of-doors during May whereas samples of cabbage were more readily available. The highest contamination level of cabbage was detected on a sample from the south midlands which had a caesium-137 value of 112 Bq kg^{-1}, caesium-134 of 55 Bq kg^{-1} and ruthenium-103 of 121 Bq kg^{-1}. The highest iodine-131 value was found on a sample from the south which had a contamination level of 77 Bq kg^{-1} shortly after the contamination occured.

Considerably lower contamination values were found on scallions, rhubarb, leeks and other vegetables. The monitoring programme was continued through the summer months and the results showed that the levels dropped sharply from the end of May onwards. The contamination of potatoes and root vegetables was negligible but monitoring will be continued to check possible later transfer from the soil.

8. MONITORING OF LAMB AND BEEF

The transfer of radionuclides from pasture land to meat takes somewhat longer than to milk. Measurements on lamb slaughtered during the third week of May showed signs of radiocaesium contamination. A countrywide survey of the levels of contamination of lamb was therefore commenced towards the end of May and continued during the following months. Samples were collected from each county with particular attention paid to lambs grazing upland pastures. The results are summarised in Table 10 which shows that the mean total radiocaesium concentrations for the four provinces varied from 270 to 341 Bq kg^{-1} during May-June decreasing slightly to 195 to 342 Bq kg^{-1} during July-August and to 22 to 237 during September-October.

The detailed results of the lamb surveys are given in Appendix 6. The results showed that the highest values of radiocaesium were found during the first survey in samples from the Kilkenny and Sligo regions where the mean values were slightly less than 600 Bq kg^{-1}. Four samples were detected during the survey with levels between 700-750 Bq kg^{-1} and one slightly over 1000 Bq kg^{-1}. A gradual reduction in contamination levels was noted after June. The results of these surveys are illustrated in Figures 6 and 7 which show the distribution across the country of the mean total radiocaesium contamination in lamb during the months of May-June and July-August respectively.

Similar surveys were carried out to determine the levels of contamination in beef during July to October. The results of these analyses are summarised in Table 11 which shows that the mean total radiocaesium concentrations for each of the four provinces were 59-139 Bq kg^{-1} during July decreasing to about 30-70 Bq kg^{-1} during August-September and to 22-33 Bq kg^{-1} during October. The highest value was found in a sample of beef from the Kilkenny-Waterford region which had a total radiocaesium concentration of 348 Bq kg^{-1}. The detailed results of the surveys are given in Appendix 7. In addition to the testing of samples from each county, some consignments of beef for the export market were tested. One sample from the south had a total radiocaesium concentration of 600 Bq kg^{-1}. The results showed that the levels of beef contamination were lower than those of lamb, probably reflecting their different feeding habits.

9. MONITORING OF MIGRATORY BIRDS

Considerable interest was expressed in the possibility of highly contaminated game birds returning from the Scandinavian and Artic regions to winter in Ireland. Consequently an extensive monitoring programme was commenced during late September to early October. The contamination levels found in the range of species analysed are summarised in Table 12 and detailed in Appendix 8. The species tested included woodcock, widgeon, snipe, teal, mallard, pochard, golden plover, tufted duck, shoveller duck and curlew sampled from various locations in Ireland.

The results showed that only five samples were detected with total radiocaesium concentrations exceeding 500 Bq kg^{-1}. These were all of the woodcock species and they had contamination levels of 508, 625, 695, 1770 and 2107 Bq kg^{-1}. The mean contamination level of woodcock was 291 Bq kg^{-1}. Other migratory bird species had lower mean contamination levels. The occurrence of significant numbers of highly contaminated game birds does not seem to have materialised at this stage. These results were confirmed by an extensive testing programme undertaken in the west of Ireland by University College, Galway. [10]

10. ESTIMATION OF THE RADIATION EXPOSURE OF THE IRISH PUBLIC

In estimating the radiation exposures of members of the Irish public as a result of the Chernobyl accident, exposures have been calculated from the pathways shown by the environmental monitoring programme to be the most likely to give rise to significant radiation exposure. These are

- external irradiation from the cloud
- external irradiation from deposited radioactivity
- internal irradiation from the inhalation of airborne radioactivity during the passage of the cloud and
- internal irradiation from the ingestion of contaminated foodstuffs.

The estimates are based upon the measured contamination levels and the exposures have therefore been calculated for the six month period, immediately after the contamination occurred, May to October 1986 inclusive. Based on the contamination levels towards the end of the first six month period it is considered that the doses delivered in the subsequent six months are not likely to exceed 25% of those of the first six months.

In estimating exposures to the whole Irish population, three representative categories of persons of different age groups have been chosen as different exposures would be received due to variations in metabolism and other factors associated with age. These factors include time spent outdoors, breathing rates, diets and body size. The groups chosen were adults, 10 year old children and one year old infants. In addition exposures have been calculated for an average member of the public and where appropriate a 'critical' member of the public. This 'critical' member of the public is considered to be a person with habits which lead to higher than average exposures from some pathways.

Radionucludes taken into the body are distributed between the various body organs and are cleared from the body at different rates. This can result in different organs receiving different exposures. Whilst the radiation dose to each organ from an intake of radioactivity can be estimated and the risk of an adverse effect assessed, it is convenient and conventional to express this in terms of the effective dose equivalent. The effective dose equivalent is calculated by taking the doses received by each of the major organs of the body and multiplying them by a weighting factor according to the risk associated with a unit dose to that organ. The sum of these weighted doses is the effective dose equivalent. Doses to individuals are expressed in terms of the effective dose equivalent.

Internal irradiation will occur both as a result of radioactivity inhaled into the lungs and of eating and drinking contaminated foodstuffs. The exposures estimated are those that will have been received over a lifetime from intakes during the first six months.

External irradiation from the Chernobyl cloud will continue only for as long as the cloud is present but deposited contamination will persist and cause external irradiation until removed by natural physical processes. The exposures from both these pathways have been estimated.

Because of the avidity of the thyroid gland for iodine and since iodine-131 was a dominant contaminant from this accident, exposures to the thyroid gland have been calculated separately.

(i) External irradiation from the cloud

The doses received by gamma irradiation from the passing cloud is influenced by such factors as the shape and height of the cloud, the distribution of radionuclides in the cloud and the energy of the radiation emitted by each radionuclide. However as a first estimate some of these factors can be ignored and the doses calculated based on the time integrated air concentration of the significant radionuclides in the cloud. The peak air concentration values and the derived time integrated air concentrations are given in Table 13. No allowance has been made for the presence of noble gases in the cloud nor has any consideration been given to the beta particles from radionuclides in the cloud. The latter give rise to doses primarily to the skin and these were considered to be negligible. The dose received was calculated by computing the products of the integrated air concentration of each radionuclide and the relevant conversion factor [11]. The effective dose equivalent was determined to be less than one μSv.

(ii) External irradiation from deposited radioactivity

The calculation of doses from deposited radioactivity is quite complex due, for example, to differences in deposition processes, the type of surface and the shielding provided by adjacent structures. Following deposition the dose rate above the surface will decrease due to radioactive decay and the removal of radioactivity from the surface by natural and climatic processes. Deposition of radioactive material across the country was very variable and was significantly influenced by the amount of rainfall which occurred during the passage of the Chernobyl cloud. It was not possible to obtain comprehensive estimates of the quantities of radioactivity deposited, its duration on the surface of the ground or of the resulting dose rates. A number of observations indicated that the immediate effect was to increase the normal dose rates by a factor of less than two. The remainder of the month of May was characterised by unusually heavy rainfall and hence the washing and soil penetration effects probably removed much of the initially deposited radioactivity from the surface within a short time.

The external irradiation from deposited radioactivity has been estimated indirectly by considering gamma dose rate observations made after the occurrence of contamination and by apportioning the dose rates according to the relative contributions of the deposited radionuclides having assumed that they are present in ratios similar to those measured in air. The quantity of each deposited radionuclide was thereby determined and translated to an integrated exposure for the first six months after the accident [12]. The total external exposure is the sum of the exposures from each deposited radionuclide.

The total integrated exposure was reduced by incorporating factors of 0.9, 0.7 and 0.1 to allow for indoor occupancy, body self-shielding and building shielding respectively. The resultant estimated individual effective dose equivalent was calculated to be 13 µSv.

(iii) Internal irradiation due to the inhalation of radioactivity

Internal irradiation arose from the direct inhalation of radionuclides from the cloud during its passage across the country. The three age groups mentioned earlier, adults, 10 year old children and 1 year old infants have been considered in estimating the radiation exposure from this pathway. The breathing rates used for the calculation of doses are those given in the ICRP Task Group report on Reference Man [13] and listed in Table 14 for the three age groups.

The values used for the activity levels in air as given in Table 2 and Appendix 1 were taken from the measurement of airborne particulates. As much of the iodine-131 released from Chernobyl was reported as being in the gaseous form use of the particulate iodine-131 activity only would result in an underestimation of the exposure received. It has been suggested that 70-80% of the iodine was in the gaseous form and hence would not have been trapped in the air sampling system. A correction factor has been applied to take this into account. The intakes due to inhalation of radionuclides in the cloud were determined by multiplying the integrated air concentrations by the breathing rates for the different age groups. The intakes were then converted to the effective dose equivalents by using the standard conversion factors recommended by the International Commission on Radiological Protection [11].

The effective dose equivalents arising from inhalation were determined to be 0.5 µSv, 0.8 µSv and 0.6 µSv, for the three age groups adults, 10 year old children and 1 year old infants respectively. The increase in dose for the 10 year old children with respect to the 1 year old infants arises from the large increase in breathing rates which is not offset by a decrease in the dose conversion factor. The corresponding thyroid doses were 11 µSv, 18 µSv and 15 µSv respectively for the same age groups.

(iv) Internal irradiation from the ingestion of foodstuffs

The second source of internal irradiation results from the ingestion of contaminated foodstuffs. The method of estimating the resulting committed dose equivalent involves the determination of the quantity of radioactivity taken into the body and then converting this intake to dose using standard conversion factors [11]. The total intake of radioactivity is equal to the product of the specific activity of the foodstuff consumed and the amount of the foodstuff consumed. This calculation must be made for each significant foodstuff consumed to enable the total effective dose equivalent to be determined.

As no detailed dietary information is readily available on the consumption rates of different foodstuffs in Ireland, it was necessary to assume consumption rates. The consumption rates which were assumed are similar to those used in the United Kingdom and some other countries[14]. The rates used are given in Table 15. In estimating the doses due to ingestion, account has been taken of the age of the person at the time of the intake and doses have therefore been calculated for the three age groups, adults, 10 year old children and one year old infants. In addition two groups of the population have been considered, an average consumer and a consumer with high intakes of particular foodstuffs. The latter are, as mentioned earlier, considered to be members of the critical group.

The large number of measurements made on foodstuffs have been reduced to mean and peak concentrations for the six month period of May to October inclusive for the foodstuffs of significance insofar as exposure of members of the Irish public are concerned. These concentrations are given in Tables 16 and 17. The mean concentrations represent the average of the measurements made all over the country whereas the peak concentrations are representative of the average levels determined in the regions of the country most severely affected by contamination.

The effective dose equivalents to Irish individuals based on average consumption rates and mean concentrations in foodstuffs are given in Table 18. The doses are summed over all the foodstuffs of significance. For an adult the committed effective dose equivalent during the six month period following the deposition was determined to be 65 µSv, for ten year old children 70 µSv and for one year old infants 111 µSv. The relative importance of any foodstuff for a particular age group is determined by the ingestion rates for that group. As might be expected milk is very much the dominant contributor to dose for the youngest age category and is in fact the single largest component for all age groups.

The effective dose equivalents received by individuals continuously consuming foodstuffs with peak contamination levels and with the higher food intakes during the six month period will be correspondingly increased. Taking a worst possible case when both of these occur, it is estimated that the effective dose equivalents for adults would be 290 µSv, for ten year old children 290 µSv and for one year old infants 340 µSv. As no individual is likely to consume all of these types of foodstuffs with the above average peak contamination levels and at a high rate throughout the six month period, these assumptions will lead to an overestimate of exposure to actual individuals.

One further calculation that must be carried out concerns the intake of iodine-131. This isotope is concentrated in the thyroid and therefore the dose to this organ must be considered. Based upon the values of ingested iodine-131 used in the previous calculation and using appropriate factors to convert ingested activity to the dose to the thyroid [11], the dose to the thyroid of an adult was determined to be 270 µSv, of a ten year old child 690 µSv and of a one year old infant 2300 µSv.

(v) Total average individual doses
The total committed effective dose equivalent to members of the Irish public received during the first six months following the Chernobyl contamination from the various pathways has been estimated to be 79 µSv for adults, 84 µSv for ten year old children and 126 µSv for one year old infants. The contributions from the different pathways are summarised in Table 19. The doses which will be received during the second six months are being monitored but will be considerably lower, in the region of 25% of the doses received during the first six months. If this turns out to be the case, then the total average individual doses for the first year might be 99 µSv, 105 µSv and 158 µSv for the three age groups adults, ten year old children and one year old infants respectively. The average individual natural background radiation dose during the same period would be about 1870 µSv.

(vi) Collective doses to the population
Estimates of the total dose received by the Irish population, i.e. the collective effective dose equivalent, in the first six months and in the first year after the accident were based upon the assumption that 80% of the Irish population of 3.5 million persons were adults, 10% ten year old children and 10% one year old infants. The collective effective dose equivalent was estimated to be 295 man-Sv and 370 man-Sv for the first six months and for the first year respectively.

The main pathways contributing to the collective effective dose equivalent during the first year are the consumption of contaminated food and external irradiation from deposited materials. In later years the latter pathway will increase in relative importance due to the decreasing contamination in foodstuffs.

The total collective thyroid doses using the same assumptions regarding the population distribution is estimated to be 1844 man-Sv. The principal contributing radionuclide is iodine-131 and as this has a short physical half-life of about 8 days, the majority of the exposure was delivered within a few weeks of the accident.

The health impact on the Irish population can be assessed by considering the excess numbers of cancers and other diseases which may be attributed to the radiation exposures received by the population. The United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR, which reviews all the available information on radiation effects has provided estimates of risk factors for cancers and hereditary effects as a result of radiation exposure of various tissues. This Committee has estimated that, in a population receiving a collective effective dose equivalent of 10000 man-sieverts, the total number of cancer fatalities would be 125 [15]. In the special case of exposure of the thyroid gland a collective dose to the thyroid of 10000 man-sieverts is estimated to give rise to 100 cases of thyroid tumours of which five would be expected to be fatal.

The total number of fatal cancers which would be statistically expected to occur in Ireland over the next seventy years as a result of the collective dose incurred during the first six months after the accident is about four and during the first year five. There might also be about eighteen people who would develop thyroid tumours of which one might be fatal. These cancer cases would not be individually identifiable among the very large number of fatal cancers (some 450,000) expected to occur during this period.

The UNSCEAR risk factors for radiation induced cancers are based to a large extent on data from the effects of the Japanese atomic bombs. UNSCEAR is currently reviewing these factors in the light of recent reassessments of the Japanese data. It is possible that the risk factors could be increased by two or even five times. Such a revision of UNSCEAR would result in the five fatal cancers which might be statistically probable in Ireland as a consequence of the Chernobyl accident being increased to ten or possibly twenty-five.

Genetic effects arising from exposure to radiation have been observed in animals and much effort has been devoted to identifying similar effects in man, but so far without result. Despite this lack of evidence, UNSCEAR and the International Commission on Radiological Protection has deemed it wise to assume that the genetic damage observed in animals might also occur in man. Using these assumptions it can be estimated that two to three genetic effects may arise in the Irish population from the Chernobyl accident over the next seventy years.

II. SUMMARY AND CONCLUSIONS

Early Information

1. When news of the major accident at the Chernobyl nuclear power station near Kiev in the USSR became gradually available, it became apparent that widespread radioactive contamination was possible in Europe. The Irish air monitoring stations and the Nuclear Energy Board's laboratory were placed on the alert. Radioactive contamination of the Irish environment was detected during the period of May 2-5 1986.

2. A major monitoring programme was immediately commenced to monitor closely the developing situation and to assess the levels of contamination and the potential radiation exposure of members of the Irish public. Additional laboratory accommodation and equipment had to be acquired, sampling arrangements established and analytical procedures expanded to meet the unprecedented and unique situation which the Chernobyl accident created. This was achieved with considerable assistance from the Irish universities, Civil Defence and other organisations.

3. The most significant radionuclides detected were iodine-131, caesium-137 and caesium-134 but many others including ruthenium-103, ruthenium-106, barium-140, lanthanum-140, tellurium-132 and iodine-132 were also detected. Actinides such as plutonium were only detected in very small amounts.

4. The monitoring programme quickly showed that external exposures both from the Chernobyl cloud and the deposited radioactivity and internal exposure due to the inhalation of radionuclides were not likely to be of major significance. It showed however that internal exposure from the ingestion of contaminated foodstuffs was likely to be the most significant pathway by which exposure of the Irish public would occur.

Monitoring Programme

5. The passage of the Chernobyl cloud over Ireland coincided with extremely heavy showers of rain which varied considerably at local and regional level. This resulted in enhanced ground contamination due to washout from the radioactive cloud. The monitoring programme showed that the deposition was very unevenly distributed with the more significantly affected areas located in the south midlands and the north west. Whilst detailed testing is being continued to determine the extent of the ground deposition, the results indicate iodine-131 deposition levels of 3000-16000 Bq m^{-2} and a mean total caesium of about 5000 Bq m^{-2}.

6. The exposure pathway of most immediate concern was the consumption of milk from animals grazing contaminated pastures. Iodine-131, caesium-137 and -134 contamination in milk was detected soon after deposition occurred. While the iodine-131 disappeared rapidly and had virtually disappeared by the end of May, the caesium contamination has persisted at decreasing levels although a slight increase is again appearing during the winter months. The highest contamination levels detected in individual milk samples were 441 Bq l^{-1} iodine-131 and 340 Bq l^{-1} caesium-137. The mean contamination levels were considerably lower with the caesium-137 being 120 Bq l^{-1} during early May, 74 Bq l^{-1} during later May, 14 Bq l^{-1} during June and decreasing to 2 Bq l^{-1} during September and October. The caesium-134 contamination levels were approximately half those of caesium-137. The monitoring programme covered a wide range of foodstuffs including drinking water, vegetables, dairy products, beef and lamb. In addition imported foodstuffs were extensively tested. People returning from severely contaminated areas in Eastern Europe were monitored at Irish hospitals and ships and their cargos from Eastern Europe were checked for contamination by the Board.

Radiation Exposure of the Irish Public

7. The estimates of the radiological impact of the Chernobyl accident on the Irish public are based on measurements made during the first six months after the accident. The committed effective dose equivalent to adults, ten year old children and one year old infants have been estimated to be 79 µSv, 84 µSv and

126 µSv respectively. The doses which will be received during the second six months are being monitored but will be considerably lower probably in the region of 25% of the doses received during the first six months. The doses for the three age groups might therefore be 99 µSv, 105 µSv and 158 µSv respectively for the first year. Studies are continuing to provide estimates of the doses which might be received in subsequent years. The collective effective dose equivalent to the Irish population is estimated to be 295 man-Sv for the first six months and 370 man-Sv for the first year.

8. The individual doses to the thyroid due to the intake of iodine-131 were estimated to be 270 µSv to adults, 690 µSv to ten year old children and 2300 µSv to one year old infants. The collective thyroid dose was estimated to have been 1844 man-Sv.

9. Many European countries used whole body monitors to assess the doses received by members of the public. It was found that the doses estimated by this method were less than those calculated using contamination levels and assumed intake rates. Experience showed that it would have been valuable to have had a whole body monitor to assist in the assessment of doses to the Irish public and in the monitoring of travellers returning from the vicinity of the Chernobyl accident. Unfortunately no such monitor is available in Ireland.

10. The health impact on the Irish population was assessed by considering the excess numbers of cancers and other diseases which may be attributed to the radiation exposures received by the public. The total number of additional fatal cancers that may occur during the next seventy years, as a result of the committed radiation exposures arising from the first six months after the Chernobyl accident is four and from the first year five. The United Nations Scientific Committee on the effects of atomic radiation, (UNSCEAR), risk factors for radiation induced cancers are based to a large extent on data from the effects of the Japanese atomic bombs. UNSCEAR is currently reviewing these factors in the light of recent reassessments of the Japanese data. An increase in the risk factors by two or even five times could result in the five fatal cancers which might be statistically probable being increased to ten or possibly twenty-five. These cancers will not be identifiable among the 450,000 cancers caused by other agents that will occur during that seventy year period.

11. The results of the monitoring programme showed that the contamination levels in Ireland did not warrant the introduction of specific control measures. Members of the public were however advised to wash fresh vegetables grown out-of-doors. In addition advice was issued to intending travellers to avoid severely contaminated areas close to the reactor accident and restrictions were placed on foodstuffs being imported into Ireland.

Lessons Learned

12. The most important lesson learned from the Chernobyl accident was the need to have an integrated comprehensive environmental monitoring system with clearly defined objectives capable of responding to abnormal levels of radioactive contamination. Parts of the country with high deposition levels should be quickly identifiable so that intense monitoring can be carried out to decide whether control measures are necessary. The public demand for monitoring was overwhelming and the monitoring of people returning from contaminated areas and of imported foodstuffs and other cargos at ports of entry were important features of the monitoring programme. The Chernobyl accident also demonstrated the need to provide extensive monitoring in support of our agricultural industry.

13. Since the accident occurred there have been considerable improvements in our monitoring facilities but there remain areas for improvement. These include the development of early warning systems such as continuous dose rate monitoring systems and more extensive air monitoring systems. Many of these are being considered within the framework of a national emergency plan to provide a rapid response to an emergency and to coordinate the responses of the different national authorities.

14. A second and very important lesson that has been learned is the need to develop better communications with the public. Information on contamination levels is required with explanations on the significance of possible radiation exposures and of radiological protection concepts. Improved communication procedures are included in the proposals for a national emergency plan.

15. A third lesson was the need for early notification of accidents and the provision of detailed information by the country responsible for the release. This has been addressed by the recently agreed International Atomic Energy Agency Convention on the Prompt Notification of Nuclear Accidents [16].

16. Differences in intervention levels adopted by countries after the accident demonstrated the need to develop internationally recognised criteria for the protection of the public in the event of an emergency. These differences continue to cause concern and confusion among the public and difficulties to national authorities.

17. Finally the Chernobyl accident demonstrated that if a similar accident occurred close to Ireland a much larger national response would be required. It is therefore recommended that the proposed national emergency plan be finalised so that a rapid response is available for any such emergency in the future.

12. ACKNOWLEDGEMENTS

The Board wishes to acknowledge the substantial assistance received from Dr. I. R. McAulay, Dr. P. I. Mitchell and Dr. P. Walton of the Physics Departments of T.C.D., U.C.D., and U.C.G. respectively without whose assistance it would not have been possible to analyse the large numbers of environmental and foodstuff samples necessary after the Chernobyl fallout.

The Board also wishes to acknowledge the assistance of the Meteorological Service of the Department of Communications, the Civil Defence Organisation, the Irish hospitals, particularly the Mater Hospital, which monitored returning travellers, the Department of Agriculture, local authorities and the many organisations who provided samples for analysis. A special word of thanks is also due to the Department of Energy for their general assistance and advice.

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Activity
Quantity of a radionuclide. It describes the rate at which spontaneous decays occur in it. It is measured in becquerels (Bq).

Dose
A general term denoting a quantity of radiation. It can be qualified as *absorbed dose, dose equivalent or effective dose equivalent.*

Absorbed Dose
Quantity of energy imparted by ionising radiation to the unit mass of matter such as tissue. It is measured in grays (Gy). One Gy produces different biological effects on tissue depending on the type of radiation.

Dose Equivalent
The quantity obtained by multiplying the *absorbed dose* by a factor representing the different effectiveness of the various types of radiation in causing harm to tissues. It is measured in sieverts (Sv). One Sv produces the same biological effect irrespective of the type of radiation.

Organ Dose Equivalent
Dose equivalent imparted to a given organ or tissue. It is measured in sieverts (Sv).

Effective Dose Equivalent
Weighted sum of the *dose equivalents* to the various organs and tissues. The weighting factor for each organ or tissue expresses the fractional contribution of the risk of death or serious genetic defect from irradiation of that organ or tissue to the total risk from uniform irradiation of the whole body. It is measured in sieverts (Sv).

Collective Dose Equivalent
Total dose over a population group exposed to a given source. It is represented by the product of the average dose equivalent to the individuals in the group by the number of persons comprising the group. It can be expressed as *collective organ dose equivalent* or *collective effective dose equivalent.* It is measured in man-sieverts (manSv).

Critical Group
A homogeneous group of the population representative of the persons receiving the highest dose among all the population exposed.

Maximum Individual Dose
Average dose to the individuals of the *critical group.*

Committed Dose
Total dose (expressed as *organ dose equivalent* or *effective dose equivalent)* gradually delivered to an organism during a given period of time by the decay of a radionuclide fixed in the organism following its intake into the body. The integration time is usually taken as 50 years for workers and 70 years for members of the public.

Intervention Level
The value of a quantity (dose, activity concentration) which, if exceeded or predicted to be exceeded in case of an accident, requires the application of a given protective action.

RADIATION QUANTITIES AND UNITS

For many years special measurement units for quantities of interest in radiation protection were used, which were not coherent with the International System of Units (SI). These old units, rad, rem and curie, have been superseded in the last few years by a new set of units which are coherent with the SI system.

These new units are the gray for the absorbed doses, the sievert for the dose equivalent and the becquerel for the activity of radioactive materials. The relationships between the new SI units and those previously used are shown in the following table:

Quantity	New Name and Symbol	Old Unit and Symbol	Conversion Factors
Absorbed dose	gray (Gy)	rad (rad)	1 Gy = 100 rad 1 rad = 10^{-2} Sv
Dose equivalent	sievert (Sv)	rem (rem)	1 Sv = 100 rem 1 rem = 10^{-2} Sv
Activity	becquerel (Bq)	curie (Ci)	1 Bq = 2.7m x 10^{-11} Ci 1 Ci = 3.7 x 10^{-10} Bq

In addition multiples and sub-multiples of the above units are frequently used. The most common ones are the following with their correspondence to old units.

Dose Equivalent:

1 Sievert (1 Sv)	= 100 rem
1 millisievert (1 mSv)	= 100 millirem (100 mrem)
1 microsievert (1 µSV)	= 0.1 millirem (0.1 mrem)

Activity:

1 becquerel (1 Bq)	= 2.7 x 10^{-11} Curie (Ci)	= 27 pico-curie (pCi)
1 kilo Becquerel (1 kBq)	= 2.7 x 10^{-8} Ci	= 27 nanocuries (nCi)
1 mega Becquerel (1 MBq)	= 2.7 x 10^{-5} Ci	= 27 microcuries (µCi)
1 giga Becquerel (1 GBq)	= 2.7 x 10^{-2} Ci	= 27 millicuries (mCi)
1 tera Becquerel (1 TBq)	= 27 Ci	

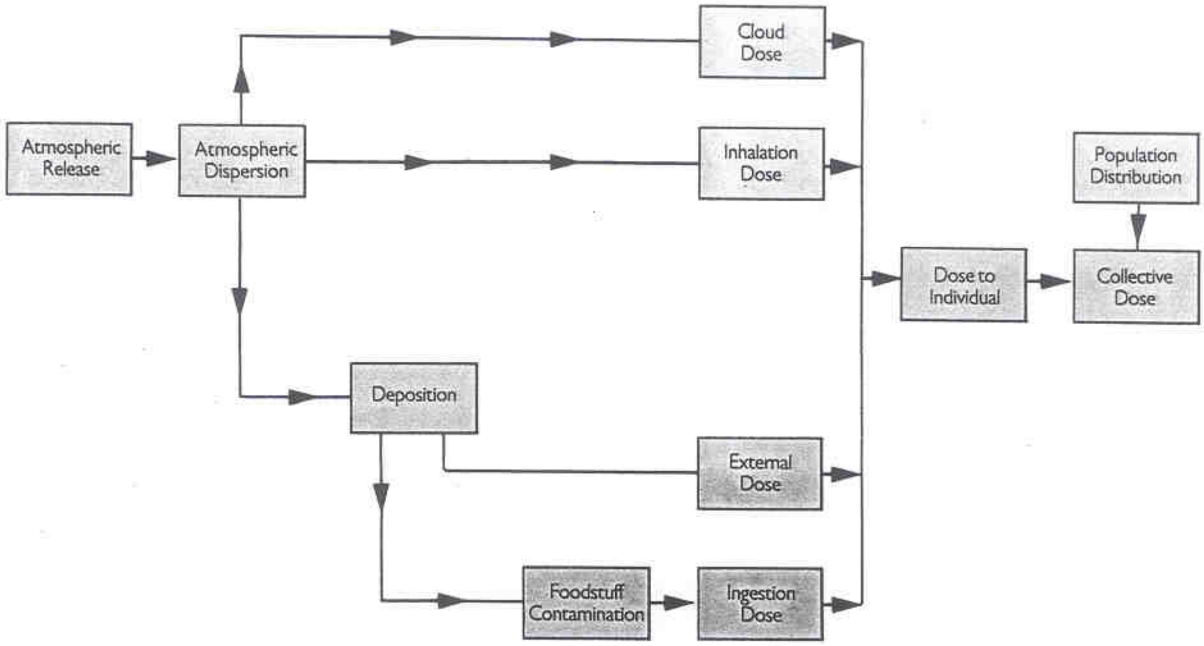

Figure 1: Schematic Diagram of Exposure Pathways to Man following an Atmospheric Release of Radioactivity

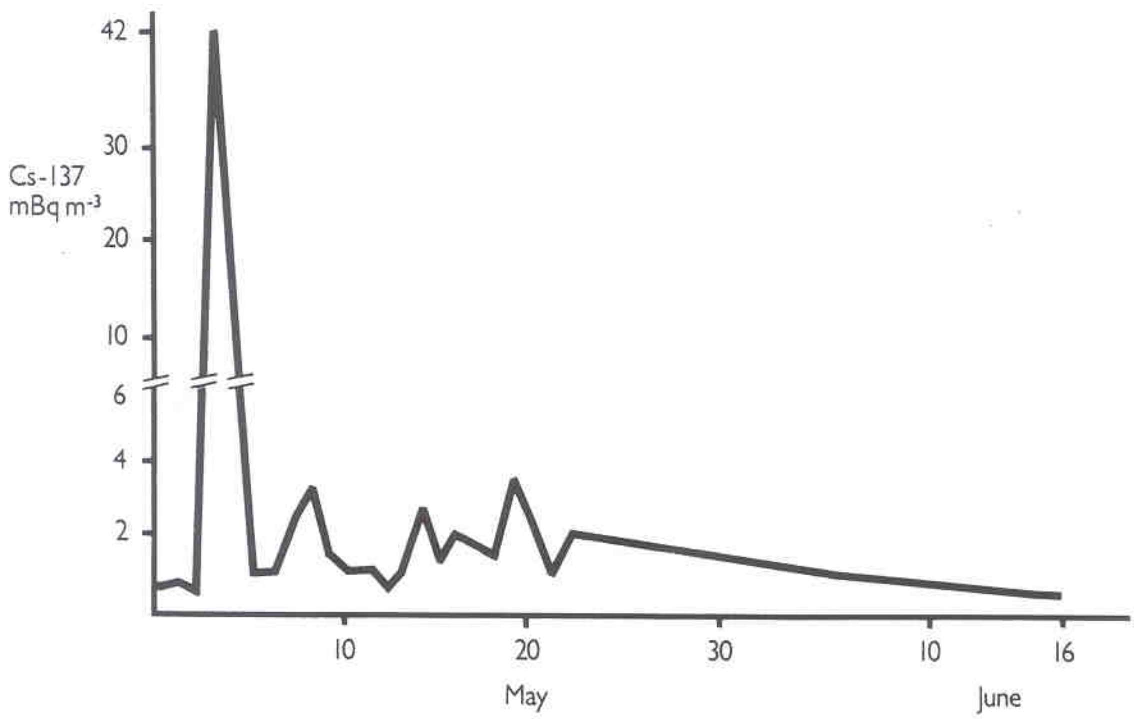

Figure 2: Caesium-137 Concentrations in Airborne Particulates May-June 1986

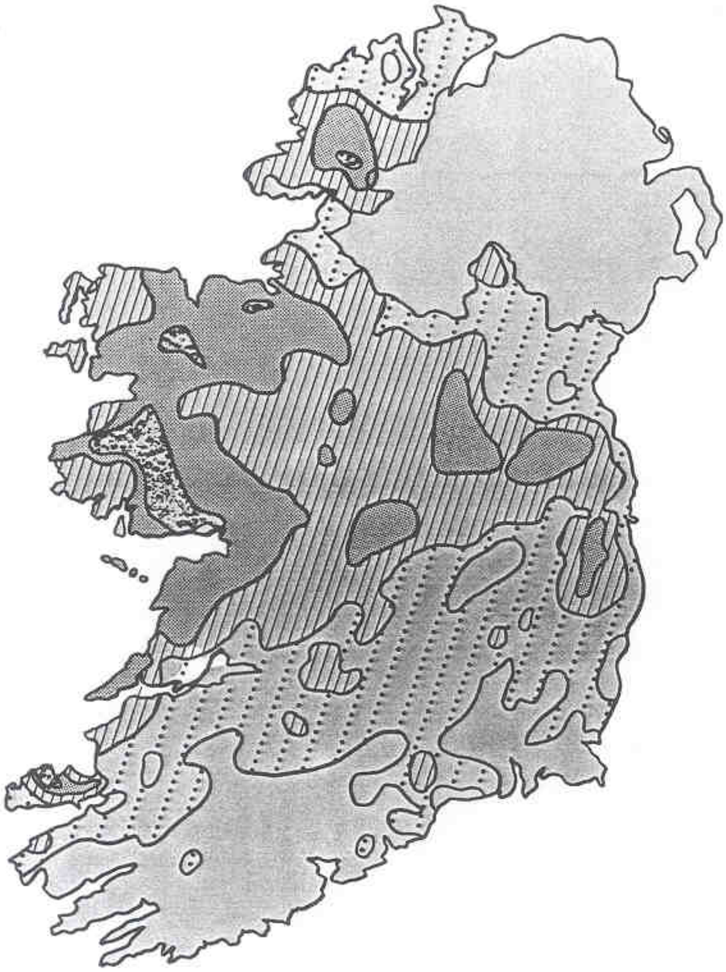

Figure 3: Distribution of Rainfall, 1000 hrs Saturday-1000 hrs Sunday, May 3-4th, 1986.

Key
mm

>20
15-20
10-15
5-10
<5

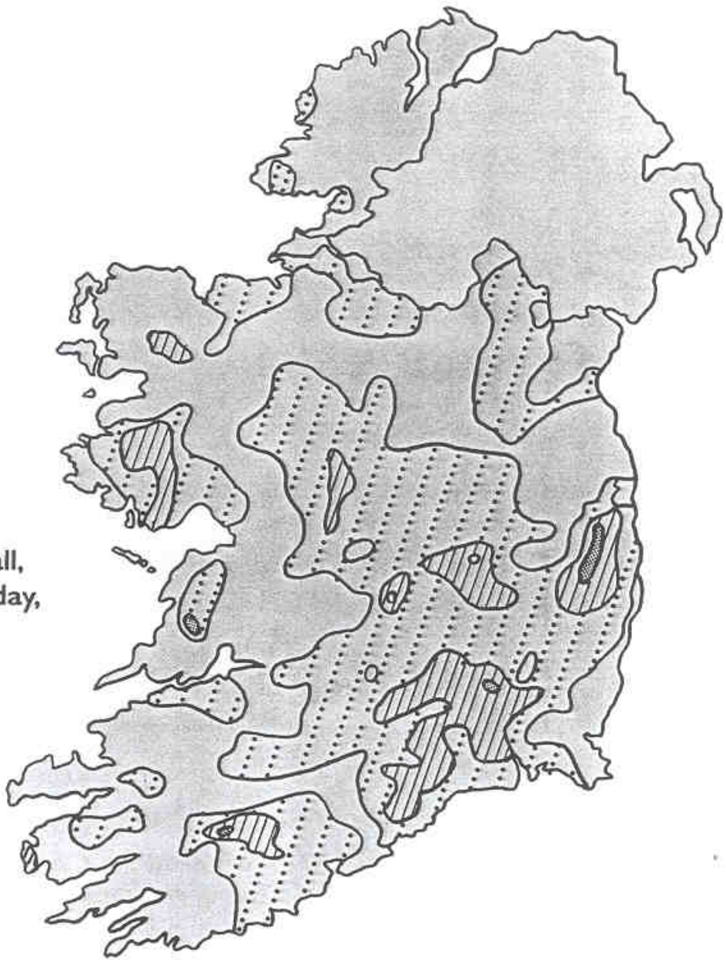

Figure 4: Distribution of Rainfall, 1000 hrs Sunday-1000 hrs Monday, May 4-5th, 1986.

Key
mm

15-20
5-10
10-15
<5

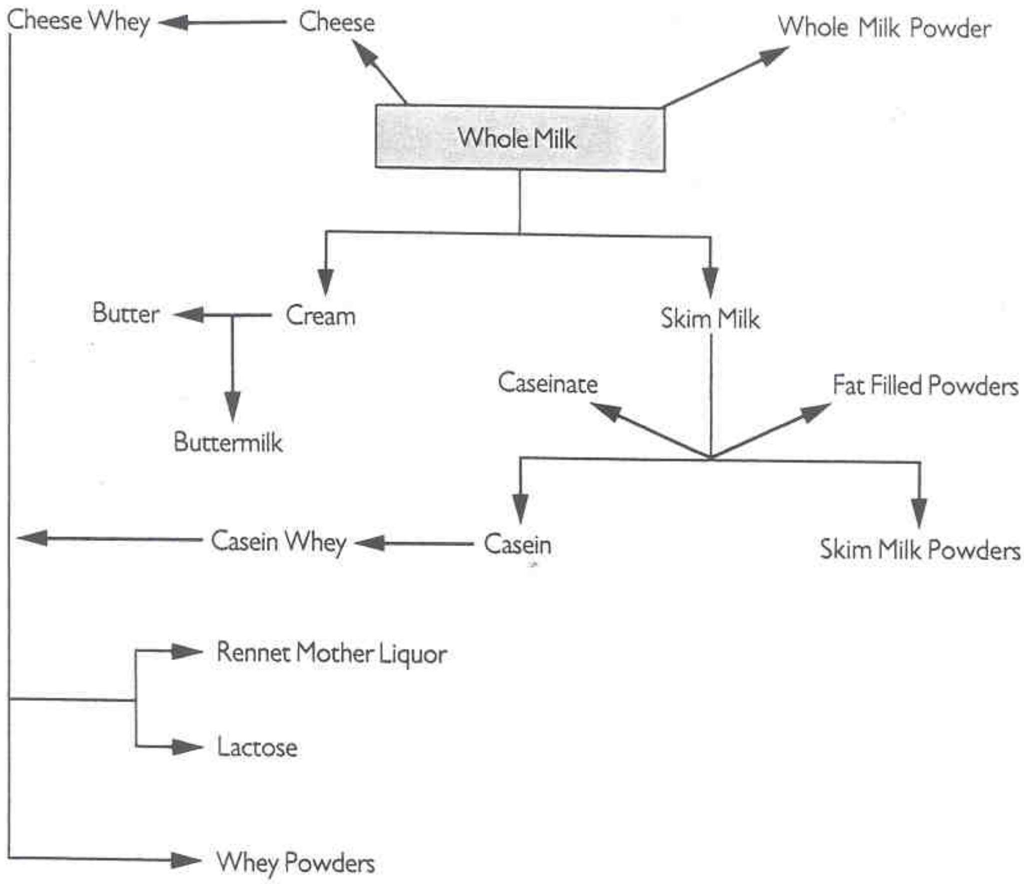

Figure 5: Milk Processing Pathways

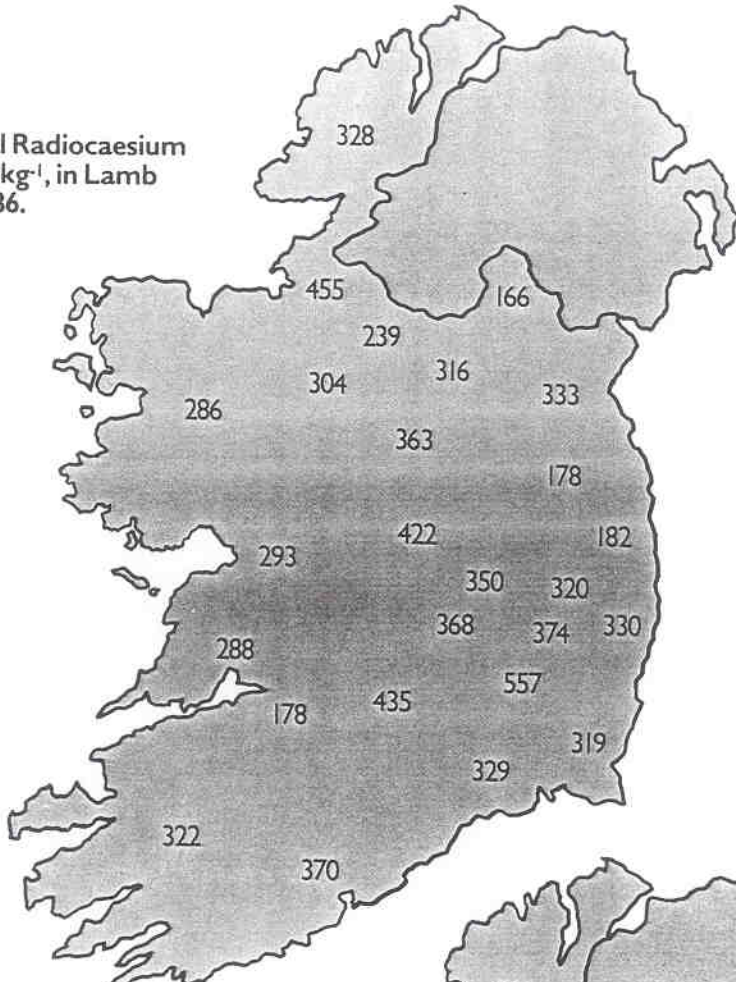

Figure 6:
Distribution of Total Radiocaesium Concentrations, Bq kg^{-1}, in Lamb during May-June 1986.

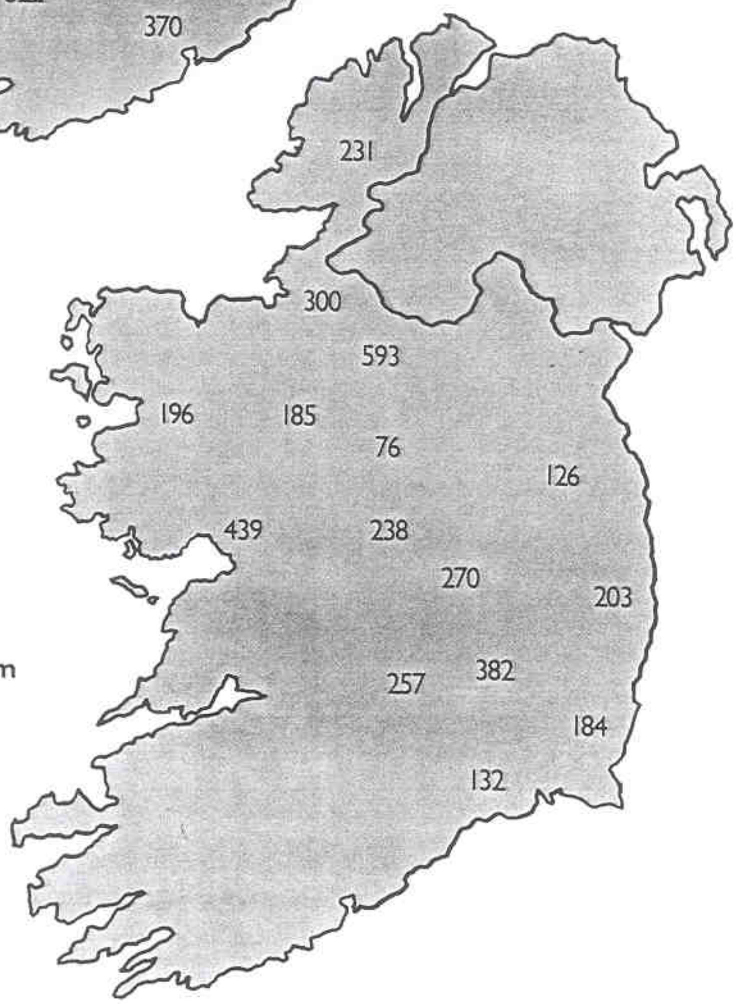

Figure 7:
Distribution of Total Radiocaesium Concentrations, Bq kg^{-1}, in Lamb during July-August 1986.

TABLE 1

CHERNOBYL REACTOR NO. 4
CORE INVENTORIES AND TOTAL RELEASES

Element	Half-life (days)	Inventory[a] (Bq)	Percentage released
85-Kr	3930	3.3×10^{16}	ca. 100
133-Xe	5.27	1.7×10^{18}	ca. 100
131-I	8.05	1.3×10^{18}	20
132-Te	3.25	3.2×10^{17}	15
134-Cs	750	1.9×10^{17}	10
137-Cs	1.1×10^{4}	2.9×10^{17}	13
99-Mo	2.8	4.8×10^{18}	2.3
95-Zr	65.5	4.4×10^{18}	3.2
103-Ru	39.5	4.1×10^{18}	2.9
106-Ru	368	2.0×10^{18}	2.9
140-Ba	12.8	2.9×10^{18}	5.6
141-Ce	32.5	4.4×10^{18}	2.3
144-Ce	284	3.2×10^{18}	2.8
89-Sr	53	2.0×10^{18}	4.0
90-Sr	1.02×10^{4}	2.0×10^{17}	4.0
239-Np	2.35	1.4×10^{17}	3
238-Pu	3.15×10^{4}	1.0×10^{15}	3
239-Pu	8.9×10^{6}	8.5×10^{14}	3
240-Pu	2.4×10^{6}	1.2×10^{15}	3
241-Pu	4800	1.7×10^{17}	3
242-Cm	164	2.6×10^{16}	3

[a] Decay corrected to 6 May 1986 and calculated as prescribed by the Soviet experts.

TABLE 2

RADIOCAESIUM CONCENTRATIONS IN AIRBORNE PARTICULATES AT GLASNEVIN, DUBLIN MAY 1-10, 1986

Date	Radioactivity mBq m^{-3}	
	Cs-137	Cs-134
1	0.99 ± 15.7%	<0.86
2	<0.71	<0.77
3	42.39 ± 3.0%	21.04 ± 3.6%
4	15.90 ± 8.4%	7.81 ± 11.1%
5	1.04 ± 13.5%	<0.62
6	1.11 ± 13.7%	<0.72
7	2.27 ± 9.4%	1.18 ± 12.1%
8	3.32 ± 6.8%	1.98 ± 8.2%
9	1.44 ± 6.3%	0.38 ± 11.2%
10	1.18 ± 13.3%	<0.74

TABLE 3

TOTAL BETA CONCENTRATIONS IN AIRBORNE PARTICULATES, MAY 2-10, 1986

Date	Total Beta in Airborne Particulates, mBq m^{-3}	
	Glasnevin, Dublin	Valentia, Co. Kerry
May 2	ND	ND
May 3	236.5	2.5
May 4	171.6	6.4
May 5	2.2	3.4
May 6	2.7	0.4
May 7	0.9	0.9
May 8	15.2	2.1
May 9	11.0	1.4
May 10	0.9	1.6

ND = Not detectable, less than 0.3.

TABLE 4

PLUTONIUM CONCENTRATIONS IN AIRBORNE PARTICULATES, MAY 2-3, 1986

Location	Sampling Period	Radioactivity Concentration, mBq m^{-3}	
		Pu-238	Pu-239, 240
Belfield, Dublin	2-3/5/86	0.0006	.0012
Glasnevin, Dublin	2-3/5/86	0.0002	.0004

TABLE 5

IODINE-131 CONTAMINATION LEVELS IN RAINFALL, MAY 1-5, 1986

Sampling Location	Iodine-131 Bq l^{-1}	Rainfall mm	Deposition Bq m^{-2}
Dublin	963	14.0	13482
Rosslare	483	5.9	2850
Roches Point	798	21.0	16838
Valentia	182	46.2	8408
Belmullet	280	22.5	6300
Mullingar	519	24.2	12560

TABLE 6

RADIOACTIVITY CONCENTRATIONS IN MILK, MAY-OCTOBER 1986

Period	No. of Samples	Radioactivity Concentration in Bq l^{-1}							
		Iodine-131		Cs-137		Cs-134		Total Cs	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
May 4-10	27	120	20-441	147	38-340	79	20-125	226	58-515
May 11-30	21	14	2- 50	74	15-166	39	8- 86	113	23-279
June	22	0	—	14	8- 23	7	4- 11	21	12- 34
July	15	0	—	8.6	5- 13	4.3	3- 7	12.9	8- 20
August	13	0	—	4.2	1.5-12.0	1.9	0.7-5.0	6.1	2.2-17.0
September	11	0	—	2.1	0.5- 5.1	0.9	0.2-2.3	3.0	0.7- 7.4
October	11	0	—	1.9	0- 3.8	0.9	0- 1.8	2.8	0- 5.6

TABLE 7

RADIOACTIVITY CONCENTRATIONS IN DRIED MILK POWDERS MAY-OCTOBER 1986

Date	No. of Samples	Radioactivity Concentration Bq kg^{-1}					
		Cs-137		Cs-134		Total Caesium	
		Mean	Range	Mean	Range	Mean	Range
May 5- 6	10	684	196-1719	362	85- 898	1046	281-2617
May 7-12	41	974	23-2586	511	13-1361	1485	36-3947
May 13-19	36	512	75-1189	267	39- 626	779	114-1815
May 20-31	19	389	245- 653	209	130- 325	598	375- 978
June	72	223	81- 834	105	35- 358	328	116-1192
July	62	77	26- 142	37	14- 68	114	40- 210
August	38	51	24- 99	23	12- 40	74	36- 139
September	27	25	12- 52	13	6- 23	38	18- 75
October	33	20	10- 40	10	5- 20	30	15- 60

TABLE 8

RADIOACTIVITY CONCENTRATIONS IN VARIOUS MILK PRODUCTS IN MAY 1986

Product	No. of Samples	Radioactivity Concentration Bq kg^{-1}					
		Cs-137		Cs-134		Total Cs	
		Mean	Range	Mean	Range	Mean	Range
Butter	13	16	7- 45	7	4- 16	23	11- 61
Cheddar Cheese	11	43	<5- 115	22	<3- 60	65	<7- 175
Casein	12	12	5- 22	7	2- 11	19	7- 33
Lactose	9	18	<5- 36	9	<3- 19	27	<7- 55
RML powder	13	3368	53-6483	1572	18-3214	4940	71-9651
Whey powders	19	551	94-1274	317	198- 637	868	292-1911
Baby foods	15	<5	—	<5	—	<10	—

TABLE 9

RADIOACTIVITY CONCENTRATIONS IN VEGETABLES MAY-SEPTEMBER 1986

Species	Sampling Period	No. of Samples	Radioactivity Bq kg^{-1}			
			I-131	Cs-137	Cs-134	Ru-103
Cabbage	May 5- 9	6	36	45	22	68
	May 12-15	9	34	66	33	73
	May 20-30	8	7	43	22	34
	June	3	0	1	1	0
	July	3	0	3	1	0
Cauliflower	May	4	10	41	21	22
Lettuce	May 6-15	5	54	78	42	68
	June	2	ND	ND	ND	ND
	July	4	ND	<1	ND	ND
	August	1	ND	ND	ND	ND
Scallions	May	2	9	7	4	8
	July	2	ND	ND	ND	ND
Rhubarb	May	3	19	23	10	32
	July	1	<1	ND	ND	ND
Leeks	May	6	4	11	6	6
	July	1	ND	7	3	ND
Broccoli	May	2	12	45	24	35
	August	1	ND	ND	ND	ND
Spinach	May	2	25	46	22	64
	July	2	ND	ND	ND	ND
	August	1	ND	ND	ND	ND
Parsley	May	1	39	185	86	242
	July	1	ND	ND	ND	ND
	August	1	ND	ND	ND	ND

Note: Various samples of potatoes, carrots and sugar-beet showed negligible contamination.

TABLE 10

RADIOACTIVITY CONCENTRATIONS IN LAMB MAY-OCTOBER 1986

Province	Period	No. of Samples	Mean Radioactivity Bq kg^{-1}		
			Cs-137	Cs-134	Total Cs
Leinster	May-June	58	227	114	341
	July-August	25	142	69	211
	Sept-Oct	23	15	7	22
Munster	May-June	20	213	107	320
	July-August	7	130	65	195
	Sept-Oct	4	21	10	31
Connacht	May-June	19	210	106	316
	July-August	24	227	115	342
	Sept-Oct	3	170	67	237
Ulster	May-June	13	180	90	270
	July-August	4	115	76	231
	Sept-Oct	4	34	16	50

TABLE 11

RADIOACTIVITY CONCENTRATIONS IN BEEF, JULY-OCTOBER 1986

Province	Period	No. of Samples	Radioactivity Bq kg^{-1}		
			Cs-137	Cs-134	Total Cs
Leinster	July	55	72	34	106
	August	38	38	19	57
	September	38	20	10	30
	October	18	22	11	33
Ulster	July	10	39	20	59
	August	6	38	19	57
	September	9	46	20	66
	October	2	19	9	28
Munster	July	28	69	35	104
	August	30	31	15	46
	September	21	26	13	39
	October	7	15	7	22
Connacht	July	9	93	46	139
	August	17	48	22	70
	September	16	32	16	48
	October	3	19	9	28

TABLE 12

RADIOACTIVITY CONCENTRATIONS IN MIGRATORY BIRDS SEPTEMBER-NOVEMBER 1986

Species	No. of Samples	Radioactivity Concentration Bq kg^{-1}					
		Cs-137		Cs-134		Total Cs	
		Mean	Range	Mean	Range	Mean	Range
Woodcock	32	200	0-1433	91	0-674	291	0-2107
Widgeon	9	40	0- 270	19	0-130	59	0- 400
Snipe	14	61	0- 300	29	0-136	90	0- 436
Teal	11	16	0- 51	8	0- 25	24	0- 76
Mallard	11	56	8- 242	27	4-110	83	12- 352

TABLE 13

TIME INTEGRATED AIR CONCENTRATIONS OF RADIONUCLIDES IN THE CLOUD

Radionuclide	Peak Air Concentration mBq m^{-3}	Time Integrated Air Concentration, Bq m^{-3} s
Ruthenium-103	67	1.4×10^4
Ruthenium-106	17	3.8×10^3
Iodine-131	195	2.9×10^4
Tellurium-132/Iodine-132	217	3.2×10^4
Caesium-134	21	5.0×10^3
Caesium-137	42	9.7×10^3
Barium-140/Lanthanum 140	39	7.4×10^3

TABLE 14

BREATHING RATES USED FOR THE CALCULATION OF INHALATION DOSES

Age Group	Breathing Rates	
	Litres per Day	Litres per Year
Adults	2.3×10^4	8.4×10^6
Children	1.5×10^4	5.5×10^6
Infants	0.38×10^4	1.4×10^6

TABLE 15

FOODSTUFF CONSUMPTION RATES ASSUMED FOR THE IRISH PUBLIC

Foodstuff	Intake Rates kg yr^{-1}					
	Adults		Children		Infants	
	Average Group	Critical Group	Average Group	Critical Group	Average Group	Critical Group
Milk (litres)	150	300	150	300	170	260
Milk Products	13	40	9	30	5	16
Beef	18	60	12	40	2	7
Lamb	7	30	5	20	1	3
Green Vegetables	40	80	27	60	15	30
Root Vegetables	50	120	33	80	20	50

TABLE 16

MEAN CONTAMINATION LEVELS OF FOODSTUFFS IN ALL REGIONS MAY-OCTOBER 1986

Foodstuff	Radioactivity Bq kg^{-1}			
	I-131	Cs-137	Cs-134	Ru-103
Milk	6.9	20.6	10.4	0
Cheese	0	19	10	0
Butter	0	5	2.5	0
Beef	0	46	23	0
Lamb	0	127	63	0
Green Vegetables	4.3	15	7.5	9.3
Root Vegetables	0	1	0.5	0

TABLE 17

MEAN CONTAMINATION LEVELS OF FOODSTUFFS IN REGIONS MOST SEVERELY AFFECTED BY CONTAMINATION MAY-OCTOBER 1986

Foodstuff	Radioactivity Bq kg^{-1}			
	I-131	Cs-137	Cs-134	Ru-103
Milk	15	30	15	0
Cheese	0	45	22	0
Butter	0	9	5	0
Beef	0	50	25	0
Lamb	0	196	98	0
Green Vegetables	5.5	17	8	10
Root Vegetables	0	2	1	0

TABLE 18

INDIVIDUAL EFFECTIVE DOSE EQUIVALENTS ARISING FROM THE INGESTION OF FOODSTUFFS DURING THE FIRST SIX MONTHS

Foodstuff	Effective Dose Equivalent µSv		
	Adults	Children	Infants
Milk	38.3	50.2	102.2
Meat	17.6	12.1	2.1
Vegetables	7.4	6.4	6.4
Others	1.4	0.9	0.5
Total	64.7	69.6	111.2

TABLE 19

INDIVIDUAL EFFECTIVE DOSE EQUIVALENTS FROM ALL PATHWAYS DURING THE FIRST SIX MONTHS

Pathway	Committed Effective Dose Equivalent µSv		
	Adults	Children	Infants
External irradiation from the cloud	< 1.0	<1.0	<1.0
External irradiation from deposited radioactivity	13.0	13.0	13.0
Internal irradiation due to inhalation	0.5	0.8	0.6
Internal irradiation due to ingestion	64.7	69.6	111.2
Total	79.2	84.4	125.8

LONG-LIVED RADIONUCLIDE CONCENTRATIONS IN AIRBORNE PARTICULATES (mBq m^{-3}) AT GLASNEVIN, DUBLIN, MAY-JULY 1986

Nuclide	May 1	May 2	May 3	May 4	May 5	May 6	May 7
Cs-134	< 0.86	< 0.77	21.04	7.81	< 0.62	< 0.72	< 1.18
Cs-137	0.99	< 0.71	42.39	15.9	1.04	1.11	2.27
Ru-103	< 0.82	< 0.71	67.17	20.97	< 0.64	< 1.18	< 0.7
Ru-106	< 6.92	< 6.61	17.67	<17.04	< 5.7	< 6.17	< 5.9
Eu-154	< 0.95	< 0.87	< 1.03	< 2.2	< 0.82	< 0.89	< 0.9
Eu-155	< 1.62	< 1.55	< 2.10	< 3.6	< 1.17	< 1.25	< 1.3
Am-241	< 0.43	< 0.43	< 0.47	< 1.8	< 0.43	< 0.44	< 0.4
Sb-125	< 2.22	< 2.20	< 2.86	< 7.7	< 1.9	< 1.85	< 1.9
Ce-144	< 3.58	< 3.49	< 3.78	< 9.6	< 3.2	< 3.2	< 3.2
K-40	26.72	25.10	19.81	NM	NM	NM	NM
Nuclide	**May 8**	**May 9**	**May 10**	**May 11**	**May 12**	**May 13**	**May 14**
Cs-134	1.98	0.38	< 0.74	< 0.70	< 0.32	< 0.81	1.18
Cs-137	3.32	1.44	1.18	1.17	0.63	1.21	2.78
Ru-103	< 0.62	< 0.36	< 0.71	< 0.67	< 0.34	< 0.69	< 0.64
Ru-106	< 5.36	< 3.23	< 6.68	< 6.18	< 3.16	< 6.22	< 6.03
Eu-154	< 0.72	< 0.44	< 0.85	< 0.87	< 0.42	< 0.85	< 0.88
Eu-155	< 4.94	< 0.76	< 1.57	< 1.46	< 0.74	< 1.30	< 1.55
Am-241	< 0.35	< 0.21	< 0.41	< 0.42	< 0.21	< 0.42	< 0.44
Sb-125	< 1.72	< 0.99	< 2.02	< 2.01	< 0.98	< 0.94	< 1.91
Ce-144	< 2.79	< 1.61	< 3.31	< 3.30	< 1.61	< 4.56	< 3.48
K-40	NM	21.05	24.32	25.38	22.47	18.14	21.32
Nuclide	**May 15**	**May 16**	**May 17**	**May 18**	**May 19**	**May 20**	**May 21**
Cs-134	0.98	1.24	< 0.74	< 0.66	< 0.77	0.93	< 0.69
Cs-137	1.41	2.05	1.82	1.57	3.47	2.26	1.07
Ru-103	0.71	< 0.68	< 0.76	< 0.74	< 0.65	< 0.68	< 0.64
Ru-106	< 5.86	< 6.31	< 6.43	< 6.27	< 6.56	< 6.19	< 6.01
Eu-154	< 0.86	< 0.87	< 0.88	< 0.87	< 0.87	< 0.85	< 0.82
Eu-155	< 1.21	< 1.52	< 1.53	< 1.51	< 1.47	< 1.48	< 1.40
Am-241	< 0.40	< 0.40	< 0.44	< 0.41	< 0.44	< 0.41	< 0.41
Sb-125	< 1.90	< 1.89	< 2.07	< 1.97	< 1.92	< 1.97	< 1.91
Ce-144	< 3.22	< 3.27	< 3.46	< 3.31	< 3.42	< 3.28	< 3.17
K-40	23.07	25.49	23.74	23.31	22.56	20.39	15.50
Nuclide	**May 22**	**June 5**	**June 19**	**July 1**	**July 15**	**July 29**	
Cs-134	1.26	< 0.79	< 0.58	< 0.66	< 0.62	< 0.64	
Cs-137	2.17	1.02	< 0.56	< 0.66	< 0.68	< 0.63	
Ru-103	< 0.71	< 0.73	< 0.56	< 0.66	< 0.64	< 0.63	
Ru-106	< 6.06	< 7.29	< 5.06	< 5.85	< 6.04	< 5.49	
Eu-154	< 0.87	< 0.88	< 0.75	< 0.80	< 0.87	< 0.80	
Eu-155	< 1.50	< 1.29	< 1.31	< 1.42	< 1.41	< 1.34	
Am-241	< 0.41	< 0.43	< 0.37	< 0.38	< 0.39	< 0.36	
Sb-125	< 1.94	< 2.13	< 1.72	< 1.88	< 1.89	< 1.82	
Ce-144	< 3.22	< 3.44	< 2.84	< 3.16	< 3.00	< 2.95	
K-40	<28.73	<24.2	<23.66	<22.29	<22.2	<22.89	

Note: NM — Not measured

TOTAL BETA RADIOACTIVITY CONCENTRATIONS IN AIRBORNE PARTICULATES AT GLASNEVIN, DUBLIN AND VALENTIA, CO. KERRY IN mBq m^{-3} APRIL TO JULY 1986

Date	Total Beta mBq m^{-3} Dublin	Valentia	Date	Total Beta mBq m^{-3} Dublin	Valentia
April 1-2	NM	ND	April 16-17	ND	ND
April 2-3	ND	1.1	April 17-18	ND	0.7
April 3-4	ND	1.0	April 18-19	NM	0.8
April 4-5	NM	1.9	April 19-20	NM	0.8
April 5-6	NM	1.9	April 20-21	NM	0.6
April 6-7	NM	0.7	April 21-22	ND	1.2
April 7-8	ND	ND	April 22-23	ND	ND
April 8-9	1.9	ND	April 23-24	ND	ND
April 9-10	ND	0.5	April 24-25	ND	ND
April 10-11	1.8	ND	April 25-26	NM	ND
April 11-12	NM	ND	April 26-27	NM	0.8
April 12-13	NM	ND	April 27-28	NM	0.3
April 13-14	NM	ND	April 28-29	1.2	1.1
April 14-15	ND	0.3	April 29-30	ND	ND
April 15-16	ND	ND			
April 30-1/5	ND	ND	May 16-17	1.7	0.8
May 1-2	ND	ND	May 17-18	1.9	ND
May 2-3	236.5	2.5	May 18-19	6.0	ND
May 3-4	171.6	6.4	May 19-20	4.5	2.0
May 4-5	2.2	3.4	May 20-21	ND	1.3
May 5-6	2.7	0.4	May 21-22	1.4	1.3
May 6-7	0.9	0.9	May 22-23	0.9	2.2
May 7-8	15.2	2.1	May 23-24	ND	1.8
May 8-9	11.0	1.4	May 24-25	1.7	ND
May 9-10	0.9	1.6	May 25-26	1.4	ND
May 10-11	1.6	1.3	May 26-27	0.9	2.0
May 11-12	3.1	1.4	May 27-28	ND	ND
May 12-13	1.4	2.1	May 28-29	1.1	ND
May 13-14	5.6	0.3	May 29-30	0.7	0.9
May 14-15	1.8	1.4	May 30-31	0.6	0.9
May 15-16	15.1	ND			

Date	Total Beta $mBq\ m^{-3}$ Dublin	Total Beta $mBq\ m^{-3}$ Valentia	Date	Total Beta $mBq\ m^{-3}$ Dublin	Total Beta $mBq\ m^{-3}$ Valentia
June 31/5-1/6	ND	1.5	June 15-16	NM	0.9
June 1-2	ND	0.5	June 16-17	ND	ND
June 2-3	ND	ND	June 17-18	ND	ND
June 3-4	1.0	ND	June 18-19	ND	ND
June 4-5	ND	1.0	June 19-20	2.2	0.2
June 5-6	ND	0.4	June 20-21	NM	ND
June 6-7	0.4	0.6	June 21-22	NM	ND
June 7-8	ND	ND	June 22-23	NM	0.6
June 8-9	ND	ND	June 23-24	ND	ND
June 9-10	1.9	0.7	June 24-25	0.6	1.3
June 10-11	0.5	0.2	June 25-26	ND	0.3
June 11-12	ND	0.8	June 26-27	ND	ND
June 12-13	ND	ND	June 27-28	NM	0.6
June 13-14	NM	ND	June 28-29	NM	ND
June 14-15	NM	ND	June 29-30	NM	0.5
July 30/6-1/7	ND	0.8	July 16-17	2.3	ND
July 1-2	ND	ND	July 17-18	2.2	ND
July 2-3	1.4	0.5	July 18-19	NM	0.5
July 3-4	ND	ND	July 19-20	NM	0.6
July 4-5	NM	ND	July 20-21	NM	ND
July 5-6	NM	ND	July 21-22	ND	0.7
July 6-7	NM	ND	July 22-23	ND	ND
July 7-8	0.9	ND	July 23-24	1.1	ND
July 8-9	ND	ND	July 24-25	ND	ND
July 9-10	ND	ND	July 25-26	NM	0.7
July 10-11	ND	ND	July 26-27	NM	1.3
July 11-12	NM	0.5	July 27-28	NM	0.4
July 12-13	NM	ND	July 28-29	ND	ND
July 13-14	NM	0.3	July 29-30	ND	ND
July 14-15	2.1	0.6	July 30-31	ND	ND
July 15-16	0.5	ND			

Note: NM — Not measured and
ND — Not detected i.e. <0.3

SURVEY OF THE RADIOACTIVITY CONCENTRATIONS IN MILK MAY-OCT 1986

Location	Date	Radioactivity Bq l^{-1}			
		I-131	Cs-137	Cs-134	Total Cs
Dublin	May 3	ND	ND	ND	ND
	May 4	67	86	50	136
	May 5	115	85	40	125
	May 6	120	NM	NM	NM
	May 7	60	135	77	212
	June 3	ND	12	5	17
	July 4	ND	10	6	16
	July 5	ND	5	3	8
	July 7	ND	7	4	11
	July 15	ND	10	5	15
	Aug. 29	ND	1.9	1.0	2.9
	Sept. 28	ND	1.2	0.5	1.7
	Oct. 17	ND	2.5	1.3	3.8
Wicklow/ Wexford	May 5	26	NM	NM	NM
	May 6	78	136	73	209
	May 7	20	38	20	58
	May 13	7	41	20	61
	May 18	2	24	13	37
	June 16	ND	11	6	17
	June 26	ND	8	4	12
	July 7	ND	7	3	10
	Aug. 6	ND	2.7	1.5	4.2
	Sept. 4	ND	1.8	0.8	2.6
Kilkenny	May 4	250	NM	NM	NM
	May 5	441	172	90	262
	May 6	320	340	NM	NM
	May 7	243	210	111	321
	May 13	50	108	60	168
	July 8	ND	6	3	9
	Aug. 6	ND	1.5	0.7	2.2
	Sept. 9	ND	0.5	ND	0.5
	Oct. 17	ND	2.4	1.0	3.4
Offaly	May 6	129	214	111	325
	May 7	76	203	111	314
	May 13	24	166	86	252
	May 18	8	111	55	166
Cavan	May 7	81	107	55	162
	May 13	30	101	55	156
	May 18	11	56	28	84
	June 10	ND	14	8	22
	June 24	ND	11	6	17
	July 1	ND	10	5	15
	Aug. 5	ND	4.8	1.7	6.5
	Sept. 2	ND	3.3	1.5	4.8
	Oct. 1	ND	1.2	0.6	1.8
	Oct. 10	ND	2.3	1.1	3.4
Monaghan	May 21	NM	78	44	122
Donegal	May 5	380	NM	NM	NM
	May 7	50	101	50	151
	May 13	28	62	34	96
	May 18	8	48	25	73

Location	Date	Radioactivity Bq l⁻¹			
		I-131	Cs-137	Cs-134	Total Cs
Sligo	May 5	158	NM	NM	NM
	May 7	62	78	45	123
	May 13	17	115	57	172
	May 18	6	63	33	96
	June 23	ND	13	6	19
Roscommon/ Leitrim	May 6	74	NM	NM	NM
	May 7	50	78	45	123
	May 13	25	67	37	104
	May 18	6	38	19	57
	June 9	ND	23	11	34
	June 17	ND	18	9	27
	June 30	ND	16	7	23
	July 7	ND	10	6	16
	July 14	ND	8.2	4.2	12.4
	July 28	ND	7.5	3.5	10.4
	Aug. 4	ND	5.8	2.9	8.7
	Aug. 11	ND	6.2	3.0	8.2
	Aug. 18	ND	12.0	5.0	17.0
	Sept. 1	ND	5.1	2.3	7.4
	Oct. 5	ND	3.8	1.8	5.6
Galway	May 4	54	NM	NM	NM
	May 5	152	NM	NM	NM
	May 6	106	160	89	249
	May 9	91	161	77	238
	May 13	32	79	45	124
	May 18	8	50	26	76
Limerick	May 6	40	89	58	147
	May 7	25	70	49	119
	May 14	4	88	47	135
	May 18	4	42	22	64
Kerry	May 7	ND	ND	ND	ND
	May 13	20	97	49	146
	May 18	4	37	20	57
	June 3	ND	18	9	27
	June 10	ND	16	7	23
	June 16	ND	12	6	18
	Aug. 14	ND	4.3	2.3	6.6
	Sept. 15	ND	.0	1.0	3.0
Tipperary	May 6	78	133	70	203
	June 8	ND	19	10	29
	June 16	ND	13	7	20
	June 23	ND	9	4	13

Location	Date	Radioactivity Bq l⁻¹ I-131	Cs-137	Cs-134	Total Cs
Tipperary (Cont'd)	July 3	ND	8	4	12
	July 14	ND	8	4	12
	Aug. 5	ND	2.6	1.3	3.9
	Sept. 10	ND	1.7	0.7	2.4
	Oct. 10	ND	2.9	1.0	3.9
Cork	June 11	ND	19	10	29
	June 12	ND	13	6	19
	June 16	ND	16	8	24
	June 16	ND	14	7	21
	June 26	ND	12	6	18
	June 28	ND	11	6	17
	July 1	ND	7	3	10
	July 3	ND	10	5	15
	Aug. 8	ND	3.5	1.8	5.3
	Aug. 22	ND	3.9	1.7	5.6
	Aug. 28	ND	2.5	1.2	3.7
	Sept. 3	ND	2.8	1.2	4.0
	Sept. 8	ND	1.3	0.5	1.8
	Sept. 10	ND	2.1	1.0	3.1
	Oct. 1	ND	0.9	0.5	1.4
	Oct. 1	ND	1.3	0.7	2.0
	Oct. 1	ND	1.1	0.5	1.6
	Oct. 1	ND	ND	ND	ND
	Oct. 2	ND	1.9	1.0	2.9
Waterford	May 5	116	213	111	324
	May 7	98	212	114	326
	May 13	23	141	74	215
	May 18	3	81	39	120
	May 30	ND	15	8	23
	July 6	ND	12	5	17
	July 9	ND	13	7	20
	Aug. 18	ND	2.5	1.2	3.7
	Sept. 8	ND	1.2	0.5	1.7

Note: NM — Not measured and
ND — <0.5 Bq kg⁻¹

RADIOACTIVITY CONCENTRATIONS IN MILK PRODUCTS

(a) RADIOACTIVITY CONCENTRATIONS IN DRIED MILK POWDERS, MAY 1986

Production Date	No. of Samples	Radioactivity Concentration Bq kg^{-1}					
		Cs-137		Cs-134		Total Cs	
		Mean	Range	Mean	Range	Mean	Range
May 4	6	75	10- 83	39	5- 37	114	15- 120
May 5	4	718	309-1224	386	199- 637	1104	508-1861
May 6	6	650	196-1719	338	85- 898	988	281-2617
May 7	6	902	226-2423	475	115-1275	1377	341-3698
May 8	8	1013	23-2586	534	13-1361	1547	36-3947
May 9	7	1044	250-2377	548	130-1251	1598	380-3628
May 10	7	986	258-2494	522	141-1313	1508	399-3807
May 11	7	968	262-1999	503	125-1052	1471	387-3051
May 12	6	928	202-1990	481	114-1047	1410	316-3037
May 13	4	634	210-1189	325	133- 626	959	343-1815
May 14	7	518	185-1096	278	98- 574	796	283-1664
May 15	6	556	200- 830	290	113- 406	846	313-1236
May 16	6	604	221- 861	299	110- 417	903	331-1278
May 17	5	474	168- 882	253	82- 487	727	250-1369
May 18	3	379	75- 674	201	45- 354	580	120-1028
May 19	5	421	79- 774	226	39- 410	647	118-1184
May 20-25	9	428	282- 653	246	140- 325	644	422- 978
May 26-31	10	349	245- 484	171	130- 264	520	375- 748

(b) RADIOACTIVITY CONCENTRATIONS IN DRIED MILK POWDERS, JUNE-OCTOBER 1986

Date	No. of Samples	Radioactivity Concentration Bq kg^{-1}					
		Caesium-137		Caesium-134		Total Caesium	
		Mean	Range	Mean	Range	Mean	Range
June 1- 7	13	304	179-427	146	102-199	450	281- 626
8-14	21	260	128-834	123	64-358	383	192-1192
15-21	18	198	101-775	88	43-332	286	144-1107
22-30	20	128	81-169	62	35- 87	190	116- 256
July 1- 7	14	101	78-142	47	34- 68	148	112- 210
8-14	11	80	49-118	41	27- 63	121	76- 181
15-21	14	68	26- 99	33	14- 48	101	40- 147
22-31	23	59	29- 91	27	15- 40	86	44- 131
Aug 1- 7	9	59	41- 99	24	23- 30	83	63- 129
8-14	11	52	36- 86	25	18- 14	77	54- 126
15-21	14	53	24- 96	23	12- 40	76	36- 136
22-31	4	39	34- 46	19	13- 25	58	47- 71
Sept 1- 7	3	25	21-27	14	13- 14	39	34- 41
8-14	2	29	23- 34	15	12- 18	44	35- 52
15-21	8	20	12- 30	9	6- 14	29	18- 44
22-30	14	24	17- 52	12	6- 23	36	23- 75
Oct 1- 7	12	19	10- 40	10	5- 20	29	15- 60
8-14	6	16	13- 19	8	6- 10	24	19- 29
15-21	5	24	14- 21	11	5- 12	35	19- 33
22-31	10	20	11- 24	10	7- 13	30	18- 37

(b) TYPICAL VARIATION OF THE RADIOACTIVITY CONCENTRATIONS OF MILK POWDERS PRODUCED IN A SPECIFIC REGION

Date	Radioactivity Concentrations Bq kg^{-1}			
	I-131	Cs-137	Cs-134	Total Cs
May 4	34	94	56	150
May 5	90	350	213	563
May 6	147	797	428	1225
May 7	114	862	461	1323
May 8	92	842	420	1262
May 9	71	841	430	1271
May 10	65	830	472	1302
May 11	67	836	440	1276
May 13	50	660	371	1031
May 14	<70	569	305	874
May 15	37	514	257	771
May 16	35	570	285	855
May 20	ND	653	310	963
June 10	ND	223	131	354
June 18	ND	135	49	184
June 27	ND	89	46	135
July 29	ND	40	16	56
July 29	ND	42	18	60
Aug. 12	ND	36	18	54
Aug. 13	ND	46	20	66
Aug. 14	ND	45	20	66
Aug. 15	ND	44	22	66

(c) RADIOACTIVITY CONCENTRATIONS IN VARIOUS MILK PRODUCTS

Product	Production Date	Radioactivity Concentration Bq kg^{-1}		
		Cs-137	Cs-134	Total Cs
Butter	May 5	12	6	18
	7	8	4	12
	9	13	6	19
	12	21	10	31
	12	45	16	61
	12	17	9	26
	13	17	8	25
	14	16	8	24
	19	18	9	27
	20	10	4	14
	20	13	7	20
	20	10	5	15
	20	7	4	11
	June 4	5	3	8
	July 14	9	5	14
	16	2	1	3
	Aug. 19	—	—	<10
	Sept. 8	—	—	<10

(c) RADIOACTIVITY CONCENTRATIONS IN VARIOUS MILK PRODUCTS (Cont'd)

Product	Production Date	Radioactivity Concentration Bq kg^{-1}		
		Cs-137	Cs-134	Total Cs
Cheddar Cheese	May 5	32	16	48
	7	115	60	175
	7	114	58	172
	9	104	46	150
	16	43	22	65
	17	—	—	<10
	17	—	—	<10
	19	18	11	29
	19	5	2	7
	19	—	—	<10
	28	22	16	38
	June 3	13	7	20
	Nov. 20	—	—	<20
Casein	May 3	—	—	<30
	4	10	5	15
	5	15	8	23
	6	22	11	33
	8	11	6	17
	9	14	9	23
	18	5	2	7
	Aug. 21	—	—	<10
	Oct. 31	—	—	<10
Lactose	May 2	—	—	<10
	4	—	—	<10
	6	—	—	<10
	8	8	5	13
	13	36	17	53
	19	36	19	55
	26	28	9	37
	Oct. 5	—	—	<10
RML Powder	May 4	53	18	71
	6	368	178	546
	7	1106	552	1658
	8	6108	3133	9241
	10	6483	3063	9546
	12	6437	3214	9651
	13	5699	2754	8453
	15	4492	2215	6707
	17	3463	1608	5071
	20	4678	2282	6960
	22	2074	978	3052
	27	2478	1281	3757
	June 9	926	498	1424
	14	788	366	1154
	22	501	254	755
	23	509	250	759
	25	389	175	564
	July 7	387	160	547
	14	284	145	429
	Aug. 12	144	65	209
	Oct. 1	110	50	160

(c) RADIOACTIVITY CONCENTRATIONS IN VARIOUS MILK PRODUCTS (Cont'd)

Product	Production Date	Radioactivity Concentration Bq kg^{-1}		
		Cs-137	Cs-134	Total Cs
Whey Protein Concentrate	May 8	296	134	430
	9	292	144	436
	10	508	244	752
	11	1274	637	1911
	12	803	388	1191
	13	1129	569	1698
	14	1056	520	1576
	18	909	361	1270
	19	231	145	376
	20	804	392	1196
	21	811	389	1200
	22	589	307	896
	23	513	231	744
	25	168	81	249
	31	496	227	723
	June 1	625	312	937
	7	108	54	162
	12	94	52	146
	15	220	112	332
	18	140	72	212
	22	51	19	70
	23	179	85	264
	July 8	91	46	137
	10	23	15	38
	11	63	30	93
	12	24	11	35
	15	68	34	102
	Sept. 2	29	19	48
	Oct. 6	19	9	28
	14	23	12	35
	17	11	<6	<17
Baby Foods	May 6	—	—	<10
	12	—	—	<10
	21	—	—	<10
	28	—	—	<10
	June 4	—	—	<10
	16	—	—	<10
	17	—	—	<10
	18	—	—	<10
	19	—	—	<10
	23	10	6	16
	23	13	9	22
	24	—	—	<10
	25	22	12	34
	25	—	—	<10
	26	22	12	34
	27	27	16	43
	30	25	14	39
	July 1	19	10	29
	1	21	10	31
	2	28	7	35
	Aug. 13	—	—	<10
	26	—	—	<10
	Sept. 3	—	—	<10
	17	3	1	4
	25	—	—	<10
	Oct. 1	—	—	<10
	10	—	—	<10

RADIOACTIVITY CONCENTRATIONS IN VEGETABLES MAY-AUGUST 1986

Vegetable Type	Date	Location	Radioactivity Bq kg⁻¹			
			I-131	Cs-137	Cs-134	Ru-103
Cabbage	May 5-9	Dublin	18	11	7	28
		Waterford	77	81	38	74
		Clare	15	25	12	42
		Limerick	40	67	37	107
		Cork	34	47	22	88
		Donegal	33	40	18	70
		Mean (6)	36	45	22	68
	May 12-15	Offaly	46	84	38	80
		Wicklow	20	33	16	31
		Laois	21	70	37	81
		Laois	58	112	55	121
		Limerick	12	43	22	57
		Leitrim	20	29	16	45
		Sligo	48	83	47	96
		Donegal	49	73	38	78
		Donegal	32	66	30	64
		Mean (9)	34	66	33	73
	May 20-30	Dublin	7	14	7	17
		Dublin	7	21	11	18
		Kildare	3	6	3	5
		Clare	10	45	23	36
		Limerick	5	19	9	25
		Mean (5)	6	21	11	20
	July	Dublin	ND	ND	ND	ND
		Tipperary	ND	ND	ND	ND
		Mayo	ND	10	4	ND
		Donegal	ND	ND	ND	ND
		Mean (4)	ND	3	1	ND
Cauliflower	May 6-15	Dublin	40	92	49	87
		Dublin	ND	ND	ND	ND
	May 16-30	Dublin	ND	12	6	ND
		Cork	ND	60	28	ND
Lettuce	May 6-15	Dublin	24	40	23	29
		Wicklow	32	166	91	111
		Wicklow	8	14	7	8
		Kildare	64	63	35	90
		Donegal	140	108	53	103
		Mean (5)	54	78	42	68
	June	Dublin	ND	ND	ND	ND
		Wexford	ND	ND	ND	ND
	July	Dublin	ND	ND	ND	ND
		Donegal	ND	<1	ND	ND
		Mayo	ND	ND	ND	ND
		Tipperary	ND	<1	ND	ND
	August	Wexford	ND	ND	ND	ND

APPENDIX 5 (Cont'd)

RADIOACTIVITY CONCENTRATIONS IN VEGETABLES MAY-AUGUST 1986

Vegetable Type	Date	Location	Radioactivity Bq kg^{-1} I-131	Cs-137	Cs-134	Ru-103
Scallions	May	Dublin	15	14	8	15
		Dublin	3	ND	ND	ND
	July	Dublin	ND	ND	ND	ND
		Wexford	ND	ND	ND	ND
Rhubarb	May	Dublin	33	26	11	38
		Clare	13	15	7	26
		Limerick	11	27	13	32
	July	Mayo	ND	<1	ND	ND
Leeks	May	Wexford	20	19	12	23
		Wexford	3	6	3	ND
		Dublin	ND	10	4	3
		Waterford	ND	22	12	ND
		Clare	<1	<1	<1	<1
		Cork	3	10	4	11
	July	Tipperary	ND	7	3	ND
Broccoli	May	Leitrim	23	68	39	65
		Dublin	ND	22	9	5
	August	Dublin	ND	ND	ND	ND
Spinach	May	Dublin	32	40	19	104
		Wicklow	18	51	25	23
	July	Dublin	ND	ND	ND	ND
		Dublin	ND	ND	ND	ND
	August	Dublin	ND	ND	ND	ND
Parsley	May	Cork	39	185	86	242
		Dublin	ND	ND	ND	ND
		Dublin	ND	ND	ND	ND
Potatoes	June	Dublin	ND	<1	<1	—
		Louth	ND	ND	ND	—
	July	Wexford	ND	ND	ND	—
		Tipperary	ND	ND	ND	—
		Cork	ND	ND	ND	—
	August	Tipperary	ND	<1	<1	—
Carrots	June	Dublin	ND	3	2	—
		Wexford	ND	ND	ND	—
	July	Dublin	ND	ND	ND	—
		Donegal	ND	ND	ND	—
Sugar Beet	June	Galway	ND	3	2	—
	July	Wexford	ND	ND	ND	—
		Galway	ND	ND	ND	—
		Tipperary	ND	ND	ND	—
		Dublin	ND	ND	ND	—
	August	Dublin	ND	ND	ND	—

Turnips, beetroot, thyme and celery from the Dublin region were checked during July and August and no contamination was detected.

RADIOACTIVITY CONCENTRATIONS IN LAMB MAY-JUNE 1986

Location	No. of Samples	Mean Radioactivity Bq kg^{-1}			
		Cs-137	Cs-134	Total Cs	Total Cs Range
Leinster					
Wicklow	6	217	113	330	211-507
Wexford	5	213	106	319	97-618
Kilkenny	9	371	186	557	203-1155
Kildare	4	215	105	320	117-422
Carlow	5	249	125	374	299-401
Laois	6	244	124	368	276-501
Offaly	4	232	118	350	215-507
Westmeath	3	279	143	422	198-706
Longford	2	243	120	363	320-406
Dublin	4	124	58	182	124-277
Meath	5	118	60	178	133-270
Louth	5	223	110	333	121-827
Munster					
Waterford	4	218	111	329	306-354
Cork	2	244	126	370	247-493
Tipperary	7	287	148	435	202-666
Kerry	3	220	102	322	54-175
Limerick	3	118	60	178	175-180
Clare	1	192	96	288	—
Connacht					
Galway	2	193	100	293	291-299
Mayo	2	191	95	286	199-373
Leitrim	3	162	77	239	221-234
Roscommon	5	202	102	304	168-486
Sligo	7	301	154	455	221-765
Ulster					
Donegal	4	221	107	328	186-446
Monaghan	4	110	56	166	108-246
Cavan	5	209	107	316	96-520

RADIOACTIVITY CONCENTRATIONS IN LAMB, JULY-AUGUST 1986

Location	No. of Samples	Mean Radioactivity Bq kg^{-1}			
		Cs-137	Cs-134	Total Cs	Total Cs Range
Leinster					
Kilkenny	8	253	129	382	167-387
Offaly	2	184	86	270	198-347
Wicklow	5	135	68	203	136-336
Westmeath	6	162	76	238	149-394
Longford	2	51	25	76	50-101
Wexford	1	124	60	184	—
Meath	1	86	40	126	—
Munster					
Tipperary	6	172	85	257	140-671
Waterford	1	87	45	132	—
Connacht					
Leitrim	1	397	196	593	—
Sligo	11	200	100	300	199-566
Mayo	8	132	64	196	36-246
Galway	2	283	156	439	335-542
Roscommon	2	125	60	185	70-115
Ulster					
Donegal	4	155	76	231	100-364

RADIOACTIVITY CONCENTRATIONS IN LAMB, SEPTEMBER-OCTOBER 1986

Location	No. of Samples	Mean Radioactivity Bq kg^{-1}			
		Cs-137	Cs-134	Total Cs	Total Cs Range
Leinster					
Wicklow	3	14	6	20	12- 23
Wexford	2	12	5	17	13- 20
Kilkenny	3	15	7	22	19- 25
Kildare	1	12	6	18	—
Carlow	2	15	7	21	21- 22
Laois	2	13	6	19	18- 19
Offaly	2	15	8	23	15- 30
Longford	2	13	6	19	16- 22
Meath	4	14	7	21	13- 28
Louth	2	28	13	41	31- 51
Munster					
Waterford	2	18	9	27	23- 30
Limerick	2	24	11	35	26- 43
Connacht					
Galway	2	219	80	299	284-313
Roscommon	1	120	54	174	—
Ulster					
Donegal	1	58	26	84	—
Monaghan	1	13	6	19	—
Cavan	2	32	16	48	40- 55

RADIOACTIVITY CONCENTRATIONS IN BEEF, JULY 1986

Location	No. of Samples	Mean Radioactivity Bq kg^{-1}			
		Cs-137	Cs-134	Total Cs	Total Cs Range
Leinster					
Wicklow	2	76	36	112	53-166
Wexford	6	73	34	107	71-129
Kilkenny	6	79	36	115	70-163
Kildare	3	41	20	61	31- 99
Carlow	1	68	33	101	—
Laois	12	104	48	152	39-297
Offaly	8	65	31	96	45-221
Westmeath	5	70	36	106	38-279
Longford	2	60	30	90	59-121
Dublin	4	75	31	106	34-199
Meath	4	48	23	71	27-145
Louth	2	103	44	147	30-264
Munster					
Waterford	9	120	60	180	88-348
Cork	4	86	42	128	37-242
Tipperary	12	40	20	60	34-105
Kerry	1	49	27	76	—
Limerick	1	48	22	70	—
Clare	1	73	36	109	—
Connacht					
Mayo	2	72	35	107	93-121
Leitrim	2	97	50	147	145-148
Roscommon	3	78	34	112	57-156
Sligo	2	125	65	190	184-194
Ulster					
Donegal	3	43	20	63	59- 66
Monaghan	3	39	21	60	47- 75
Cavan	4	34	18	52	20- 87

RADIOACTIVITY CONCENTRATIONS IN BEEF, AUGUST 1986

Location	No. of Samples	Mean Radioactivity Bq kg^{-1}			
		Cs-137	Cs-134	Total Cs	Total Cs Range
Leinster					
Kildare	18	48	23	71	21-125
Meath	2	13	7	20	16- 24
Dublin	1	28	15	43	—
Laois	3	65	34	99	49-145
Offaly	2	47	22	69	45- 92
Westmeath	2	43	20	63	34- 91
Louth	3	12	7	19	14- 29
Carlow	3	26	14	40	24- 51
Kilkenny	2	52	27	79	70- 86
Longford	3	49	25	74	35-100

RADIOACTIVITY CONCENTRATIONS IN BEEF, AUGUST 1986

Location	No. of Samples	Mean Radioactivity Bq kg⁻¹ Cs-137	Cs-134	Total Cs	Total Cs Range
Munster					
Waterford	17	60	28	88	ND-172
Cork	3	29	14	43	ND- 43
Tipperary	4	31	15	46	13-113
Limerick	3	15	7	22	12- 27
Kerry	3	21	10	31	18- 39
Ulster					
Monaghan	2	33	16	49	39- 58
Donegal	1	63	32	95	—
Cavan	3	18	9	27	11- 50
Connacht					
Roscommon	3	42	21	63	44- 96
Mayo	4	27	12	39	14- 76
Sligo	5	41	19	60	16-137
Galway	2	96	42	138	52-212
Leitrim	3	32	14	46	8- 87

RADIOACTIVITY CONCENTRATIONS IN BEEF, SEPTEMBER 1986

Location	No. of Samples	Mean Radioactivity Bq kg⁻¹ Cs-137	Cs-134	Total Cs	Total Cs Range
Leinster					
Dublin	2	16	8	24	12- 36
Carlow	3	20	10	30	16- 51
Wicklow	3	11	5	16	10- 24
Wexford	3	13	7	20	12- 27
Meath	3	8	4	12	ND-12
Louth	3	13	7	20	9- 39
Westmeath	1	15	7	20	—
Laois	3	47	22	69	31-111
Longford	3	25	11	36	14- 67
Offaly	8	14	7	21	ND-31
Kildare	3	22	10	32	21- 49
Kilkenny	3	37	18	55	27- 84
Munster					
Cork	3	9	5	14	12- 15
Kerry	3	14	7	21	6- 31
Tipperary	6	27	13	40	20- 70
Limerick	3	28	13	41	21- 70
Clare	3	44	22	66	51- 90
Waterford	3	32	16	48	24- 93
Connacht					
Mayo	3	22	12	34	12- 51
Galway	4	58	27	85	ND-218
Roscommon	3	29	14	43	9- 89
Sligo	3	42	22	64	48- 90
Leitrim	3	10	5	15	12- 19
Ulster					
Donegal	3	79	33	112	45-246
Monaghan	3	17	8	25	15- 34
Cavan	3	41	17	58	15-119

RADIOACTIVITY CONCENTRATIONS IN BEEF, OCTOBER 1986

Location	No. of Samples	Mean Radioactivity Bq kg^{-1}			
		Cs-137	Cs-134	Total Cs	Total Cs Range
Leinster					
Dublin	1	20	10	30	-
Carlow	1	19	9	28	—
Wicklow	1	6	3	9	—
Meath	4	17	8	25	12-46
Westmeath	1	24	12	36	—
Louth	1	8	4	12	—
Laois	1	25	11	36	—
Longford	1	73	33	106	—
Offaly	2	25	13	38	16-58
Kildare	1	—	—	<10	—
Kilkenny	4	17	8	25	14-36
Munster					
Cork	2	22	11	33	22-43
Kerry	1	18	8	26	—
Tipperary	1	11	5	16	—
Limerick	2	11	5	16	—
Waterford	1	12	6	18	—
Connacht					
Mayo	1	29	13	42	—
Galway	1	13	6	19	—
Leitrim	1	14	7	21	—
Ulster					
Monaghan	1	12	6	18	—
Cavan	1	25	11	36	—

RADIOACTIVITY CONCENTRATIONS IN MIGRATORY BIRDS SEPTEMBER-NOVEMBER 1986

1. WOODCOCK SPECIES

Sampling Location	Date of Measurement	Specific Activity Bq kg^{-1}		
		Cs-137	Cs-134	Total Cs
Kilkenny	12/11/86	253	115	368
Galway	13/11/86	1433	674	2107
Sligo	13/11/86	1187	583	1770
Mayo	13/11/86	18	7	25
Kilkenny	13/11/86	105	50	155
Clare	14/11/86	88	40	128
Mayo	14/11/86	115	52	167
Sligo	14/11/86	29	13	42
Longford	14/11/86	344	164	508
Wicklow	15/11/86	20	8	28
Wicklow	18/11/86	16	7	23
Cork	18/11/86	251	84	335
Tipperary	18/11/86	15	7	22
Meath	20/11/86	21	10	31
Donegal	18/11/86	42	20	62
Donegal	20/11/86	40	18	58
Donegal	19/11/86	11	5	16
Wicklow	19/11/86	309	140	449
Westmeath	19/11/86	ND	ND	ND
Meath	20/11/86	155	60	215
Cork	20/11/86	33	13	46
Mayo	21/11/86	141	64	205
Meath	21/11/86	478	217	695
Kilkenny	25/11/86	233	95	328
Meath	25/11/86	177	81	258
Kildare	26/11/86	65	25	90
Kerry	26/11/86	430	195	625
Meath	26/11/86	48	29	77
Cork	26/11/86	76	34	110
Kildare	25/11/86	38	17	55
Wicklow	26/11/86	195	89	284
Kildare	26/11/86	21	9	30

2. WIDGEON SPECIES

Sampling Location	Date of Measurement	Specific Activity Bq kg^{-1}		
		Cs-137	Cs-134	Total Cs
Wexford	8/10/86	270	130	400
Tipperary	22/10/86	7	4	11
Donegal	23/10/86	ND	ND	ND
Donegal	29/10/86	ND	ND	ND
Tipperary	5/11/86	9	4	13
Tipperary	5/11/86	10	5	15
Tipperary	6/11/86	13	6	19
Galway	14/11/86	20	9	29
Donegal	14/11/86	29	13	42

3. SNIPE SPECIES

Sampling Location	Date of Measurement	Specific Activity Bq kg^{-1}		
		Cs-137	Cs-134	Total Cs
Tipperary	23/10/86	32	16	48
Galway	23/10/86	ND	ND	ND
Tipperary	28/10/86	41	20	61
Composite[1]	28/10/86	81	40	121
Composite[2]	28/10/86	128	58	186
Composite[3]	29/10/86	21	10	31
Clare	5/11/86	52	26	78
Composite[4]	6/11/86	89	45	131
Composite[5]	6/11/86	18	8	26
Kildare	14/11/86	43	20	63
Dublin	19/11/86	8	4	12
Clare	20/11/86	300	136	436
Wicklow	19/11/86	14	6	20
Kildare	25/11/86	26	10	36

Notes: 1. This sample is composed of the flesh of birds from Tipperary, Clare and Wicklow.
2. This sample is composed of the flesh of birds from Clare, Tipperary and Cork.
3. This sample is composed of the flesh of birds from Clare and Limerick.
4. This sample is composed of the flesh of two birds from Tipperary.
5. This sample is composed of the flesh of four birds from Limerick.

4. TEAL SPECIES

Sampling Location	Date of Measurement	Specific Activity Bq kg^{-1}		
		Cs-137	Cs-134	Total Cs
Tipperary	22/10/86	10	5	15
Clare	23/10/86	ND	ND	ND
Composite[1]	29/10/86	51	25	76
Wexford	5/11/86	13	6	19
Tipperary	5/11/86	10	5	15
Kildare	6/11/86	20	10	30
Clare	14/11/86	36	16	52
Tipperary	17/11/86	9	4	13
Tipperary	17/11/86	ND	ND	ND
Wicklow	19/11/86	12	6	18
Dublin	19/11/86	20	10	30

Note: 1. This sample is composed of the flesh of birds from Clare and Wicklow.

5. MALLARD SPECIES

Sampling Location	Date of Measurement	Specific Activity Bq kg^{-1}		
		Cs-137	Cs-134	Total Cs
Clare	23/10/86	51	25	76
Louth	28/10/86	22	11	33
Clare	28/10/86	76	40	116
Composite[1]	29/10/86	242	110	352
Clare	29/10/86	126	63	189
Wexford	4/11/86	13	6	19
Galway	20/11/86	19	9	28
Galway	20/11/86	32	15	47
Galway	20/11/86	13	6	19
Galway	20/11/86	8	4	12
Galway	20/11/86	15	7	22

Note: 1. This sample is composed of the flesh of birds from Clare.

6. MISCELLANEOUS SPECIES

Species	Sampling Location	Date of Measurement	Specific Activity Bq kg^{-1}		
			Cs-137	Cs-134	Total Cs
Pochard	Wexford Donegal	8/10/86 28/10/86	10 ND	5 ND	15 ND
Golden Plover	Tipperary Tipperary	23/10/86 29/10/86	21 ND	10 ND	31 ND
Tufted Duck	Limerick Laois Galway	29/10/86 14/11/86 14/11/86	100 29 53	50 13 24	150 42 77
Shoveller Duck	Clare	29/10/86	23	12	35
Curlew	Galway	14/11/86	9	4	13

APPENDIX 9

RADIOACTIVITY CONCENTRATIONS IN FOODS IMPORTED INTO IRELAND MAY-DECEMBER 1986

1. Fruit and Vegetables

Product	Country of Origin	Date	Radioactivity Concentration Bq kg^{-1}		
			I-131	Cs-137	Cs-134
Potatoes	Holland	May '86	ND	ND	ND
Onions	Holland	May '86	ND	ND	ND
Chick Peas	Holland	May '86	ND	ND	ND
Cabbage	Holland	May '86	ND	ND	ND
Cabbage	Holland	May '86	ND	ND	ND
Onions	Holland	May '86	ND	ND	ND
Gherkins (Pickled)	Holland	May '86	ND	ND	ND
Endive	France	May '86	158	158	77
Chinese Leaves	France	May '86	34	16	7
Fennel	France	May'86	8	21	14
Mange Tout	France	May '86	ND	ND	ND
Broccoli	Italy	May'86	44	13	NM
Strawberries	Italy	May '86	ND	ND	ND
Carrots	Italy	May '86	ND	ND	ND
Artichokes	Italy	May '86	49	23	8
Iceberg Lettuce	Italy	May '86	ND	ND	ND
Iceberg Lettuce	Spain	May '86	ND	ND	ND
Celery	Spain	May '86	ND	ND	ND
Orange Juice	Israel	May '86	ND	ND	ND
Grapefruit Segments	Israel	May '86	ND	ND	ND
Oranges	Israel	May '86	ND	ND	ND
Orange Concentrate	Israel	May '86	ND	ND	ND
Orange Concentrate	Israel	May '86	ND	ND	ND
Red Apples	New Zealand	May '86	ND	ND	ND
Lettuce	E. Germany	May '86	74	170	78
Aubergines	Holland	June '86	ND	ND	ND
Spinach (frozen)	Holland	June '86	22	32	16
Croquette Potatoes	Holland	June '86	ND	ND	ND
Pickled Gherkins	Holland	June '86	ND	ND	ND
Pickled Beetroot	Holland	June '86	ND	ND	ND
Pickled Onions	Holland	June '86	ND	ND	ND
Cabbage	Holland	June '86	ND	ND	ND
Courgettes	France	June '86	ND	ND	ND
Cauliflower	France	June '86	ND	ND	ND
Carrots	France	June '86	ND	ND	ND
Swedes	France	June '86	ND	ND	ND
Carrots	France	June '86	ND	ND	ND
Strawberries	France	June '86	ND	ND	ND
Potatoes	France	June '86	ND	ND	ND
Peaches	Italy	June '86	3	12	5
Green Beans	Italy	June '86	ND	ND	ND
Fennel	Italy	June '86	ND	ND	ND
Peaches	Italy	June '86	ND	ND	ND
Carrots	Italy	June '86	ND	7.3	3.2
Courgettes	Italy	June '86	ND	ND	ND
Cherries	Italy	June '86	ND	15.6	7.2
Strawberries	Italy	June '86	ND	ND	ND
Strawberries	Spain	June '86	ND	ND	ND
Courgettes	Spain	June '86	ND	ND	ND
Plums	Spain	June '86	ND	ND	ND
Chick Peas	Belgium	June '86	ND	ND	ND
Tinned Carrots	Belgium	June '86	ND	ND	ND
Potatoes	Cyprus	June '86	ND	10	4.5
Frozen Chips	Norway	June '86	ND	ND	ND

1. Fruit and Vegetables (Cont'd)

Product	Country of Origin	Date	Radioactivity Concentration Bq kg⁻¹ I-131	Cs-137	Cs-134
Onions	Holland	July '86	ND	ND	ND
Potatoes	Holland	July '86	ND	ND	ND
Cabbage	Holland	July '86	ND	ND	ND
Potatoes	Holland	July '86	ND	ND	ND
Cabbage	Holland	July '86	ND	ND	ND
Frozen Peas	Holland	July '86	ND	ND	ND
Frozen Cauliflower	Holland	July '86	ND	ND	ND
Frozen Carrots	Holland	July '86	ND	ND	ND
Frozen Chips	Holland	July '86	ND	ND	ND
Frozen Chips	Holland	July '86	ND	ND	ND
Green Beans	Holland	July '86	ND	ND	ND
Oven Chips	Holland	July '86	ND	ND	ND
Frozen Chips	Holland	July '86	ND	ND	ND
Onions	France	July '86	ND	ND	ND
Strawberries	UK	July '86	ND	ND	ND
Pickled Beetroot	Poland	July '86	ND	ND	ND
Pickled Beetroot	Poland	July '86	ND	ND	ND
Pickled Beetroot	Poland	July '86	ND	ND	ND
Beetroot	Poland	July '86	ND	ND	ND
Potatoes	Cyprus	July '86	ND	2	ND
Onions	Holland	Aug '86	ND	ND	ND
Chilli Peppers	Holland	Aug '86	ND	ND	ND
Courgettes	Holland	Aug '86	ND	ND	ND
Fennel	Holland	Aug '86	ND	ND	ND
Peppers	Holland	Aug '86	ND	ND	ND
Watercress	Holland	Aug '86	ND	ND	ND
Chicory	Holland	Aug '86	ND	ND	ND
Iceberg Lettuce	Holland	Aug '86	ND	ND	ND
Cabbage	Holland	Aug '86	ND	ND	ND
Pears	Italy	Aug '86	ND	ND	4
Plums	Italy	Aug '86	ND	8	ND
Carrots	Italy	Aug '86	ND	ND	ND
Apples	Spain	Aug '86	ND	ND	ND
Onions	Spain	Aug '86	ND	ND	ND
Grapes	Spain	Aug '86	ND	ND	ND
Cauliflower	UK	Aug '86	ND	ND	ND
Onions	UK	Aug '86	ND	ND	ND
Bramley Apples	UK	Aug '86	ND	ND	ND
Wine Apples	Israel	Aug '86	ND	8	ND
Mangoes	Israel	Aug '86	ND	ND	ND
Spaghetti Fruit	Israel	Aug '86	ND	ND	ND
Melon	Israel	Aug '86	ND	ND	ND
Apples	New Zealand	Aug '86	ND	ND	ND
Kiwi Fruit	New Zealand	Aug '86	ND	ND	ND
Grapes	Greece	Aug '86	ND	12	6
Green Grapes	Greece	Aug '86	ND	ND	ND
Asparagus	Mexico	Aug '86	ND	ND	ND
Avocados	S. Africa	Aug '86	ND	ND	ND
Oranges	S. Africa	Aug '86	ND	ND	ND

1. Fruit and Vegetables (Cont'd)

Product	Country of Origin	Date	Radioactivity Concentration Bq kg^{-1} I-131	Cs-137	Cs-134
Lemons	S. Africa	Aug '86	ND	ND	ND
Peaches	Iran	Aug '86	ND	14	6
Onions	Hungary	Aug '86	ND	ND	ND
Limes	Martinique	Aug '86	ND	ND	ND
Onions	Poland	Oct '86	ND	ND	ND
Onions	Poland	Oct '86	ND	ND	ND
Cabbage	Holland	Oct '86	ND	ND	ND
Fellowes	Holland	Oct '86	ND	ND	ND
Onions	Holland	Oct '86	ND	ND	ND
Broccoli	Italy	Oct '86	ND	ND	ND
Pears	Italy	Oct '86	ND	ND	ND
Cauliflower	UK	Oct '86	ND	ND	ND
Cress	UK	Oct '86	ND	ND	ND
Carrots	UK	Oct '86	ND	ND	ND
Onions	Spain	Oct '86	ND	ND	ND
Courgettes	France	Oct '86	ND	ND	ND
Golden Delicious Apples	France	Oct '86	ND	3 ± 1.5	2 ± 1
Pickled Mushrooms	Czech.	Nov '86	ND	336	85
Sultanas	Turkey	Dec '86	ND	ND	ND
Iceberg Lettuce	Italy	Dec '86	ND	<2	<2
Fennel	Italy	Dec '86	ND	<2	<2
Carrots	Italy	Dec '86	ND	<2	<2
Broccoli	Italy	Dec '86	ND	<2	<2
Peas	Italy	Dec '86	ND	8.0 ± 3.6	4.0 ± 1.6
Cabbage	Holland	Dec '86	ND	<2	<2
Aubergines	Holland	Dec '86	ND	<2	<2
Leeks	Holland	Dec '86	ND	<2	<2
Chicory	Holland	Dec '86	ND	<2	<2
Radishes	Holland	Dec '86	ND	<2	<2
Onions	Holland	Dec '86	ND	<2	<2
Avocados	Israel	Dec '86	ND	4.0 ± 1.0	2.0 ± 1.0
Yams	Israel	Dec '86	ND	<2	<2
Broccoli	UK	Dec '86	ND	<2	<2
Cauliflower	UK	Dec '86	ND	<2	<2
Apples	France	Dec '86	ND	<2	<2
Cauliflower	France	Dec '86	ND	<2	<2
Apples	France	Dec '86	ND	2.7 ± 1.5	1.8 ± 1.0
Tomatoes	Canary Is.	Dec '86	ND	<2	<2
Satsumas	Spain	Dec '86	ND	<2	<2
Apples	Hungary	Dec '86	ND	19.0 ± 3.0	5.0 ± 2.0
Lemons	Cyprus	Dec '86	ND	<2	<2
Oranges	Greece	Dec '86	ND	<2	<2
Onions	Poland	Dec '86	ND	<2	<2

2. Dairy Products

Product	Country of Origin	Date	Radioactivity Concentration Bq kg^{-1}		
			I-131	Cs-137	Cs-134
Chocolate	Holland	May '86	ND	ND	ND
Edam Cheese	Holland	June '86	ND	ND	ND
Cheddar Cheese	Holland	June '86	ND	ND	ND
Soft Cheese	France	June '86	ND	ND	ND
Natural Yoghurt	France	June '86	ND	ND	ND
Parmesan Cheese	Italy	June '86	ND	ND	ND
Evaporated Milk	UK	June '86	ND	ND	ND
Evaporated Milk	UK	June '86	ND	ND	ND
Margarine	Belgium	June '86	ND	ND	ND
Mousse & Cream	Belgium	June '86	ND	ND	ND
Peach Melba	Belgium	June '86	ND	ND	ND
Huntsman Cheese	Belgium	June '86	ND	ND	ND
Mozzarella Cheese	Denmark	June '86	ND	ND	ND
Emmental Cheese	Switzerland	June '86	ND	ND	ND
Gruyere Cheese	Switzerland	June '86	ND	ND	ND
Cream Cheese	W. Germany	June '86	ND	ND	ND
Fruit Yoghurt	W. Germany	July '86	ND	23	12
Feta Cheese	Greece	July '86	ND	ND	ND
Chocolate	Finland	July '86	ND	ND	ND
Emmental Cheese	France	Sept '86	ND	ND	ND
Brie Cheese	France	Sept '86	ND	ND	ND
Tinned Milk	UK	Oct '86	ND	ND	ND
Baby Food	UK	Oct '86	ND	ND	ND
Baby Food	UK	Oct '86	ND	ND	ND
Baby Food	UK	Oct '86	ND	ND	ND
Baby Food	UK	Oct '86	ND	ND	ND
Soya Milk	W. Germany	Oct '86	ND	ND	ND
Brie Cheese	France	Oct '86	ND	ND	ND
Edam Cheese	Holland	Oct '86	ND	ND	ND
Low Fat Cheese	W. Germany	Oct '86	ND	ND	ND
Blue Cheese	Holland	Oct '86	ND	ND	ND
Mozzarella Cheese	Italy	Oct '86	ND	ND	ND
Cotswold Cheese	UK	Oct '86	ND	ND	ND
Cream	UK	Oct '86	ND	ND	ND
Brie Cheese	France	Oct '86	ND	ND	ND
Chocolate Mousse	Belgium	Dec '86	ND	ND	ND
Edam Cheese	Holland	Dec '86	ND	ND	ND
Blue Cheese	France	Dec '86	ND	ND	ND
Mozzarella Cheese	Italy	Dec '86	ND	ND	ND
Emmental Cheese	Switzerland	Dec '86	ND	52	25
Smoked Cheese	Germany	Dec '86	ND	ND	ND
Cream Cheese	Denmark	Dec '86	ND	ND	ND

3. Meat Products

Product	Country of Origin	Date	Radioactivity Concentration Bq kg⁻¹		
			I-131	Cs-137	Cs-134
Bacon	Holland	May '86	ND	ND	ND
Processed Ham	Belgium	May '86	ND	ND	ND
Brussels Pate	Belgium	June '86	ND	ND	ND
Chicken Liver Pate	Belgium	June '86	ND	ND	ND
Cooked Ham	Holland	July '86	ND	ND	ND
Boneless Salted Pork	Holland	July '86	ND	ND	ND
Tinned Meat with Egg	Denmark	July '86	ND	ND	ND
Tinned Meat with Pork Stuffing	Denmark	July '86	ND	ND	ND
Tinned Meatballs	UK	Oct '86	ND	ND	ND
Pate	Belgium	Oct '86	ND	ND	ND
Grill Steaks	UK	Dec '86	ND	ND	ND

4. Miscellaneous

Product	Country of Origin	Date	Radioactivity Concentration Bq kg⁻¹		
			I-131	Cs-137	Cs-134
Caseinate	Holland	May '86	ND	ND	ND
Mayonnaise	W. Germany	May '86	ND	ND	ND
Miracle Whip	W. Germany	May '86	ND	ND	ND
Wood Pulp	W. Germany	May '86	ND	ND	ND
Honey	Romania	May '86	ND	ND	ND
Honey	Bulgaria	May '86	ND	ND	ND
Mars Bars	Holland	June '86	ND	ND	ND
Tomato Puree	Greece	June '86	ND	ND	ND
Nat. Propanoyl Acid	Holland	July '86	ND	ND	ND
Nat. Propanoyl Acid	Holland	July '86	ND	ND	ND
Honey	Bulgaria	July '86	ND	ND	ND
Gramicidin	Denmark	July '86	ND	ND	ND
Gramicidin	Denmark	July '86	ND	ND	ND
Daloon Rolls	Denmark	July '86	ND	ND	ND
Fish Fingers	Denmark	Oct '86	ND	ND	ND
Frozen Duck	Denmark	Oct '86	ND	ND	ND
Barleycup	Poland	Oct '86	ND	ND	ND
Pulp Powder	Germany	Nov '86	ND	ND	ND
Grill Steaks	UK	Dec '86	ND	ND	ND