

# Committee on Medical Aspects of Radiation in the Environment (COMARE)

## FIFTH REPORT

The incidence of cancer and leukaemia in the area around the former Greenham Common Airbase. An investigation of a possible association with measured environmental radiation levels.

Chairman: Professor B A Bridges



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## FOREWORD

i. The Committee on Medical Aspects of Radiation in the Environment (COMARE) was established in November 1985 in response to the final recommendation of the report of the Independent Advisory Group chaired by Sir Douglas Black (Black, 1984). Our terms of reference are to “assess and advise Government on the health effects of natural and man-made radiation in the environment and to assess the adequacy of the available data and the need for further research”.

ii. The Black Advisory Group had been commissioned by the Minister of Health in 1983 to investigate reports of a high incidence of leukaemia occurring in young people living in the village of Seascale, 3 km from the Sellafield nuclear site and the suggestion that there might be an association between the leukaemia incidence and the radioactive discharges from Sellafield. The Advisory Group confirmed that there was a higher incidence of leukaemia in young people resident in the area but also concluded that the estimated radiation dose from the Sellafield discharges and other sources, received by the local population, could not account for the observed leukaemia incidence on the basis of knowledge available at that time. The uncertainties in the available data led the Advisory Group to make recommendations for further research and investigation.

iii. Our First Report (COMARE, 1986), examined the implications of some further information concerning discharges of uranium oxide particles from Sellafield in the 1950s, which had not been available to the Black Advisory Group. The Committee concluded that this additional information did not change the essential conclusions of the Black report.

iv. Our Second Report investigated the incidence of leukaemia in young people living near to the Dounreay Nuclear Establishment in Caithness, Scotland (COMARE, 1988). We found evidence of an increased incidence of leukaemia in young people in the area and although the conventional dose and risk estimates suggested that radioactive discharges could not be responsible, we noted that the raised incidence of leukaemia at both Sellafield and Dounreay tended to support the hypothesis that some feature of these two plants lead to an increased risk of leukaemia in young people living in the surrounding area. The report also considered other possible explanations and recommended further investigations.

v. Our Third Report considered suggestions of an increased incidence of childhood cancer near the Atomic Weapons Research Establishment at Aldermaston and the Royal Ordnance Factory at Burghfield (COMARE, 1989). We found a small but statistically significant increase in registration rates of childhood leukaemia and other childhood cancers in children in the vicinity of the two sites. However, we judged that the doses from the radioactive discharges were far too low to account for the observed increase in the incidence of childhood cancer. We considered a number of possible explanations for the findings including other mechanisms by which radiation could be involved, but there was insufficient

evidence to point to any one explanation, although the possibility remained that a combination of factors might be involved. Further investigations were recommended. Our Third Report concluded by saying that the distribution of cases of childhood leukaemia or other childhood cancers around nuclear installations could not be seen in proper context in the absence of comparable information about the pattern throughout the UK. We recommended, therefore, that further work be carried out to determine the national geographical pattern of distribution of childhood cancer and that this work should be given high priority.

vi. Our Fourth Report (COMARE, 1996) was the result of the Committee's review of the dosimetric, epidemiological and other scientific data relating to the Sellafield Site and the village of Seascale, together with other relevant advances in scientific knowledge, that had become available since the publication of the report of the Black Advisory Group in 1984. In the report we concluded that there was good evidence for a continuing, significantly elevated level of all malignancies in young people (0-24) in Seascale throughout the period considered by the Black report (1963-83) and our subsequent analysis (1984-92), covering a total period of three decades. We considered the current estimate of the radiation doses to the Seascale population, from both routine and accidental discharges from Sellafield, to be too small to account for the observed excess of cases of leukaemia and non-Hodgkin's lymphoma (NHL) on the basis of current knowledge. We considered a number of other hypotheses involving radiation exposure and also those involving exposures to chemicals and infectious agents, either singly or in combination. We concluded that no single factor could account for the excess of leukaemia and NHL but that a mechanism involving infection may be a significant factor affecting the risk of leukaemia and NHL in young people in Seascale. We made five recommendations for further research, all of which were accepted by Government.

vii. In this our Fifth Report we examine whether there is or has been any unusual incidence of cancer in the vicinity of the former Greenham Common Airbase and whether there is or has been any association with local levels of radioactivity in the area. With regard to childhood cancer we have examined the local incidence of these diseases in the context of the geographical distribution of these malignancies nationwide.

viii. In the preparation of this report the Committee requested data and information from a number of organisations and researchers. Many individuals have given time to present data to us and we wish to take this opportunity to thank all of them for their co-operation.

ix. The views expressed in this report are those of the Committee and not necessarily those of the Secretariat, the Assessors, or those providing evidence. Lists of the Members, the Secretariat and the Assessors are provided in Appendix B. Technical detail is unavoidable in a report such as this and a Glossary of terms is provided in Appendix A. However, a complete picture of the scientific background to this report can only be gained by reference to the scientific material consulted which is listed at the end of the report in the References.



# CHAPTER 1

## INTRODUCTION

1.1 On 14 July 1996, the Campaign for Nuclear Disarmament (CND) drew media attention to a leaked, classified, Ministry of Defence (MoD) report, written in 1961 by F H Cripps and A Stimson. This report contained environmental monitoring data from the area surrounding the Greenham Common Airbase and concluded that there had been a release of radioactivity, and noted that:

“The size of the release and the nature of the distribution pattern suggests that damage to a nuclear weapon has caused contamination of the surface of the airfield by U-235 and this has been subsequently spread to the surrounding countryside.... The only incident which appears to have been large enough to produce contamination of such magnitude is the fire which occurred on 28th February, 1958, in which an aircraft, possibly carrying a nuclear weapon, was involved.”

1.2 The levels of radioactive contamination were reported to have covered an area extending up to 8 miles from the base. There were reports of an increased number of childhood leukaemia cases in the area and this raised considerable concerns in the local community.

1.3 On 16 July, David Rendel MP and Sir David Mitchell MP who represented constituencies in the local area, signed their names to an Early Day Motion (EDM) calling on the Secretary of State for Health to set up a full epidemiological study with a view to discovering whether or not the area in which the reports indicated unnaturally high levels of radiation, correspond to the area in which sufferers from the diseases have either lived or worked.

1.4 On the same day, Tam Dalyell MP raised a question in the House of Commons asking when the Department of Health first learned of the medical consequences of the alleged nuclear accident. In response to both the EDM and Mr Dalyell’s question, reference was made to COMARE’s Third Report.

1.5 Also on 16 July 1996, the COMARE Secretariat received a letter from CND which contained extracts of the Cripps and Stimson report and a copy of the CND report entitled “Broken Arrow” (Gonçalves, 1996). In the letter, CND said that it understood that the information in the 1961 report by Aldermaston scientists was not made available to the COMARE inquiry of 1989 (COMARE’s Third Report). The letter called on COMARE to reopen its investigations.

### COMARE’s Third Report

1.6 COMARE’s Third Report (COMARE, 1989) considered whether there was any association between the incidence of childhood cancer in West Berkshire and North Hampshire and exposure to radioactivity released from the three nuclear establishments, the Atomic Weapons Research Establishment (AWRE), Aldermaston, the Royal Ordnance Factory (ROF), Burghfield, and the Atomic Energy Research Establishment (AERE), Harwell. The report did not include any estimates of possible exposure to radioactivity resulting from the activities at Greenham Common Airbase.

1.7 In the report two epidemiological studies were described. These studies indicated an increased incidence of childhood leukaemia in the area during the period 1972-85 and an excess of other childhood cancers between 1971 and 1982. The National Radiological Protection Board (NRPB) had estimated possible radiation doses from discharges from the nuclear establishments at Aldermaston, Burghfield and Harwell. NRPB had calculated that the resulting doses were a fraction of those which arise from natural background radiation in the United Kingdom.

1.8 COMARE had concluded that these releases were far too low to account for the observed increase in the incidence of childhood cancer in West Berkshire and North Hampshire. Estimates of doses from atmospheric discharges, carried out by NRPB, relied on discharge data as levels recorded by environmental monitoring were low and often indistinguishable from background levels. In that report COMARE recommended a study of the geographical distribution of childhood cancer incidence on a nationwide basis. This study is underway and nearing completion. In his reply to Mr Dalyell, the Minister told the House of Commons that when this study is complete COMARE will consider all new data in assessing whether there is an association between local levels of contamination and the incidence of cancer.

### **Remit of this report**

1.9 On 23 July 1996, the Department of Health wrote to the Chairman of COMARE requesting the Committee's advice on the potential for adverse health effects in the area surrounding Greenham Common Airbase (RAF Greenham Common).

1.10 The remit of the Committee's current investigations is as follows:

“Whether, within the context of COMARE's current considerations of the geographical distribution of childhood cancer incidence nationwide, there is, or has been any unusual incidence of childhood cancer in the vicinity of RAF Greenham Common. If any such unusual incidence is observed then whether there is or has been any association with local levels of radioactivity in the area.”

## CHAPTER 2

### THE ACCIDENT ON 28 FEBRUARY 1958

2.1 COMARE approached MoD to ask if the Committee could be provided with copies of reports or documents relating to the fire in February 1958 produced, at the time, by US Air Force service personnel, the Greenham Common Airbase Commander or by a subsequent accident investigation. We were provided with a narrative report of the accident and also a copy of the USAF air accident investigation report into the accident at Greenham Common on 28 February 1958. These documents give a detailed description of the events which took place on that day and the subsequent investigation and analysis. Essentially the documents deal with a release of aircraft fuel tanks which led to a severe fire which destroyed one B47 aircraft and damaged a hanger on the Greenham Common Airbase. In line with air accident report procedures, various sections were obliterated prior to release of the document to protect the names and actions of those who gave evidence. The following is a brief description of the accident and its outcome as taken from these reports.

2.2 At 4.00 pm on 28 February 1958, B47E number 53-6216, known as Granville 20, took off from Greenham Common Airbase with a fuel load of 103,000 lbs. Its destination was the United States of America. Approximately one minute after take off an electrical failure caused activation of warning lights indicating fire in engines numbers 2 and 3 and overheating in the wing containing these engines. The crew of the aircraft immediately shut down these engines and requested an immediate emergency landing at Greenham Common. Because of the huge fuel load on board the aircraft it was decided that the drop tanks would be released in the drop area on the Greenham Common Airbase. It was at this point in time that a series of mistakes and errors occurred (detailed in the report) which resulted, at approximately 4.23 pm, in the drop tanks striking a main hangar (Hangar No 2) and hard stand No 32 on which were parked several B47 Bombers. Both fuel tanks exploded setting fire to both the hanger and an aircraft (No 6204) on hard stand 32.

2.3 Due to the smoke now obscuring the runway, Granville 20 was diverted to Brize Norton Air Force Base and carried out a successful emergency landing at 4.51 pm.

2.4 When the aircraft (6204) on hard stand 32 was engulfed in flames, efforts were directed not at saving the aircraft but at preventing the spread of fire to aircraft parked nearby and to controlling the fire in hanger 2. The facilities located in hanger 2 are listed. They included the main aircraft maintenance facilities, base operations and base weather facilities. The chief fire officer's report on two occasions notes that "full efforts were affected to save the hanger" and "efforts to save the hanger and maintenance facility were considered primary". This accident has been referred to in several Parliamentary questions over the intervening years. The earliest we have seen is a written answer to a Parliamentary question on 5 March 1958. In it we note that the USAF authorities asked the then Secretary of State for Air to express their thanks to local firefighters for their assistance in bringing the fire under control in about one hour. This answer also noted that "the

fire at no time presented any danger to the local population. Civilian interests will be given full consideration during the Service Inquiry”.

2.5 COMARE was also provided with copies of Parliamentary correspondence concerning the accident and the Ministerial replies along with an information pack put together by MoD and containing MoD’s response to the allegation that a nuclear weapon accident had occurred at Greenham Common. This document included as annexes a narrative report by ex-American servicemen who had been on site at the time of the fire, historical Parliamentary questions relating to the fire and copies of contemporary local newspaper reports.

2.6 The Committee scrutinised these documents in an effort to address the claims that a nuclear weapon was damaged or destroyed in the fire which resulted from this accident. At no point in these documents is it categorically stated that a nuclear weapon was not involved in the fire. However, all the other available information suggests that the presence of such a weapon is extremely unlikely. The fact that the affected aircraft was allowed to burn out is extremely suggestive in its own right. It is difficult to imagine this being the case if a weapon had been on board.

2.7 Having reviewed the evidence described above we found nothing to suggest that a nuclear weapon was involved in the accident or subsequent fire.

## CHAPTER 3

### MONITORING DATA

#### Introduction

3.1 This chapter summarises the data on the measurements of radionuclides in the environment considered by COMARE. The Committee's conclusions as to the radiological implications of these data are presented. The geographical area under consideration in this report is shown in the map. The implications of the data for the Committee's Third Report on the incidence of childhood cancer in the West Berkshire and North Hampshire area are also discussed.

3.2 Following the disclosure in a CND report issued in 1996 of studies undertaken around 1960 which purported to show unexpectedly high levels of uranium-235 in the vicinity of the USAF Airbase at Greenham Common (see Chapter 1), COMARE requested copies of the relevant reports from the Ministry of Defence (MoD). COMARE was provided by MoD with a report, dated July 1961, by AWRE Aldermaston, entitled "The distribution of uranium-235 around the United States Air Force Base, Greenham Common, Berkshire" by F H Cripps and A Stimson (AWRE, 1961a). This report is the one referred to by CND. The report references four previous reports describing an 'Exercise Overture'. These reports were requested by COMARE and were subsequently provided by MoD; they are Exercise Overture Interim Reports Nos 1 to 4 (AWRE, 1960a, b and c; AWRE, 1961b). Later reports describing separate studies undertaken by AWRE Aldermaston and the Defence Radiological Protection Service (DRPS) into radionuclide levels in or around the airbase were also provided by MoD (DRPS, 1996) as were copies of the discharge and environmental monitoring reports for AWRE (now AWE) Aldermaston and Burghfield for the years 1986 to 1995 (AWE, 1987-96). The concerns raised by the CND report prompted two further surveys of radionuclide levels around Greenham Common, one for the MoD by the National Radiological Protection Board (NRPB) (Fry and Wilkins, 1996) and one for Newbury District Council and Basingstoke and Deane Borough Council by Southampton University and the Scottish Universities Research and Reactor Centre (SURRC) (Croudace et al, 1997a and b). Both of these reports were also considered by COMARE.

3.3 MoD has stated that Exercise Overture was "... the name given to a study conceived in the 1950s, at the height of the Cold War, to determine whether it might be possible to gather information about foreign nuclear weapon development activities by sampling the environment for traces of nuclear materials in locations remote from nuclear facilities. In order to test the theory, measurements were carried out at various distances from our own Atomic Weapons Research Establishment at Aldermaston. While analysing samples of vegetation taken from the vicinity of Greenham Common, some 5 miles to the west of Aldermaston, levels of uranium-235 slightly higher than those occurring naturally were found". Thus, the finding of elevated uranium-235 levels in the vicinity of Greenham Common was fortuitous in the sense that the investigators appear to have had no *a priori* reason to suspect that there would be such levels; indeed, samples from around Greenham Common were being taken to provide baseline data for comparison with samples being taken from elsewhere.

3.4 There are several isotopes of uranium. The vast majority of natural uranium by mass is uranium-238. Uranium-235 exists naturally and is present in natural uranium in a ratio of 0.73% to uranium-238 by numbers of atoms. Any method for detecting increased levels of uranium-235 in materials has to take this into account and so in Exercise Overture, materials were sampled that would be expected to have low concentrations of natural uranium. In Exercise Overture one such material was taken to be the leaves of evergreen plants, notably laurel leaves. In order to express the results, the Exercise Overture investigators presented data in terms of the percentage of uranium-235, by numbers of atoms, in the total uranium in the samples and also in terms of the ratio of this percentage to the natural percentage (the enrichment factor). Thus, a ratio in excess of one could indicate additional uranium-235 but the range of uncertainties arising during the analytical process would also have to be taken into account in reaching a decision as to whether excess uranium-235 was present in a particular sample. Taking uncertainties into account, the 1961 AWRE report states that measured enrichment factors in excess of 1.025 are highly significant (AWRE, 1961a).

## Monitoring data

3.5 As noted earlier, in Exercise Overture, samples from around Greenham Common were taken without any expectation that excess uranium-235 would be present. However, one sample of laurel leaves in particular from the vicinity of Greenham Common, sample W101 in Exercise Overture Interim Reports 2 and 3, showed an unexpectedly elevated uranium-235 to uranium-238 ratio of 1.11% by numbers of atoms (an enrichment factor of 1.52) (AWRE, 1960b and c). Exercise Overture Interim Report No 3 gives data for a different sample of laurel leaves from the same location and this also shows an elevated uranium-235 to uranium-238 ratio of 0.96% by numbers of atoms (Table II of AWRE, 1960c). Thus, we conclude that the observation was, to some extent at least, repeatable. The 1961 AWRE report states that in total 22 of 25 leaf samples from the Greenham Common area showed significant enrichment in uranium-235 (AWRE, 1961a).

3.6 It is clear from the Exercise Overture reports that AWRE Aldermaston processed uranium with elevated levels of uranium-235 at this time and is thus one possible source of elevated uranium-235 in the environment in this region. (Greenham Common is approximately 10 km away from AWRE Aldermaston at a bearing of 264°.) In this respect, surveys described in Exercise Overture Interim Report No 3 also indicate the presence of elevated uranium-235 in samples taken at distances up to 20 km from AWRE Aldermaston but in directions away from Greenham Common (AWRE, 1960c). For example, Table IV of Interim Report No 3 gives results for a sample of dust collected from a clothes dryer situated at about 20 km from AWRE at a bearing of 57°; the ratio of uranium-235 to uranium-238 was 0.9% by number of atoms. The samples in which elevated amounts of uranium-235 were detectable were generally those having the lowest levels of natural uranium. From these data, we conclude that the results for Greenham Common are not unique. We return to the question of the origin of any excess uranium-235 and the radiological implications later in this chapter.

3.7 A reappraisal of the 1961 AWRE report was conducted by AWRE Aldermaston in 1986, prompted by a Parliamentary question raised in the House of Commons. This study included the collection and analysis of samples of environmental materials from close to the perimeter fence of the airbase, together with a review of the methodology used in 1961 (AWE, 1986). No evidence for elevated levels of uranium-235 could be found in the 1986 study. However, the authors concluded that there was no reason to doubt the finding of anomalous uranium ratios made during Exercise Overture.

3.8 Other, more recent studies on radionuclide levels at and around Greenham Common have been considered by COMARE. These included the dedicated

surveys noted earlier, as well as the continuous monitoring programmes operated by the Local Authorities. All of these studies made use of soil sampling. For this material, comparisons of data between these programmes and with other published information are not always straightforward. This is because, in soil that has not been disturbed by cultivation, even after several decades most of the activity deposited remains in the surface layer. Consequently, the activity concentration that is observed depends on the depth to which the soil was sampled. Thus comparisons of data can only be made if appropriate information on sampling protocols is available.

3.9 A survey of the Greenham Common Airbase was carried out by DRPS in April 1994 (DRPS, 1996). The purpose of the study was to establish whether there was any contamination of the site as it was to be sold for redevelopment. The survey included areas where waste materials had been deposited, where aircraft had been burned, and the drainage system. Surveys with instruments to measure dose rates from gamma radiation were augmented by measurements on soil samples and on sediment samples from the drainage system. The analytical method employed on these samples was gamma-ray spectrometry, which is not as sensitive a method for determining uranium-235 as the methods used in Exercise Overture or in the two studies by NRPB and Southampton University and SURRC, but is sufficient for radiological protection purposes. The DRPS study found that all the measured values of uranium-235 were below detection limits with the exception of one value that was at the detection limit. Concentrations of a fission product, caesium-137, were also measured and were stated to be generally consistent with those expected from the testing of nuclear weapons in the atmosphere together with a contribution from Chernobyl fallout. It should be noted that the DRPS report does not state the depth to which soil samples were taken. The study by NRPB, published in December 1996 and commissioned by MoD, was based on measurements in undisturbed soil collected from 18 sites within the Greenham Common Airbase complex and from a further 29 locations in the surrounding area. Samples of undisturbed soil were taken because any activity that had been deposited in the environment during the 1950s and 1960s would by now have been incorporated into soil rather than remaining on vegetation. Soil that has remained undisturbed since that time provides the most sensitive method for assessing the total amount deposited, since any cultivation would result in dilution. NRPB obtained advice in the selection of suitable sites from Newbury District Council and from Basingstoke and Deane Borough Council. NRPB selected a control site at Hungerford, some 16 km to the west of Greenham Common, and, at the suggestion of COMARE, five sites were selected to the northeast of AWRE Aldermaston, again for comparative purposes. Samples of leaf mould were also taken from adjacent to the perimeter of the former airbase, close to the points specified in the 1961 AWRE report.

3.10 Previous studies on weapons fallout suggest that in undisturbed soil, most of the deposited caesium-137 and plutonium is retained in the top 150 mm of soil (Cawse and Horrill, 1986). However, at most of the locations considered by NRPB, the surface layer of soil was only around 40-50 mm deep before a layer of gravel was encountered. In cases where deeper soil samples could be obtained, NRPB divided some of the samples into 20 mm sections which were analysed separately in order to obtain information on the depth distribution of radionuclides. Samples were analysed by gamma-ray spectrometry, which is a sensitive method for detecting caesium-137. After radiochemical isolation, uranium-234, uranium-235, uranium-238 and plutonium-239/240 were determined using alpha spectrometry, which is also a sensitive method.

3.11 All of the soil samples were analysed for uranium isotopes; on the basis of the isotopic ratios, the uranium was found to be entirely of natural origin. The amounts of uranium-235 and uranium-238 in the soil samples were at or below

other published results for the area, which in turn are at the lower end of the range observed across the UK as a whole. Values for leaf mould were at the lower end of the range observed by NRPB for soils and again the isotopic ratios indicated that the uranium was entirely of natural origin.

3.12 The NRPB study reported levels of plutonium isotopes and of caesium-137 in soils. COMARE notes that the levels reported for the Greenham Common area are consistent with those expected from global weapons test fallout. Higher levels of plutonium-239 were found by NRPB in three out of the five samples taken up to about 5 km to the northeast of AWRE (now AWE) Aldermaston: levels ranged up to about twice the maximum expected from global weapons test fallout. It was also noted in COMARE's Third Report that levels of plutonium isotopes in soil 5 km to the northeast of AWRE Aldermaston were slightly elevated above those found at control sites elsewhere in the UK. However, in terms of concentrations in soil and the possible resulting doses to the general public, COMARE considered in its Third Report that the levels found were not of any radiological significance (para 3.30; COMARE, 1989). Taking differences in sampling protocols into account, the values observed in the NRPB study are consistent with those published by COMARE and with the results of the long-term monitoring programme operated by Basingstoke and Deane Borough Council.

3.13 The other results of the long-term monitoring programme have also been examined. Sampling of a variety of environmental materials is carried out on a routine basis by both Newbury District Council and Basingstoke and Deane Borough Council (Southampton Oceanography Centre, 1997). The samples are analysed by the University of Southampton. Activity concentrations in soils were mostly consistent with those expected from weapons testing, the only exceptions being those sampling sites close to AWE Aldermaston. Activity concentrations in other materials such as foodstuffs were very low, in many cases below the limit of detection.

3.14 The study for Newbury District Council and Basingstoke and Deane Borough Council was carried out by Southampton University and SURRC. It made use of a number of detection and analytical techniques including mass spectrometry and aerial gamma-ray spectrometry. Analyses for uranium isotopes were conducted on more than 500 samples from Greenham Common and its surroundings, from the vicinity of AWE Aldermaston and from control areas, in particular the Savernake Forest. No evidence for anything other than natural uranium could be found in any of the samples except those taken within 2-3 km of AWE Aldermaston. For plutonium, activity concentrations around Greenham Common were comparable with those at the control sites. Indeed, one of the highest observed values came from the Savernake Forest. All of the plutonium could, therefore, be attributed to weapons fallout. The aerial survey showed that caesium-137 levels in the Greenham Common area were low when compared with some other areas of the UK and were almost entirely attributable to fallout from global weapons testing; the remainder originating from the Chernobyl accident. The aerial survey also confirmed that overall levels of activity due to natural radionuclides are low in this area compared with national average values.

3.15 COMARE has also considered results from the monitoring programme operated by AWE Aldermaston. This programme includes a high volume air sampler nominally located near Newbury. Results are available from 1986, although no sampling took place between November 1993 and September 1995. Analyses for total uranium and plutonium-239/240 were included in the programme and the reported annual levels for Newbury are generally within a factor of about two of the levels reported for the control site of Hannington in Hampshire. Based on isotopic ratios, the uranium is reported to be of entirely natural origin. Soil and vegetation



are sampled annually from a site at Thatcham, although data for this specific location are only provided from 1991 onwards. Measurements are made on these samples for total beta activity, total alpha activity, tritium, uranium and, in the case of soil, caesium-137. Where measurable amounts are reported, levels of total uranium and of total alpha activity at Thatcham are within a factor of two of the levels at the Hannington control site indicating there may be little difference in radionuclide concentrations between the two locations. The measured values can also be compared with NRPB's Generalised Derived Limits (see Glossary). A GDL is the concentration of a particular radionuclide in a specified environmental medium that would give rise to an annual effective dose of 1 mSv to an individual on the basis of cautious assumptions. In the case of the measurements made at Thatcham and Newbury, for all media, air, soil and vegetation, the reported levels are a small fraction of the appropriate GDL. Values for uranium are presented in terms of total activity and are consistent with levels reported in the NRPB study. Overall, the results from the monitoring programmes are consistent with those from specific studies conducted around Greenham Common. For weapons test fallout, there is variability in the amounts of activity deposited across the UK. This is because the level of deposition is dependent on annual rainfall. In undisturbed soil, activity concentrations in areas of low rainfall, such as Berkshire and Hampshire, are about three times lower than in high rainfall areas such as northwest Wales (Cawse and Horrill, 1986).

3.16 The absence of any evidence for elevated uranium-235 levels at Greenham Common in either the NRPB study or the Southampton University/SURRC study cannot be taken as showing that the original 1961 findings were incorrect. The levels of excess uranium-235 in evergreen leaves reported in the 1961 AWRE study are all very low. Within a few years, activity on leaves would be expected to transfer to the underlying medium, usually soil, which will also contain activity from direct deposition from the air, as well as indigenous natural uranium at concentrations much higher than those observed in vegetation. The Southampton/SURRC team concludes that the addition of such small levels of uranium-235 would not produce any measurable change to the isotopic ratio of uranium in the soil samples taken for its study. Similarly, the 1986 AWRE report suggests that the absence of evidence for elevated uranium-235 levels in its study could be due to the physical and chemical dispersal of material that was deposited before 1961. What may be concluded, however, from the negative findings in materials such as vegetation and leaf mould in the later studies is that deposition of detectable quantities of uranium-235 in the Greenham Common area has not occurred on a continuing basis.

## **Radiological implications**

3.17 COMARE has considered the possible origin of the small excess of uranium-235 around the Greenham Common Airbase reported in 1961. There are two broad possibilities: (i) the levels are caused by an accident involving a nuclear weapon at the Greenham Common Airbase (the hypothesis presented in the 1961 AWRE report), and (ii) they arise from a different local source and, in this respect, the most likely one is discharges to atmosphere from AWRE Aldermaston. The first possibility is considered in Chapter 2 where COMARE concludes that the factual evidence does not support the hypothesis that such an accident occurred. Therefore, COMARE considered whether discharges of uranium-235 to atmosphere from AWRE Aldermaston could have been responsible for the observed levels. The second Exercise Overture interim report provides details of discharges to atmosphere of highly enriched uranium (93.2% uranium-235 by mass) from AWRE Aldermaston. These discharges are reported to have started in 1956 and increased up to 1959 - the last year for which discharge data are given in the Exercise Overture report. The 1961 AWRE report considered the possibility that these discharges were responsible for the elevated uranium-235 levels around Greenham Common. This hypothesis was, however, dismissed in the 1961 AWRE report on

the grounds that the measured levels were about “one hundred times more than could be accounted for by the discharges from AWRE Aldermaston”. The levels arising from AWRE discharges were estimated using empirical models that appear to have been derived largely from measurements made close to AWRE Aldermaston. Furthermore, in Exercise Overture Interim Report 4, the distribution of deposited material was estimated using an atmospheric dispersion and deposition model together with the AWRE Aldermaston discharge data. The authors comment that the general pattern predicted by the model follows the observations but individual experimental values are found to be five to ten times higher than predictions for distances beyond 600 m from AWRE. It is very difficult, given the preliminary nature of much of the work presented in the Exercise Overture reports and in the 1961 AWRE report, to establish the precise details of the work undertaken in Exercise Overture. Nevertheless, it does appear that the authors of the reports were experiencing difficulties in reconciling theoretical predictions with measurements at many locations.

3.18 COMARE has considered the hypothesis that discharges from AWRE could be responsible for the excess levels of uranium-235 found in 1961. We requested NRPB to comment on the atmospheric dispersion model used in 1961 and to calculate, using current atmospheric dispersion models, the levels of uranium-235 that would be expected to be deposited around Greenham Common from AWRE discharges. The Committee also requested, from MoD, data on annual discharges to atmosphere of uranium-235 from AWRE Aldermaston. MoD provided data on discharges of highly enriched uranium (HEU).

3.19 NRPB has informed COMARE that the atmospheric dispersion model used in the 1961 AWRE report was probably the only straightforward one available at that time. Furthermore, as far as could be ascertained, it had been applied correctly. NRPB used its own atmospheric dispersion modelling system to estimate levels of uranium-235 deposited from AWRE Aldermaston discharges. The discharge data provided by MoD were used. In order to convert the activity of becquerels of HEU to grammes of uranium-235, NRPB used an effective specific activity suggested by MoD, of 3 MBq per gramme. Table 3.1 shows that discharges of HEU and, by inference, uranium-235, reached a maximum in the year 1960 which is possibly around the time that the Exercise Overture samples were being collected for analysis. Therefore, NRPB undertook two sets of calculations, one for discharges up until the end of 1959 and one for discharges up to the end of 1960. The corresponding best estimates of the levels of uranium-235 deposited on evergreen leaves at Greenham Common were  $4.7 \times 10^{-10} \text{ g m}^{-2}$  and  $9.3 \times 10^{-10} \text{ g m}^{-2}$ , respectively. Comparison with the uranium-235 levels reported in the 1961 AWRE report (Table 3.2) shows that the majority of measured values range from a few times lower to a few times higher than the value estimated by NRPB models when discharge data for years up until the end of 1960 are used in the calculations. However, the estimated value using discharges up until the end of 1959 is at the lower end of the range of measured values. One particular problem in undertaking this work was that the excess uranium-235 levels reported in Exercise Overture were observed on measurements on evergreen leaves and there are considerable uncertainties surrounding modelling the deposition of particulate material to leaves. Given these uncertainties, NRPB concludes that the possibility that the levels of excess uranium-235 found in 1961 were the result of discharges from AWRE Aldermaston cannot be excluded (see para 3.6). COMARE considers that discharges from AWRE Aldermaston or other nuclear installations in the West Berkshire area are the most likely cause of any excess uranium-235 found near Greenham Common in 1961. Two main reasons would appear to account for the rejection of this hypothesis by Cripps and Stimson. First, their estimate of expected deposition of uranium-235 on leaves is highly questionable. They appear to have ignored their atmospheric dispersion model which, although primitive, did not yield

**Table 3.1 Discharges of Highly Enriched Uranium (HEU) to atmosphere from AWRE Aldermaston**

| Year    | Activity (MBq) | Year | Activity (MBq) | Year | Activity (MBq) |
|---------|----------------|------|----------------|------|----------------|
| 1951-55 | 0              | 1969 | 4              | 1983 | 1.7            |
| 1956    | 1.5            | 1970 | 3              | 1984 | 1.9            |
| 1957    | 4              | 1971 | 4              | 1985 | 0.5            |
| 1958    | 11             | 1972 | 1.5            | 1986 | 0.4            |
| 1959    | 38             | 1973 | 1.5            | 1987 | 0.4            |
| 1960    | 53             | 1974 | 1.5            | 1988 | 0.3            |
| 1961    | 39             | 1975 | 1.2            | 1989 | 0.06           |
| 1962    | 35             | 1976 | 0.8            | 1990 | 0.06           |
| 1963    | 7              | 1977 | 1.6            | 1991 | 0.05           |
| 1964    | 13             | 1978 | 1.4            | 1992 | 0.03           |
| 1965    | 24             | 1979 | 3              | 1993 | 0.02           |
| 1966    | 12             | 1980 | 3              | 1994 | 0.01           |
| 1967    | 13             | 1981 | 3              | 1995 | 0.01           |
| 1968    | 13             | 1982 | 2              | 1996 | 0.01           |

Data provided by MoD.

**Table 3.2 Deposits of uranium-235 on evergreen leaves from the Greenham Common area reported in 1961**

| Range of measured values for deposition of $^{235}\text{U}$ ( $\text{g m}^{-2}$ ) | Number of measurements |
|---|------------------------|
| $< 10^{-9}$   | 3                      |
| $10^{-9}$ to $5 \cdot 10^{-9}$  | 15                     |
| $5 \cdot 10^{-9}$ to $10^{-8}$  | 5                      |
| $> 10^{-8}$   | 3                      |

The measured values range from  $1.5 \cdot 10^{-10}$  to  $9 \cdot 10^{-8}$   $\text{g m}^{-2}$ .

results greatly different from those produced by the NRPB model, and relied instead on an empirical model, the validity of which, at the distance it was applied, may be questionable. Second, they were selective in the data they considered, choosing not to refer to data showing excess uranium-235 levels at locations in the opposite direction of Greenham Common from Aldermaston.

3.20 COMARE has considered the radiological implications of the excess uranium-235 levels reported in 1961. The measurement data provided by Exercise Overture are not in an ideal form for dose assessment purposes. The data relating to leaf mould are most relevant because this material is likely to have acted as an integrator for deposited activity over a period of a few years. From the data provided in the 1961 AWRE report, the activity concentration of uranium-235 in samples of leaf mould were estimated by NRPB as 0.1 to 0.3  $\text{Bq kg}^{-1}$ . This level can be placed in context by comparison with NRPB's GDLs. In this case, the most appropriate one would be that for well-mixed soil. NRPB is currently revising its system of GDLs to take account of recent research and recommendations, and

GDLs for isotopes of uranium have not yet been published. However, COMARE has been provided with the likely value for uranium-235 in well-mixed soil, 7000 Bq kg<sup>-1</sup>. The activity concentration in leaf mould is around one-thousandth of this figure. From this analysis, COMARE concludes that the radiological implications of the levels of uranium-235 reported in the 1961 AWRE report are negligible.

3.21 Furthermore, in overall terms, the environmental monitoring data indicate that levels of man-made and natural radionuclides in the Newbury area are low when compared with levels in many other areas of the UK.

3.22 COMARE's Third Report considered, *inter alia*, the radiological implications of discharges from AWRE Aldermaston in terms of radiation doses to individuals in the local population (COMARE, 1989). Those doses were estimated from discharge data provided by MoD. COMARE has reviewed these data in the light of the information on discharge levels given in the Exercise Overture reports. The dose calculations described in COMARE's Third Report used discharges for total uranium including uranium-238 as well as uranium-235 and other isotopes. The discharge data used are compared in Table 3.3 with the discharge data for total uranium given in the Exercise Overture reports for the appropriate years. It can be seen that, with the exception of one year, the discharge data used in COMARE's Third Report are higher. Furthermore, MoD has assured the Committee that the discharge data for HEU that it has now provided (see Table 3.1) are not inconsistent with the discharge data for total uranium that it provided for the Third Report. Thus, COMARE concludes the new information on discharges of uranium from AWRE Aldermaston is consistent with the discharge data used in the Committee's Third Report.

3.23 COMARE also considered the implications for its Third Report of the new monitoring data provided by Exercise Overture. A particular issue is whether these data indicate that discharges from AWRE had been underestimated. A comparison of levels of uranium-235 at Greenham Common estimated from the discharge data provided by MoD with the measured values reported in the Exercise Overture reports shows that predicted values are within the range of measurements (see para 3.19). However, as some measured values are higher than those estimated from the discharges, the possibility that uranium discharges have been underestimated cannot be excluded, although from the available information, any such underestimate is unlikely to be more than about ten fold.

**Table 3.3 Comparison of discharge data for total uranium (MBq)**

| Year | COMARE's Third Report | Exercise Overture |
|------|-----------------------|-------------------|
| 1952 | 0                     | -                 |
| 1953 | 0.15                  | 0.14              |
| 1954 | 4                     | 3.8               |
| 1955 | 8                     | 89                |
| 1956 | 150                   | 148               |
| 1957 | 150                   | 124               |
| 1958 | 200                   | 197               |
| 1959 | 200                   | 177               |

3.24 NRPB has informed COMARE that doses from discharges of uranium from AWRE Aldermaston are very small. For example, a one year old child at a distance of 5 km from AWRE Aldermaston is calculated to receive an annual dose of  $1.5 \cdot 10^{-4} \mu\text{Sv}$  from atmospheric discharges of uranium in 1955; the corresponding annual dose for discharges in 1960 is about  $3 \cdot 10^{-4} \mu\text{Sv}$  (Dionian et al, 1987). These doses are millions of times less than the average annual dose from natural background radiation. Therefore, uranium releases would have had to be substantially underestimated before the implications would become radiologically significant. It is worth noting that AWRE Aldermaston commenced discharges of tritium to atmosphere in 1959; these discharges contribute about 90% of the total annual dose in 1960 from discharges to atmosphere from AWRE Aldermaston to individuals 5 km away.

3.25 The possibility of an underestimate of discharge levels was considered in COMARE's Third Report which noted that in 1978 Sir Edward Pochin carried out an investigation into site practices in the context of radiation protection. During the course of his enquiry it was discovered that five of the stack discharge monitors were incorrectly mounted, resulting in a small underestimation of releases. However, the Pochin report concluded that this would not have resulted in an appreciable underestimate of the total discharge data, since the affected stacks contributed very little to the total airborne discharges from the site.

## Discussion

3.26 Having considered all of the monitoring data available to us we have concluded that, although there is no reason to doubt the finding of excess uranium-235 levels on leaves at Greenham Common reported in the 1961 Cripps and Stimson report, the excess levels were extremely small and of no radiological significance; the risk they pose to the public is trivial. Similarly, having reviewed both the information concerning the accident in 1958 and the early monitoring data, we can find no evidence to support the hypothesis that the excess levels of uranium-235 are the result of an accident involving nuclear weapons at the Greenham Common Airbase.

3.27 We have also examined the calculations carried out for us by NRPB and we have concluded that the excess uranium-235 reported by Cripps and Stimson is most likely to have originated from the atmospheric discharges from AWRE Aldermaston in the 1950s and the year of 1960 itself.

3.28 We feel that it is also important to point out that the information available to us demonstrates that the levels of both man-made and natural radionuclides in the Greenham Common area are low when compared with levels in many other areas of the UK. This is important when we come on later to consider whether there could be any link between these levels of radiation and the incidence of malignant disease in the same area.

## CHAPTER 4

### EPIDEMIOLOGY

#### Uranium-235 and childhood leukaemia around Greenham Common Airbase

4.1 In 1989 COMARE confirmed that there was a higher incidence of childhood cancer in West Berkshire, which was not explained by discharges from AWRE Aldermaston and ROF Burghfield. (Note: Throughout this report we adopt the usual convention that ‘childhood cancer’ refers to cases diagnosed at ages 0-14 years, ie. in the first fifteen years of life.) This followed concerns raised by a local haematologist, Dr Carol Barton. More recently, Mr and Mrs Capewell who are residents of Newbury, have carried out local surveys to try to identify people in the Newbury area diagnosed as having cancer. For this section of its report COMARE has been able to draw upon work, either directly related to the reported excess of leukaemia in the Newbury area, or directly commissioned because of this reported excess.

4.2 The first study was made available to us as a pre-publication copy of a paper entitled “Uranium-235 and childhood leukaemia around Greenham Common airfield” by Bithell and Draper. As explained in para 1.1 of this report the immediate cause of the concern about possible increases in cancer and leukaemia in the vicinity of Greenham Common and Newbury was the report by Cripps and Stimson of an increase in levels of uranium-235 in the vicinity of Greenham Common. Bithell and Draper made available to COMARE a preprint of a paper which had been written with two objectives: first to re-analyse the data presented by Cripps and Stimson in order to determine whether the pattern of deposition that they had suggested could be derived from their data using modern computer algorithms for fitting contours, and second to analyse data on the incidence of childhood leukaemia in the area to see whether it was consistent with the hypothesis of an increased rate occurring in the vicinity of the maximum measured level of uranium and whether leukaemia incidence was related to the distance from the location of this maximum level.

4.3 Bithell and Draper first reviewed the basic data in the report by Cripps and Stimson and concluded that there were a number of errors in the presentation of the data and the arithmetical calculations; revised tables of the basic data are presented in their paper and reproduced here as Table A4.1 in the Annex. On the basis of these data it was concluded first that the contour map prepared by Cripps and Stimson could not be supported by their data, and second that, on the assumption that the radiological effect of uranium-235 is similar to that of natural uranium, and neglecting the decay products of the excess uranium-235, the radiological impact of the increase in uranium levels would be insignificant.

4.4 The second part of the paper is concerned with the pattern of childhood leukaemia around Greenham Common. It is hypothesised that if there had indeed been an increase in radiation levels corresponding to the pattern proposed by Cripps and Stimson this might be reflected in the patterns of variation in incidence levels of childhood leukaemia in the vicinity of the airbase. This analysis was based on childhood leukaemia data for the 22-year period 1966-87, a period obviously relevant to the hypothesis being considered and for which appropriate data were readily available. Cases within a 6 km radius of the site of the 1958 fire (assumed

to be located at grid-reference SU 503 643) were allocated to their electoral ward at the time of diagnosis.

4.5 The area studied was a circle of radius 6 km chosen so as to include Newbury and virtually all of the contiguous built-up area. The method of statistical analysis was based on a comparison of leukaemia rates in wards at successive distances from the supposed source as compared with the numbers expected if national rates applied. Because of the known relationship between childhood leukaemia incidence and socio-economic status, these expected numbers were adjusted to allow for this relationship, using census data. Allowance was also made for the known excess of cases in West Berkshire as a whole.

4.6 In the eleven wards within the 6 km circle there was no evidence of a general increase: there were 15 cases of childhood leukaemia compared with 13.4 expected. Statistical tests were also carried out to determine whether these cases tended to occur closer to the airbase than would be expected by chance and whether they tended to be in line with the runway. Again there was no evidence of any such relationship.

4.7 The authors concluded "that although the excess uranium found has a non-random distribution it does not support the pattern depicted by the contours [as drawn by Cripps and Stimson] and bears no relation to the incidence of childhood leukaemia for the period we examined. In any case the increase in level of environmental radiation as a result of the putative release must be very small".

4.8 The second study was commissioned in July 1996 by the Berkshire Health Authority in response to local concerns about increased levels of leukaemia and other cancers in the Newbury District Council area as discussed above. The report was compiled by the Newbury Cancer Working Group (NCWG, 1997), an ad hoc group convened by the Berkshire Health Authority, and is entitled "Incidence and mortality from leukaemia and other cancers in Newbury District Council area". This report uses both cancer mortality and incidence data in its analyses.

4.9 The incidence analyses cover the period 1971-94. Data are presented for all cancers (excluding non-melanoma skin cancer) and also separately for leukaemia, lymphoma and brain and central nervous system (CNS) tumours. The areas studied are Newbury County District, West Berkshire, which includes Newbury together with the County Districts of Reading and Wokingham, and the 'Oxford Region excluding Berkshire'; the latter consists of Buckinghamshire, Northamptonshire and Oxfordshire. The incidence rates in these areas have been compared with rates for England and Wales. Comparisons between data from different cancer registries or between data from one registry and the national data will be affected by any variations in registry completeness and accuracy. England and Wales cancer registration data used here are known to be under-recorded for the years 1983-88 mainly due to problems, now corrected, with the transfer of data from the Thames Region, which contributes nearly one-quarter of all cancer registrations in England and Wales. For childhood leukaemia these problems are less important as the majority of these cases are independently notified to the Childhood Cancer Research Group, in Oxford.

4.10 Population data were based on 1971, 1981 and 1991 census data and inter-census estimates. Ward and county district boundaries relate to 1981. In most of the analyses 1981 census data were used.

4.11 In order to ensure the completeness and accuracy of the local leukaemia data the following procedures were carried out.

## **Newbury Cancer Working Group study**

## **DATABASES AND METHODS USED IN THE ANALYSES**

### **Incidence data**

### **Population data**

### **West Berkshire and Oxford Region data**



A manual check of haematology records at the Royal Berkshire Hospital.

A comparison of patient administration data from the Royal Berkshire Hospital and the Oxford Cancer Registry data.

A check of records held by the neighbouring Wessex Cancer Registry to ensure that cases who are Berkshire residents but who were treated outside the district were properly registered.

Checks were made on the data from community sources collected by Mr and Mrs Capewell.

Comparisons were made between data held by the Oxford Cancer Registry and the Childhood Cancer Research Group for childhood cancer cases 0-14 years of age.

A comparison with data held on the Oxford Regional Leukaemia Register was made (both adult and childhood leukaemia).

## **Newbury County District**

4.12 Much of the report relates to Newbury County District, the geographical area stretching from Hungerford in the west to Tilehurst in the east. Some analyses have also been undertaken for local electoral wards. Such analyses are difficult because boundaries and populations have changed over time, also the number of cancer cases is small. Variations in small numbers of cases can result in large variations in incidence or mortality rates which may be extremely difficult to interpret.

## **Ward level analysis**

4.13 The ward analysis also covers the period 1971-94. During this time period the ward boundaries within Newbury town were altered and thus the analysis is based on ward boundaries as they existed at the time of the 1981 census. These boundaries are close to the 1991 boundaries for St John's and Craven wards (the area identified by Mr and Mrs Capewell as having an apparent excess of cases of leukaemia) but are not identical. The authors of the report note the following:

94% of St John's population in 1991 was in ward No 2 in 1981.

78% of Craven's population in 1991 was in ward No 3 in 1981 and 22% in ward No 2.

100% of Falkland's population in 1991 was in ward No 3 in 1981.

The analysis was performed for leukaemia incidence, and also for all cancers combined, in ward No 2 and ward No 3.

## **Statistical analyses**

4.14 Tests of statistical significance were performed using the Poisson distribution where the expected number of cases was 40 or less and the normal approximation to the Poisson distribution where the expected number was greater than 40. All tests of significance were one sided as the authors were only looking to detect areas where rates were higher than expected.

## **Cancer mortality analyses**

4.15 The authors included an analysis of the number of deaths from cancer which occurred in the area in the years 1980-95. In this they compared deaths observed in the area with those expected from national rates. The use of childhood cancer mortality data for such analyses, however, is liable to be subject to several problems of interpretation, some of which can be quite large. Nowadays mortality from childhood cancer, particularly childhood leukaemia, is considerably lower than 100%. Death from cancer is also dependent on many variable factors such as the



period of time from disease onset to diagnosis, the start of treatment and the consequent cure rate. Variations between quite small areas are, therefore, very likely. We were also made aware of a study by Dr Chris Busby and Molly Scott Cato and subsequent correspondence, which has since been published in the *British Medical Journal* (1997). We are grateful for having this study brought to our attention. This study also uses cancer mortality data and is likely to be subject to the problems of interpretation we have already described. For the reasons given above we have, therefore, chosen to use only the cancer incidence data analyses in our considerations. We believe this will allow us to reach conclusions which are more directly related to the underlying incidence of cancer.

## **Results of incidence analyses**

### *District level analysis*

4.16 The data produced by this analysis are presented in tabular form in the Annex to this chapter, for those who wish to examine the detail. The data are presented for all cancer types, leukaemia, brain and CNS cancers and lymphomas, for Newbury County District, West Berkshire and the Oxford Region (excluding Berkshire). The data are subdivided into the age groups 0-24, 25-64, and 65+ years; the 0-24 age group is then subdivided into the 0-4, 5-9, 10-14 and 15-24.

4.17 The NCWG study concluded that in general, cancer incidence rates in Newbury and West Berkshire were higher than the national rates but in line with rates in the surrounding area (ie. in the counties of Buckinghamshire, Northamptonshire and Oxfordshire combined). The higher rates in the Oxford Region may partly reflect the social composition of the area. This is because childhood cancer, particularly leukaemia, is more common in areas of higher social class and would, therefore, be expected to be more common in the areas studied than in some other parts of Great Britain (Draper, 1991). The higher rates may also reflect more complete cancer registration in the area covered by the Oxford Cancer Registry, particularly in view of the detailed validation carried out as part of the present study.

4.18 In West Berkshire and to a less marked extent in the Newbury County District, cancer incidence rates in the 0-4 age group were higher than both national and regional rates for all the cancer groups analysed.

### *Ward level analysis*

4.19 The data for the ward level analysis are presented in tabular form for the same age groups and areas as for the District level analysis. Again the detailed data are contained in tables in the Annex.

4.20 Ward 2, in south Newbury, is an area equating to St John's ward plus one-fifth of the neighbouring Craven ward in 1991. In this ward there was a significant excess of leukaemia in the 0-24 age group as compared with the national rate (Table A4.10). The authors note that this may be a chance finding. There was no significant increase in cancers in the 0-24 age group in any of the other wards in or around Newbury town.

## **Childhood leukaemia and other cancers in West Berkshire in relation to rates in other areas of Britain**

4.21 It is known that there are geographical variations in incidence rate for childhood cancers, and in order to put the West Berkshire data into context we present here the rates for the three County Districts comprising West Berkshire, ie. Newbury, Reading and Wokingham, in relation to rates for other County Districts in England and Wales and Districts and Island Areas in Scotland. The rates given are for the 25-year period 1969-93.

4.22 For the 459 County Districts in Great Britain we ranked incidence rates separately for leukaemias and other cancers at ages 0-4 years and 0-14 years. In Tables 4.1-4.4 we show the rates for the three West Berkshire County Districts and

**Table 4.1 Childhood leukaemia 1969-93 at ages 0-4 in County Districts of West Berkshire compared with national rates and the 5th and 95th percentiles**

| Area                      | Rank | Number of cases | Annual age-standardised rate/million |
|---------------------------|------|-----------------|--------------------------------------|
| England, Wales & Scotland |      | 5740            | 61.8                                 |
| Newbury                   | 140  | 17              | 74.4                                 |
| Reading                   | 43   | 23              | 95.5                                 |
| Wokingham                 | 65   | 20              | 88.1                                 |
| 5th percentile            | -    | -               | 25.5                                 |
| 95th percentile           | -    | -               | 104.1                                |

**Table 4.2 Childhood cancer other than leukaemia 1969-93 at ages 0-4 in County Districts of West Berkshire compared with national rates and the 5th and 95th percentiles**

| Area                      | Rank | Number of cases | Annual age-standardised rate/million |
|---------------------------|------|-----------------|--------------------------------------|
| England, Wales & Scotland |      |                 | 9197                                 |
| Newbury                   | 91   | 28              | 122.5                                |
| Reading                   | 69   | 31              | 128.8                                |
| Wokingham                 | 59   | 30              | 132.1                                |
| 5th percentile            | -    | -               | 59.4                                 |
| 95th percentile           | -    | -               | 151.2                                |

the rates for the whole of England, Scotland and Wales. Also shown are the values of the 5th and 95th percentiles of the rates, ie. those such that 5 per cent of the rates are respectively below or above them. For these tables, rates for County Districts have been ranked from 1 to 459, the County District with the highest incidence rate being given the rank 1. The data in these tables show that the West Berkshire Districts are well above average though none of them is in the top 5 per cent. The results are in line with previous findings that rates for West Berkshire (and indeed Berkshire generally, Buckinghamshire and Oxfordshire) are high.

## Discussion

4.23 The data on the incidence of childhood cancer and leukaemia in the area under study show that there is a significant increase in leukaemia in the age group 0-4 years in West Berkshire as compared to national rates. This observation confirms the similar finding described and discussed in our Third Report. It is known that childhood cancers, particularly leukaemia, show incidence rates that are higher in areas of higher social class. Given the social class structure in the West Berkshire area such an increase might be predicted given this known association. Thus we cannot rule out the fact that, given the demographic structure of the West Berkshire area, some unknown risk factors associated with known differences in rates between social classes may have a part to play in explaining this excess.

**Table 4.3 Childhood leukaemia 1969-93 at ages 0-14 in County Districts of West Berkshire compared with national rates and the 5th and 95th percentiles**

| Area                      | Rank | Number of cases | Annual age-standardised rate/million |
|---------------------------|------|-----------------|--------------------------------------|
| England, Wales & Scotland |      | 10903           | 38.3                                 |
| Newbury                   | 69   | 34              | 49.2                                 |
| Reading                   | 162  | 30              | 41.8                                 |
| Wokingham                 | 47   | 37              | 52.7                                 |
| 5th percentile            | -    | -               | 21.3                                 |
| 95th percentile           | -    | -               | 58.3                                 |

**Table 4.4 Childhood cancer other than leukaemia 1969-93 at ages 0-14 in County Districts of West Berkshire compared with national rates and the 5th and 95th percentiles**

| Area                      | Rank | Number of cases | Annual age-standardised rate/million |
|---------------------------|------|-----------------|--------------------------------------|
| England, Wales & Scotland |      | 21896           | 76.3                                 |
| Newbury                   | 51   | 65              | 94.1                                 |
| Reading                   | 133  | 60              | 84.0                                 |
| Wokingham                 | 79   | 64              | 90.9                                 |
| 5th percentile            | -    | -               | 57.4                                 |
| 95th percentile           | -    | -               | 101.6                                |

4.24 There are other factors which might explain this observed excess. An important factor may be the local efficiency of cancer registration. Thus we note that although this observed increase in childhood leukaemia may be real, it is also possible that it may be attributable, at least in part, to more complete registration of these childhood diseases in this area, as compared to that in other parts of the country which contribute to the national rate.

4.25 In ward 2 in Newbury there was a significant excess of leukaemia in people aged 0-24 years. There were no significant increases in cancers in any other wards in or around Newbury. We conclude that the excess in ward 2 is likely to be a chance finding commonly observed in studies involving such small areas and small numbers of cases.

4.26 We also note that the rates of childhood cancer and leukaemia in West Berkshire, though not in the highest 5 per cent, are well above the average for England and Wales. Once again this may be because of the demographic structure of the area. We hope to be able to address this finding in greater depth when the geographical studies recommended in our Third Report are complete.

**TABLE A4.1 Uranium data from the 1961 Aldermaston report: original values calculated for excess uranium-235 with revised values and those selected for the calculations by Bithell and Draper. The revised values are also used for calculating the excess as a percentage of natural uranium**

| Sampling point (1) | Grid reference |           | <sup>238</sup> U<br>µg m <sup>-2</sup><br>(4) | <sup>235</sup> U<br>ng m <sup>-2</sup><br>(5) | Enrichment factor (6) | Excess <sup>235</sup> U (ng m <sup>-2</sup> ) |             |              | Excess <sup>235</sup> U as percentage of natural uranium: |   |
|--------------------|----------------|-----------|---|---|-----------------------|---|-------------|--------------|---|---|
|                    | East (2)       | North (3) |   |   |                       | Original (7)                                  | Revised (8) | Analysed (9) | of <sup>235</sup> U (10)                                  | of <sup>235</sup> U + <sup>238</sup> U (11) |
| 101a               | 434            | 617       | 1.66  | 17.6  | 1.47                  | 5.2   | 5.60        | 4.76         | 46.6  | 0.34  |
| 101b               | 434            | 617       | 1.76  | 16.7  | 1.31                  | 3.5   | 3.92        |              | 30.7  | 0.22  |
| 156                | 550            | 640       | 2.06  | 24.4  | 1.63                  | 9.1   | 9.48        | 9.48         | 63.5  | 0.46  |
| 157                | 524            | 649       | 2.01  | 89.9  | 6.17                  | 88.5  | 75.4        | 75.4         | 517.3   | 3.72  |
| 158                | 482            | 651       | 1.23  | 12.3  | 1.37                  | 3.2   | 3.33        | 3.33         | 37.2  | 0.27  |
| 159                | 451            | 630       | 1.14  | 12.4  | 1.49                  | 4.1   | 4.10        | 4.10         | 49.5  | 0.36  |
| 162                | 506            | 643       | 2.07  | 19.8  | 1.31                  | 4.3   | 4.73        | 4.73         | 31.5  | 0.22  |
| 165                | 490            | 643       | ----  | ----  | ----                  | 6.9   | 6.9         | 6.9          | ----  | ----  |
| 166                | 390            | 643       | 1.96  | 15.9  | 1.12                  | 1.4   | 1.72        | 1.72         | 12.1  | 0.09  |
| 167                | 567            | 629       | 4.36  | 40.4  | 1.28                  | 9.2   | 8.78        | 5.69         | 27.8  | 0.20  |
| 187                | 567            | 629       | 1.94  | 16.7  | 1.18                  | 2.5   | 2.60        |              | 18.5  | 0.13  |
| 186                | 567            | 629       | 0.322   | 2.84  | 1.22                  | 0.5   | 0.503       | ----         | 21.6  | 0.16  |
| 169                | 500            | 490       | 2.50  | 24.1  | 1.33                  | 6.2   | 6.02        | 6.02         | 33.2  | 0.24  |

**Table A4.1 continued**

| Sampling point (1) | Grid reference |           | <sup>238</sup> U<br>µg m <sup>-2</sup><br>(4) | <sup>235</sup> U<br>ng m <sup>-2</sup><br>(5) | Enrichment factor (6) | Excess <sup>235</sup> U (ng m <sup>-2</sup> ) |             |              | Excess <sup>235</sup> U as percentage of natural uranium: |   |
|--------------------|----------------|-----------|---|---|-----------------------|---|-------------|--------------|---|---|
|                    | East (2)       | North (3) |   |   |                       | Original (7)                                  | Revised (8) | Analysed (9) | of <sup>235</sup> U (10)                                  | of <sup>235</sup> U + <sup>238</sup> U (11) |
| 170                | 492            | 567       | 1.88  | 15.3  | 1.12                  | 1.7   | 1.69        | 1.69         | 12.3  | 0.09  |
| 171                | 500            | 614       | 1.81  | 15.5  | 1.19                  | 1.2   | 2.43        | 2.43         | 18.5  | 0.13  |
| 172                | 500            | 639       | 2.23  | 18.0  | 1.11                  | 1.8   | 1.80        | 1.80         | 11.1  | 0.08  |
| 173                | 525            | 643       | 5.80  | 56.7  | 1.35                  | 14.4  | 14.6        | 14.6         | 34.7  | 0.25  |
| 174                | 485            | 655       | 3.15  | 25.1  | 1.10                  | 2.3   | 2.22        | 2.22         | 9.7   | 0.07  |
| 176                | 508            | 700       | 1.97  | 16.3  | 1.14                  | 1.7   | 1.99        | 1.84         | 14.0  | 0.10  |
| 177                | 508            | 700       | 3.00  | 23.4  | 1.08                  | 1.7   | 1.68        | 1.68         | 7.7   | 0.06  |
| 178                | 500            | 727       | 2.74  | 20.2  | 1.02                  | 0.3   | 0.341       | 0.341        | 1.7   | 0.01  |
| 181a               | 536            | 629       | 6.05  | 42.3  | 0.96                  | -1.8  | -1.63       | ----         | ----  | ----  |
| 181b               | 536            | 629       | 6.77  | 49.4  | 1.01                  | 0.15  | 0.337       | 0.337        | 0.7   | 0.00  |
| 182                | 508            | 633       | 3.65  | 30.0  | 1.13                  | 3.2   | 3.56        | 3.56         | 13.5  | 0.10  |
| 183                | 468            | 627       | 1.55  | 43.6  | 3.88                  | 31.3  | 32.4        | 32.4         | 288.4   | 2.08  |
| 184                | 408            | 599       | 2.87  | 22.1  | 1.06                  | 1.0   | 1.31        | 1.31         | 6.3   | 0.05  |
| 185                | 433            | 655       | 1.34  | 18.1  | 1.87                  | 8.5   | 8.44        | 8.44         | 87.2  | 0.63  |

Details of the differences between the original data of Cripps and Stimson and the modifications above are available from Bithell and Draper. The grid references are relative to the point (4000,1000); the units are of 100 m.

**Table A4.2 Cancer type: all cancers (ICD9 140-208 excl 173)  
Time period: 1971-94**

| Age (years)  | Newbury DC  |                |                 | West Berkshire |                 |                 | Oxford Region (excl Berkshire) |                  |                 |
|--------------|-------------|----------------|-----------------|----------------|-----------------|-----------------|--------------------------------|------------------|-----------------|
|              | Observed    | Expected       | Incidence ratio | Observed       | Expected        | Incidence ratio | Observed                       | Expected         | Incidence ratio |
| 0-24         | 187         | 154.06         | 1.21**          | 645            | 521.29          | 1.24***         | 2255                           | 1945.49          | 1.16***         |
| 25-64        | 3385        | 3703.78        | 0.91            | 12426          | 12446.07        | 1.00            | 49862                          | 47014.87         | 1.06***         |
| 65+          | 5155        | 5452.06        | 0.95            | 19442          | 18298.07        | 1.06***         | 78818                          | 73759.65         | 1.07***         |
| <b>Total</b> | <b>8727</b> | <b>9309.90</b> | <b>0.94</b>     | <b>32513</b>   | <b>31265.43</b> | <b>1.04***</b>  | <b>130935</b>                  | <b>122720.01</b> | <b>1.07***</b>  |

\* P<0.05, \*\* P<0.01, \*\*\* P<0.001

Newbury DC data for 'All cancers' may be under-recorded before 1986 as postcoding only complete for leukaemias, lymphomas and brain and CNS tumours.

**Table A4.3 Cancer type: all cancers (ICD9 140-208 excl 173)  
Time period: 1971-94**

| Age (years)       | Newbury DC |               |                 | West Berkshire |               |                 | Oxford Region (excl Berkshire) |                |                 |
|-------------------|------------|---------------|-----------------|----------------|---------------|-----------------|--------------------------------|----------------|-----------------|
|                   | Observed   | Expected      | Incidence ratio | Observed       | Expected      | Incidence ratio | Observed                       | Expected       | Incidence ratio |
| 0-4               | 47         | 33.47         | 1.40*           | 173            | 107.92        | 1.60***         | 465                            | 416.72         | 1.12**          |
| 5-9               | 24         | 19.72         | 1.22            | 72             | 64.43         | 1.12            | 275                            | 246.06         | 1.12*           |
| 10-14             | 27         | 19.76         | 1.37            | 75             | 65.14         | 1.15            | 312                            | 249.37         | 1.25***         |
| 15-24             | 89         | 81.11         | 1.10            | 325            | 283.80        | 1.15**          | 1203                           | 1033.34        | 1.16***         |
| <b>Total 0-24</b> | <b>187</b> | <b>154.06</b> | <b>1.21**</b>   | <b>645</b>     | <b>521.29</b> | <b>1.24***</b>  | <b>2255</b>                    | <b>1945.49</b> | <b>1.16***</b>  |

\* P<0.05, \*\* P<0.01, \*\*\* P<0.001

Newbury DC data for 'All cancers' may be under-recorded before 1986 as postcoding only complete for leukaemias, lymphomas and brain and CNS tumours.

**Table A4.4 Cancer type: leukaemia (ICD9 204-208)  
Time period: 1971-94**

| Age (years)  | Newbury DC |               |                 | West Berkshire |               |                 | Oxford Region (excl Berkshire) |                |                 |
|--------------|------------|---------------|-----------------|----------------|---------------|-----------------|--------------------------------|----------------|-----------------|
|              | Observed   | Expected      | Incidence ratio | Observed       | Expected      | Incidence ratio | Observed                       | Expected       | Incidence ratio |
| 0-24         | 41         | 33.71         | 1.22            | 145            | 111.41        | 1.30***         | 512                            | 420.38         | 1.22***         |
| 25-64        | 78         | 70.41         | 1.11            | 242            | 237.13        | 1.02            | 1014                           | 891.78         | 1.14***         |
| 65+          | 118        | 123.81        | 0.95            | 491            | 415.33        | 1.18***         | 1943                           | 1674.05        | 1.16***         |
| <b>Total</b> | <b>237</b> | <b>227.93</b> | <b>1.04</b>     | <b>878</b>     | <b>763.86</b> | <b>1.15***</b>  | <b>3469</b>                    | <b>2986.21</b> | <b>1.16***</b>  |

\* P<0.05, \*\* P<0.01, \*\*\* P<0.001

Table A4.4 shows that leukaemia rates are raised above levels expected by chance in the 0-24 and over 65 age groups in West Berkshire and in all age groups in the Oxford Region.



**Table A4.5 Cancer type: leukaemia (ICD9 204-208)  
Time period: 1971-94**

| Age (years)       | Newbury DC |              |                 | West Berkshire |               |                 | Oxford Region (excl Berkshire) |               |                 |
|-------------------|------------|--------------|-----------------|----------------|---------------|-----------------|--------------------------------|---------------|-----------------|
|                   | Observed   | Expected     | Incidence ratio | Observed       | Expected      | Incidence ratio | Observed                       | Expected      | Incidence ratio |
| 0-4               | 17         | 12.83        | 1.33            | 71             | 41.40         | 1.71***         | 191                            | 159.76        | 1.20**          |
| 5-9               | 8          | 6.91         | 1.16            | 24             | 22.61         | 1.06            | 104                            | 86.21         | 1.21*           |
| 10-14             | 7          | 5.00         | 1.40            | 16             | 16.49         | 0.97            | 71                             | 63.03         | 1.13            |
| 15-24             | 9          | 8.97         | 1.00            | 34             | 30.91         | 1.10            | 146                            | 111.36        | 1.31***         |
| <b>Total 0-24</b> | <b>41</b>  | <b>33.71</b> | <b>1.22</b>     | <b>145</b>     | <b>111.41</b> | <b>1.30***</b>  | <b>512</b>                     | <b>420.36</b> | <b>1.22***</b>  |

\* P<0.05, \*\* P<0.01, \*\*\* P<0.001

The 5 year age band analysis of the 0-24 age group shows an elevation above levels expected by chance in the 0-4 age group in West Berkshire (1.7 times the national average) and the Region (1.2 times the national average). Newbury rates in the 0-4 age group are also elevated (1.3 times the national average) but one would expect this by chance more often than 1 in 20 times. The regional rates are also elevated in the 5-9 and 15-24 age groups.

**Table A4.6 Cancer type: brain and other CNS tumours (ICD9 191, 192)  
Time period: 1971-94**

| Age (years)  | Newbury DC |               |                 | West Berkshire |               |                 | Oxford Region (excl Berkshire) |                |                 |
|--------------|------------|---------------|-----------------|----------------|---------------|-----------------|--------------------------------|----------------|-----------------|
|              | Observed   | Expected      | Incidence ratio | Observed       | Expected      | Incidence ratio | Observed                       | Expected       | Incidence ratio |
| 0-24         | 32         | 23.17         | 1.38*           | 88             | 77.29         | 1.14*           | 337                            | 290.44         | 1.16**          |
| 25-64        | 130        | 99.03         | 1.31**          | 431            | 333.45        | 1.29***         | 1448                           | 1250.59        | 1.16***         |
| 65+          | 60         | 42.03         | 1.43**          | 221            | 139.96        | 1.58***         | 893                            | 567.27         | 1.57***         |
| <b>Total</b> | <b>222</b> | <b>164.23</b> | <b>1.35***</b>  | <b>740</b>     | <b>550.72</b> | <b>1.34***</b>  | <b>2678</b>                    | <b>2108.30</b> | <b>1.27***</b>  |

\* P<0.05, \*\* P<0.01, \*\*\* P<0.001

Brain and CNS cancer incidence rates were significantly elevated overall in Newbury (1.4 times the national average), West Berkshire and the Oxford Region (both 1.3 times the national average). The increased incidence was observed across all age groups in Newbury District Council Area and the Oxford Region, but only the 25-64 and over 65 age groups in West Berkshire.

**Table A4.7 Cancer type: brain and other CNS tumours (ICD9 191, 192)  
Time period: 1971-94**

| Age (years)       | Newbury DC |              |                 | West Berkshire |              |                 | Oxford Region (excl Berkshire) |               |                 |
|-------------------|------------|--------------|-----------------|----------------|--------------|-----------------|--------------------------------|---------------|-----------------|
|                   | Observed   | Expected     | Incidence ratio | Observed       | Expected     | Incidence ratio | Observed                       | Expected      | Incidence ratio |
| 0-4               | 8          | 6.25         | 1.28            | 29             | 20.23        | 1.43*           | 79                             | 77.61         | 1.02            |
| 5-9               | 6          | 5.34         | 1.12            | 15             | 17.46        | 0.86            | 78                             | 66.69         | 1.17            |
| 10-14             | 11         | 3.97         | 2.77**          | 20             | 13.25        | 1.51*           | 66                             | 50.49         | 1.31*           |
| 15-24             | 7          | 7.60         | 0.92            | 24             | 26.35        | 0.91            | 114                            | 95.65         | 1.19*           |
| <b>Total 0-24</b> | <b>32</b>  | <b>23.16</b> | <b>1.38*</b>    | <b>88</b>      | <b>77.29</b> | <b>1.14</b>     | <b>337</b>                     | <b>290.44</b> | <b>1.16**</b>   |

\* P<0.05, \*\* P<0.01, \*\*\* P<0.001

Table A4.7 shows the breakdown by 5 year age bands for the 0-24 age group. In West Berkshire, there was a significantly elevated rate (1.4 times the national average) in the 0-4 age group, and also in the 10-14 age group. In Newbury the rates were significantly elevated only in the 10-14 age group and the regional rates were significantly elevated in the 10-14 and 15-24 age groups.

**Table A4.8 Cancer type: lymphoma (ICD8 200-202)  
Time period: 1971-94**

| Age (years)  | Newbury DC |               |                 | West Berkshire |                |                 | Oxford Region (excl Berkshire) |                |                 |
|--------------|------------|---------------|-----------------|----------------|----------------|-----------------|--------------------------------|----------------|-----------------|
|              | Observed   | Expected      | Incidence ratio | Observed       | Expected       | Incidence ratio | Observed                       | Expected       | Incidence ratio |
| 0-24         | 32         | 30.23         | 1.06            | 119            | 103.66         | 1.15            | 416                            | 382.53         | 1.09*           |
| 25-64        | 180        | 149.62        | 1.20**          | 589            | 502.87         | 1.17***         | 2221                           | 1883.32        | 1.18***         |
| 65+          | 124        | 122.49        | 1.01            | 467            | 410.67         | 1.14**          | 2011                           | 1660.24        | 1.21***         |
| <b>Total</b> | <b>336</b> | <b>302.34</b> | <b>1.11*</b>    | <b>1175</b>    | <b>1017.21</b> | <b>1.16***</b>  | <b>4648</b>                    | <b>3926.11</b> | <b>1.18***</b>  |

\* P<0.05, \*\* P<0.01, \*\*\* P<0.001

Lymphoma incidence rates were significantly raised in the 25-64 age group in Newbury and West Berkshire (both 1.2 times the national average). West Berkshire rates were also significantly higher in the over 65 age group (1.1 times the national average). Regional rates were raised in all age groups.

**Table A4.9 Cancer type: lymphoma (ICD9 200-202)  
Time period: 1971-94**

| Age (years)       | Newbury DC |              |                 | West Berkshire |               |                 | Oxford Region (excl Berkshire) |               |                 |
|-------------------|------------|--------------|-----------------|----------------|---------------|-----------------|--------------------------------|---------------|-----------------|
|                   | Observed   | Expected     | Incidence ratio | Observed       | Expected      | Incidence ratio | Observed                       | Expected      | Incidence ratio |
| 0-4               | 4          | 1.70         | 2.35            | 13             | 5.48          | 2.37**          | 16                             | 21.30         | 0.75            |
| 5-9               | 4          | 2.68         | 1.49            | 11             | 8.75          | 1.26            | 24                             | 33.37         | 0.72            |
| 10-14             | 1          | 3.66         | 0.27            | 11             | 12.07         | 0.91            | 61                             | 46.11         | 1.32*           |
| 15-24             | 23         | 22.19        | 1.04            | 84             | 77.36         | 1.09            | 315                            | 281.75        | 1.12*           |
| <b>Total 0-24</b> | <b>32</b>  | <b>30.23</b> | <b>1.06</b>     | <b>119</b>     | <b>103.66</b> | <b>1.15</b>     | <b>416</b>                     | <b>382.53</b> | <b>1.09*</b>    |

\* P<0.05, \*\* P<0.01, \*\*\* P<0.001

Table A 4.9 shows the breakdown by 5 year age band for the 0-24 age group. The incidence in the 0-4 age group in West Berkshire was significantly elevated at 2.4 times the national average. The Newbury rate in the 0-4 age group was similarly elevated but this did not reach statistical significance, ie. the likelihood of this occurring simply by chance was more than 1 in 20. Regional rates were significantly elevated in the 10-14 and 15-24 age groups.

**Table A4.10 Cancer type: leukaemia (ICD9 204-208)  
Time period: 1971-94**

| Age (years)  | Ward No 2 |              |                 |
|--------------|-----------|--------------|-----------------|
|              | Observed  | Expected     | Incidence ratio |
| 0-24         | 7         | 1.82         | 3.85**          |
| 25-64        | 8         | 4.36         | 1.83            |
| 65+          | 11        | 9.70         | 1.13            |
| <b>Total</b> | <b>26</b> | <b>15.88</b> | <b>1.64*</b>    |

\* P<0.05, \*\* P<0.01

**Table A4.11 Cancer type: leukaemia (ICD9 204-208)  
Time period: 1971-94**

| Age (years)  | Ward No 3 |              |                 |
|--------------|-----------|--------------|-----------------|
|              | Observed  | Expected     | Incidence ratio |
| 0-24         | 3         | 2.34         | 1.28            |
| 25-64        | 9         | 5.61         | 1.60            |
| 65+          | 5         | 10.98        | 0.46            |
| <b>Total</b> | <b>17</b> | <b>18.93</b> | <b>0.90</b>     |

\* P<0.05, \*\* P<0.01

**Table A4.12 Cancer type: all cancers (ICD9 204-208)  
Time period: 1971-94**

| Ward No 2    |            |               |                 |
|--------------|------------|---------------|-----------------|
| Age (years)  | Observed   | Expected      | Incidence ratio |
| 0-24         | 15         | 8.45          | 1.78*           |
| 25-64        | 231        | 233.5         | 0.99            |
| 65+          | 428        | 430.9         | 1.00            |
| <b>Total</b> | <b>674</b> | <b>672.09</b> | <b>1.00</b>     |

\* P<0.05, \*\* P<0.01

**Table A4.13 Cancer type: all cancers (ICD9 204-208)  
Time period: 1971-94**

| Ward No 3    |            |               |                 |
|--------------|------------|---------------|-----------------|
| Age (years)  | Observed   | Expected      | Incidence ratio |
| 0-24         | 15         | 10.93         | 1.37            |
| 25-64        | 286        | 301.95        | 0.95            |
| 65+          | 517        | 485.89        | 1.06            |
| <b>Total</b> | <b>818</b> | <b>798.77</b> | <b>1.02</b>     |

\* P<0.05, \*\* P<0.01

## CHAPTER 5

### DISCUSSION

#### **The object of this report and the questions addressed**

5.1 In the introduction we described the events which have resulted in the production of this our Fifth Report. There are five main points which we have addressed in this report and they are:

- i. Does the available evidence, whether documentary or radiation monitoring data, support the allegation that an accident and fire involving a nuclear weapon occurred at Greenham Common Airbase in 1958, with a subsequent release of radioactive material?
- ii. If there was an excess of uranium-235 in the Greenham Common area in the 1960s, what was its source?
- iii. Do the measured levels of uranium-235 and other radionuclides in the environment local to the Greenham Common Airbase constitute a radiological hazard?
- iv. Is the reported excess of childhood cancer and leukaemia in the Newbury and West Berkshire areas confirmed and if so is this linked to levels of radionuclides in the local environment?
- v. Do any of the findings of our current investigations have any bearings on the conclusions of our Third Report?

#### **The accident at Greenham Common Airbase on 28 February 1958**

5.2 In Chapter 2 we reviewed the available documentary evidence concerning the accident and fire which took place at Greenham Common Airbase on 28 February 1958. We noted that at no point in these documents is it categorically stated that a nuclear weapon was not involved in the fire. However, we also noted that all the other available information suggests that the presence of such a weapon is extremely unlikely. The fact that the affected aircraft was allowed to burn out was extremely suggestive and it is difficult to imagine this being the case if a weapon had been on board.

5.3 Having reviewed all of the available information, we have found no evidence that nuclear weapons were involved in the accident or subsequent fire which occurred on 28 February 1958.

#### **Radiation environmental monitoring data**

5.4 In Chapter 3, we examined all of the available environmental monitoring data for the local area, whether current or historic. We have noted that the absence of any excess levels of uranium-235 in the 1996 studies cannot be taken as showing the 1961 findings to be incorrect. However, the levels of uranium-235 in evergreen leaves reported by Cripps and Stimson in their report of 1961, are all very low. We considered the radiological implications of the levels reported in 1961 and concluded that they are negligible. Furthermore, the environmental monitoring data, whether current or historic, indicate that the levels of man-made and natural radionuclides in this area are low when compared with many other areas of the UK.



5.5 We also considered the possible sources of the uranium-235 found in the local environment. These were principally a possible accident involving a nuclear weapon or discharges from the Atomic Weapons Establishment at Aldermaston. We have concluded that there is no evidence to support the hypothesis that radiation levels are the result of an accident involving nuclear weapons at Greenham Common. In fact, radiation doses to people living in the area have always been extremely low and the current doses reflect the fall in discharges from Aldermaston over the years. We have, therefore, concluded that the data arising from environmental monitoring undertaken in the past and currently are consistent with Aldermaston discharges given the uncertainties pointed out in the monitoring data as described in Chapter 3 of this report.

## **Epidemiological data**

5.6 In Chapter 4 we described the finding of a raised incidence of leukaemia in the age group 0-4 years in West Berkshire as compared to national rates. This observation confirms the similar finding described and discussed in our Third Report. In Chapter 4 we have discussed the known association between some childhood cancers, including leukaemia and the social class of the area. We have noted that given the social class structure in the West Berkshire area such an increase in childhood leukaemia might have been predicted and we cannot rule out the fact that some unknown risk factors associated with known differences in rates between social classes may have a part to play in explaining this excess.

5.7 We have noted that there are other factors which might explain this observed excess. We have pointed out that an important factor may be the local efficiency of cancer registration. Although the observed increase in childhood leukaemia may be real, it is also possible that it may be attributable, at least in part, to more complete registration of these childhood diseases in this area, as compared to that in other parts of the country which contribute to the national rate.

5.8 Again we have noted that in ward 2 in Newbury there was a significant excess of leukaemia in people aged 0-24 years. There were no significant increases in cancers in any other wards in or around Newbury. We have concluded that the excess in ward 2 is likely to be a chance finding commonly observed in studies involving such small areas and small numbers of cases.

5.9 Using the calculations of the Childhood Cancer Research Group it can be shown that the rates of cancer and childhood leukaemia in the county districts of West Berkshire are well above the average rates, though they are not in the highest 5 per cent. We have suggested that this may be a result of the demographical structure of the area and we hope to be able to address this finding in greater depth when the geographical studies recommended in our Third Report are complete.

## **Childhood leukaemia and radiation**

5.10 Finally, the remit of this report was to decide whether there is or has been any unusual incidence of childhood cancer in the vicinity of RAF Greenham Common and if any such unusual incidence is observed then whether there is or has been any association with local levels of radioactivity in the area. We have noted previously that the environmental levels of radiation in the Newbury area are similar to the national average and lower than those in many other parts of the country. From this and the other data and information presented to us we conclude that the levels of radiation in the local area are far too low to account for any increase in cancer or leukaemia.

## CHAPTER 6

### SUMMARY AND CONCLUSIONS

6.1 We have reviewed the environmental monitoring, epidemiological and other data relating to the area around Greenham Common Airbase, taking into account Newbury District Council area and the West Berkshire area. Our conclusions are reported below.

#### **The 1958 accident**

6.2 We have reviewed all the available evidence, whether scientific or documentary. We have found nothing to suggest that a nuclear weapon was involved in the accident or subsequent fire that took place on 28 February 1958.

#### **Radiation environmental monitoring**

6.3 We have reviewed all of the available monitoring data undertaken to measure the levels of radioactivity in the local environment. The levels of uranium-235 in evergreen leaves reported by Cripps and Stimson in 1961 are all very low. We considered the radiological implications of the levels reported in 1961 and concluded that they are negligible. Furthermore, the environmental monitoring data, whether current or historic, indicate that the levels of man-made and natural radionuclides in this area are low when compared with many other areas of the UK.

6.4 We also considered the possible sources of the uranium-235 found in the local environment and we have concluded that the data arising from environmental monitoring undertaken in the past and currently are consistent with Aldermaston discharges, given the uncertainties pointed out in the monitoring data as described in Chapter 3 of this report.

#### **Epidemiological data**

6.5 The finding of an excess of leukaemia in children aged 0-4 years in the West Berkshire area in the current study confirms the excess observed in the studies described in our Third Report. We also noted the excess of leukaemia in young people aged 0-24 years in ward 2 in Newbury, but there was no significant increase of cancer in this age group in the other wards in and around Newbury.

#### **Radiation and possible association with the incidence of childhood leukaemia**

6.6 Part of the remit of this report was to investigate the levels of radioactivity in the area around Greenham Common and the incidence of cancer and leukaemia in the related area and determine whether these two items are associated. We have concluded that the levels of radiation in the local area are so low that they could not be responsible for the local incidence of childhood leukaemia.

#### **Other factors**

6.7 We have pointed out other factors which might explain the noted excess of childhood leukaemia, particularly those which may be associated with the social class structure of the local area. We hope to examine this further when the results of the geographical studies recommended in our Third Report are complete.

#### **COMARE's Third Report**

6.8 Part of the reason for undertaking the work in this report was to examine the possibility that the environmental monitoring data in the 1961 Cripps and Stimson report and the Operation Overture reports might have had some effect on the conclusions of our Third Report. These data were not made available to us at the time.

6.9 The failure of organisations to make available information about relevant activities constrains the ability of COMARE to comply with its remit. As we have noted before, if information is withheld from us, our reports are potentially compromised. In this instance the environmental monitoring measurements that were contained in a classified document, of which COMARE was not made aware, would have been useful in assessing the exposure around Aldermaston and Burghfield in our Third Report. Their unavailability meant that COMARE performance had to rely on atmospheric discharge data which could only be estimated. In the event, the ultimately declassified information proved to be vital to an understanding of the Greenham Common question but fortunately has not altered the overall conclusions of our Third Report. We wish to make it clear that organisations whose predecessors have released radioactivity into the environment, whether those releases were authorised or accidental, have a responsibility to make that information available to COMARE. MoD has had a major participation in the nuclear field in the last 50 years and should not be regarded as exempt from this responsibility. Clearly, however, security issues need to be addressed. MoD has accepted these points and representatives of MoD and COMARE have met to discuss a way forward on this issue. Should issues arise in the future where a high security classification is deemed to be still appropriate, mechanisms are being developed whereby information may be made available to appropriate Committee members after security clearance.

6.10 We have also considered whether any of the other information that has come to light has implications for the conclusions of our Third Report, in particular the elevated rate of childhood leukaemia in West Berkshire. We have noted the signals of caesium-137 and thallium-208 and gamma-ray dose rates emanating from the Harwell site as reported in the aerial survey undertaken by Croudace et al (1997). The existence of legitimate and known sources was taken into account in the critical group dose assessment carried out for Harwell by NRPB (NRPB-R271, Robinson et al, 1994). We would suggest that the source of these aerial survey signals be confirmed, to determine their legitimacy and to ensure that their implications for dose at ground level have been fully assessed. COMARE will examine more closely the epidemiological data relevant to West Berkshire, South Oxfordshire and the area around the Harwell site when the results of the geographical studies recommended in our Third Report become available.

## REFERENCES

Atomic Weapons Research Establishment (1960a). Exercise Overture: Interim Report (7.3.1960). AWRE, Berkshire.

Atomic Weapons Research Establishment (1960b). Exercise Overture: Interim Report No 2. AWRE, Berkshire.

Atomic Weapons Research Establishment (1960c). Exercise Overture: Interim Report No 3. AWRE, Berkshire.

Atomic Weapons Research Establishment (1961a). The distribution of uranium-235 and plutonium-239 around the United States airforce base, Greenham Common, Berkshire, by F H Cripps and A Stimson. AWRE, Aldermaston.

Atomic Weapons Research Establishment (1961b). Exercise Overture: Interim Report No 4. AWRE, Berkshire.

Atomic Weapons Establishment (1986). Greenham Common revisited. AWE, Aldermaston. CXD Memorandum No 995.

Atomic Weapons Establishment (1987). Radiological monitoring in the environment surrounding the Atomic Weapons Establishment, Aldermaston and the Royal Ordnance Factory, Burghfield. 1986. AWE, Aldermaston. EMG AR 1/1986.

Atomic Weapons Establishment (1988). Radiological monitoring during 1987 in West Berkshire and Northern Hampshire in the general locality surrounding AWE stations in Berkshire. AWE, Aldermaston. EMG AR 1/1987.

Atomic Weapons Establishment (1989). Radiological monitoring during 1988 in West Berkshire and Northern Hampshire in the general locality surrounding AWE stations in Berkshire. AWE, Aldermaston. BMS/AWE SDTN 20/89.

Atomic Weapons Establishment (1990). Radiological monitoring during 1989 in West Berkshire and Northern Hampshire in the general locality surrounding AWE stations in Berkshire. AWE, Aldermaston. BMS/AWE SDTN 25/90.

Atomic Weapons Establishment (1991). Radiological monitoring during 1990 in West Berkshire and Northern Hampshire in the general locality surrounding Ministry of Defence premises at Aldermaston and Burghfield. AWE, Aldermaston. EMG AR 1990.

Atomic Weapons Establishment (1992). Aldermaston and Burghfield: discharges and environmental monitoring for 1991. AWE, Aldermaston. EMG AR 1991.

Atomic Weapons Establishment (1993). Aldermaston and Burghfield: discharges and environmental monitoring for 1992. AWE, Aldermaston. EMG AR 1992.

Atomic Weapons Establishment (1994). Aldermaston and Burghfield: discharges and environmental monitoring for 1993. AWE, Aldermaston. EMG AR 1993.

- Atomic Weapons Establishment (1995). Aldermaston and Burghfield: discharges and environmental monitoring for 1994. AWE, Aldermaston. ESAG AR 1995.
- Atomic Weapons Establishment (1996). Aldermaston and Burghfield: discharges and environmental monitoring for 1995. AWE, Aldermaston. ESAG AR 1996.
- Black D (1984). Investigation of the possible increased incidence of cancer in West Cumbria. Report of the Independent Advisory Group. HMSO, London.
- Busby C and Cato M S (1997). Death rates from leukaemia are higher than expected in areas around nuclear sites in Berkshire and Oxfordshire (letter). *British Medical Journal*, **315**, 309.
- Cawse P A and Horrill A D (1986). A survey of caesium-137 and plutonium in British soils in 1977. UKAEA, Harwell. AERE R10155.
- Committee on Medical Aspects of Radiation in the Environment (COMARE) (1986). First Report. The implications of the new data on the releases from Sellafield in the 1950s for the conclusions of the report on the investigation of the possible increased incidence of cancer in West Cumbria. HMSO, London.
- Committee on Medical Aspects of Radiation in the Environment (COMARE) (1988). Second Report. Investigation of the possible increased incidence of leukaemia in young people near the Dounreay Nuclear Establishment, Caithness, Scotland. HMSO, London.
- Committee on Medical Aspects of Radiation in the Environment (COMARE) (1989). Third Report. Report on the incidence of childhood cancer in the West Berkshire and North Hampshire area, in which are situated the Atomic Weapons Research Establishment, Aldermaston and the Royal Ordnance Factory, Burghfield. HMSO, London.
- Committee on Medical Aspects of Radiation in the Environment (COMARE) (1996). Fourth Report. The incidence of cancer and leukaemia in young people in the vicinity of the Sellafield site, West Cumbria: further studies and an update of the situation since the publication of the report of the Black Advisory Group in 1984. HMSO, London.
- Croudace I W, Sanderson D C W, Warwick P E and Allyson J D (1997a). A regional study of the radiation environment of Greenham Common, Newbury District and surrounding areas. Southampton Oceanography Centre/SURRC.
- Croudace I W, Warwick P E, Taylor R N and Dee S J (1997b). An investigation of radioactive contamination at Greenham Common, Newbury District and surrounding areas. Final report. Southampton University, Southampton Oceanography Centre, Geosciences Advisory Unit.
- Defence Radiological Protection Service (1996). RAF Greenham Common Environmental Monitoring Report. DRPS, Alverstoke. Report 19/94 (Amended 17 July 1996).
- Dickinson H O, Dummer T J B, Pearce M S, Crofts J A, Sallit G C R, Atkinson W D, Carpenter B C, Draper G J, Vincent T J, Barton C, Busby C, Cato M S and Bolger P G (1997). Death rates from childhood leukaemia near nuclear sites (letters). *British Medical Journal*, **315**, 1232-1234.
- Dionian J, Wan S L and Wrixon A D (1987). Radiation doses to members of the public around AWRE, Aldermaston, ROF, Burghfield and AERE, Harwell. NRPB-R207, Chilton.

Draper G (1991). The geographical epidemiology of childhood leukaemia and non-Hodgkin lymphomas in Great Britain, 1966-83. Studies on Medical and Population Subjects No. 53, OPCS, pp. 1-131. HMSO, London.

Fry F A and Wilkins B T (1996). Assessment of radionuclide levels around the former airbase at Greenham Common, Berkshire. NRPB-M752, Chilton.

Gonçalves E. (1996). Broken Arrow. The secret of Greenham Common's nuclear accident. CND Report, London.

Newbury Cancer Working Group (1997). Report to Berkshire Health Authority. Incidence and mortality from leukaemia and other cancers in Newbury District Council area.

Robinson C A, Mayall A, Attwood C A, Cabianca T, Dodd D, Fayers C A, Jones J A and Simmonds J R (1994). Critical group doses around nuclear sites in England and Wales. NRPB-R271, Chilton.

Southern England Radiation Monitoring Programme Annual Report. November 1995-October 1996. Southampton Oceanography Centre, Geosciences Advisory Unit (1997).

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## THE APPENDICES

## APPENDIX A

### GLOSSARY

*Notes: the descriptions below are intended to help the reader understand the text; they are not necessarily definitive scientific terms, for which the reader is advised to consult specialist sources. This Glossary does not form part of the Report.*

*Underlined words are defined separately.*

#### **5TH and 95TH PERCENTILES**

The 5th percentile of a distribution is the value that only 5% of the values in the data set are below, and the 95th percentile is the value that only 5% of the values are above.

#### **ABSORBED DOSE (Radiation)**

The quantity of energy imparted by ionising radiation to a unit mass of matter such as tissue. Absorbed dose has the units  $\text{J kg}^{-1}$  and the special name gray (Gy).  $1 \text{ Gy} = 1 \text{ joule per kilogramme}$ .

#### **ALPHA ACTIVITY**

The alpha activity is the number of alpha particles emitted by many heavy radionuclides per unit time. An alpha particle is identical to the nucleus of a helium atom, consisting of two protons plus two neutrons. An alpha particle has low penetrating power but high linear energy transfer (LET). The unit of activity is the becquerel (Bq).

#### **ALPHA SPECTROMETRY**

A method of measuring alpha-particle emissions from a sample to give the energy spectrum of the alpha activity, which can be used to determine activities of specific alpha-emitting radionuclides present in the sample.

#### **AMERICIUM-241**

A radionuclide with a half-life of 460 years, which decays with the emission of alpha particles and gamma rays. It is formed as a daughter product of the decay of plutonium-241.

#### **ATMOSPHERIC DISPERSION MODEL**

A mathematical model used to estimate the dispersion of material released to the atmosphere and the resulting concentrations of the material in air. An example is the Gaussian plume dispersion model. See also deposition model.

#### **BACKGROUND RADIATION**

The radiation level to which the general population is exposed. It consists of natural radiation from outer space, rocks, air, soil and substances within the human body, and from food. Natural radiation accounts for about 85% of the annual average radiation dose to members of the public.

### **BECQUEREL (Bq)**

The international (SI) unit for the number of nuclear disintegrations occurring per unit time, in a quantity of radioactive material. 1 Bq = 1 radioactive disintegration per second. Replaced the Curie (Ci) -  $1 \text{ Bq} = 2.7 \times 10^{-11} \text{ Ci}$ . Because this is an extremely small unit, levels of activity expressed in Bq are often prefixed with mega ( $10^6 \text{ Bq}$  - MBq), giga ( $10^9 \text{ Bq}$  - GBq) and tera ( $10^{12} \text{ Bq}$  - Tbq), particularly in the context of discharges of activity into the environment. Conversely, under normal circumstances activity concentrations in environmental materials are generally low and so prefixes such as milli ( $10^{-3} \text{ Bq}$  - mBq) and micro ( $10^{-6} \text{ Bq}$  -  $\mu\text{Bq}$ ) may be employed.

### **BETA ACTIVITY**

Beta activity is a form of radioactivity in which beta particles are emitted from the radioactive body. It has greater penetrative power than an alpha particle, but has a low linear energy transfer (LET). A beta particle has a mass and charge identical to that of an electron. Beta particles can be either positively or negatively charged. If the electric charge is positive, the particle emitted is called a positron. If the electric charge is negative, the particle emitted is called an electron.

### **CAESIUM-137**

A radionuclide which has a half-life of about 30 years and which decays with the emission of beta particles and gamma rays.

### **CANCER REGISTRATION**

In England and Wales, this is a formally coordinated but non-statutory scheme whereby all cases of cancer should be notified to regional registries, in agreed detail, as soon as possible after diagnosis. Coordination is undertaken by the National Cancer Registration Scheme. The data are forwarded to the Office for National Statistics (ONS) for collation and publication.

### **DAUGHTER PRODUCT see DECAY PRODUCT**

### **DECAY**

The process of spontaneous transformation of a radionuclide. The decrease in the activity of a radioactive substance.

### **DECAY PRODUCT**

A nuclide or radionuclide produced by decay. A decay product may be formed directly from a radionuclide or as a result of a series of successive decays through several radionuclides.

### **DEPOSITION**

Any radioactive material that has been deposited on a surface.

### **DEPOSITION MODEL**

A mathematical model used to estimate the deposition on to the ground of material in the atmosphere. It may include both deposition during rainfall (wet deposition) and dry deposition. See also atmospheric dispersion model.

### **DISCHARGES see RADIOACTIVE DISCHARGES**

### **EFFECTIVE DOSE**

The effective dose is the sum of the weighted equivalent doses in all the tissues and organs of the body. It takes account of the relative biological effectiveness (RBE) of different types of radiation and variation in the susceptibility of organs and tissues to radiation damage. Unit sievert (Sv).

**ENRICHMENT FACILITY**

A facility where the proportion of a desired isotope is raised above that present initially in isotope separation.

**ENRICHMENT FACTOR**

The abundance ratio of a product divided by that of the raw material.

**EPIDEMIOLOGY**

The study of the distribution and determinants of health-related states or events in specified populations and the application of this study to control of health problems. In the past 50 years or so, the definition of epidemiology has broadened from concern about communicable disease epidemics to include all phenomena related to health in populations.

**EQUIVALENT DOSE**

The quantity obtained by multiplying the absorbed dose by a factor to allow for the different effectiveness of the various ionising radiations in causing harm to tissue. Unit sievert, symbol Sv. Usually the factor for gamma rays, X rays and beta particles is 1 but for alpha particles 20.

**EXPECTED NUMBERS**

The average number of events or cases that will occur in a specified location and time period if overall mortality or incidence rates apply to that location and time period.

**FISSION**

The spontaneous or induced disintegration of a heavy atomic nucleus into two or more lighter fragments (nuclei). The energy released in the process is referred to as nuclear energy.

**FREE RADICAL**

A grouping of atoms that normally exists in combination with other atoms, but can sometimes exist independently. Generally very reactive in a chemical sense.

**GAMMA RAYS**

High energy photons, without mass or charge, emitted from the nucleus of a radionuclide following radioactive decay, as an electromagnetic wave. They are very penetrating but have a low linear energy transfer (LET).

**GAMMA-RAY SPECTROMETRY**

A method of measuring gamma-ray emissions from a sample to give the energy spectrum of the gamma radiation, which can be used to determine activities of specific gamma-ray emitting radionuclides present in the sample.

**GENERALISED DERIVED LIMITS (GDLs)**

Generalised derived limits are convenient reference levels against which the results of environmental monitoring (eg. foods, grass and soil) can be compared. GDLs are related to the dose limit for members of the public through a defined model, and are calculated such that if the monitoring results do not exceed the appropriate GDL, then it is very unlikely that the dose limit would be exceeded.

**GRAY (Gy)**

The international (SI) unit of absorbed dose. 1 Gy is equivalent to 1 joule of energy absorbed per kilogramme of matter such as body tissue.

**HALF-LIFE ( $t_{1/2}$ )**

The time taken for the activity of a radionuclide to lose half its value by decay. During each subsequent half-life its activity is halved again so its activity decays exponentially.

**HIGH VOLUME AIR SAMPLER**

A motor-driven air pump which passes air through a special filter and is used to determine the concentration of activity in air. The air is sampled at a rate of  $\geq 1 \text{ m}^3$  per minute. The filter is then used to measure the gamma-ray spectrum of the particulates by gamma-ray spectrometry. Other radionuclides are then determined by radiochemical analysis.

**HYPOTHESIS**

A suggested explanation for a group of facts or phenomena. See also null hypothesis.

**INCIDENCE**

The number of instances of illness commencing or of persons falling ill during a given period in a specified population. The term incidence is sometimes used to denote "incidence rate".

**ION**

Electrically charged atom or grouping of atoms.

**IONISATION**

The process by which a neutral atom or molecule acquires or loses an electron. The production of ions.

**IONISING RADIATION**

Radiation which is sufficiently energetic to remove electrons from atoms in its path. In human or animal exposures, ionising radiation can result in the formation of highly reactive particles in the body (known as free radicals) which can cause damage to individual components of living cells and tissues. The term includes radiation at least as energetic as X rays; gamma rays and charged particles such as alpha and beta particles are also forms of ionising radiation.

**ISOTOPE**

Nuclides containing the same number of protons (ie. same atomic number) but different numbers of neutrons.

**LEUKAEMIA**

A group of malignant diseases of the blood-forming tissues characterised by abnormal white blood cells which divide in a manner outside the control of the body. Most leukaemias start in the red bone marrow but some start in the lymphatic system. In all instances the bone marrow ends up being the main site of the disease. The principal groups are the chronic leukaemias (very rare in the 0-24 age group) and the acute leukaemias, of which acute lymphoblastic leukaemia (ALL, also known as acute lymphatic leukaemia) currently accounts for 75-80% of all cases of childhood leukaemia in the UK. Both ALL and non-Hodgkin's lymphoma (NHL, which is closely related to ALL) derive from lymphoid cells. Acute myeloblastic leukaemia (AML, also known as acute myeloid or acute non-lymphoblastic leukaemia, ANLL) derives from myeloid bone marrow cells.

**LINEAR ENERGY TRANSFER (LET)**

A measure of the density of ionisation along the track of an ionising particle in biological tissue or other medium. Particles or rays of radiation are generally

described as having a high or low LET, ie. their tracks leave high or low density deposits of energy in the tissue they pass through. High LET radiation is more damaging to body tissue than low LET radiation.

### **LYMPH NODES**

Discrete nodules of tissue situated along the course of the lymphatic vessels which help protect against infection. A source of lymphocytes.

### **LYMPHOCYTE**

A type of white blood cell that is part of the body's immune system.

### **LYMPHOMA**

A malignant tumour of the lymphatic system (lymph nodes, reticulo-endothelial system and lymphocytes).

### **MASS SPECTROMETRY**

A technique that measures the mass (molecular weight) of a molecule. It can also provide structural information on an unknown compound. Molecules are ionised by collision with a high-energy electron beam. These ions fragment into smaller pieces which are magnetically sorted according to their mass-to-charge ratio ( $m/z$ ).

### **MELANOMA**

A tumour due to overgrowth of melanin-producing cells in the basal layer of the skin. A proportion become malignant, enlarge rapidly and spread to other parts of the body.

### **NON-HODGKIN'S LYMPHOMA**

A heterogenous but histologically recognisable group of cancers whose primary cell of origin is in lymphoid tissue and which tends to form solid tumours. A leukaemic form of the disease is seen in some cases. It is closely related to acute lymphoblastic leukaemia (ALL), both being part of a spectrum of disease, rather than truly separate entities, in most cases.

### **NUCLEAR REACTOR**

A structure in which neutron-induced nuclear fission can be sustained and controlled in a self-supporting chain reaction. In power reactors, the heat produced by fission is absorbed by coolant, producing steam which in turn powers a turbine for generating electricity. Some reactors can be put to other uses, eg. materials testing, plutonium production. In a thermal reactor the fission is brought about by slow or thermal neutrons which are produced by slowing fast neutrons by the use of a moderator such as carbon or water. In a fast reactor most of the fission is produced by fast neutrons and therefore requires no moderator. Most thermal reactors use uranium as fuel, in which the uranium-235 content has been artificially raised (this fuel is known as enriched uranium). Fast reactors use a mixture of plutonium and uranium dioxide.

### **NULL HYPOTHESIS**

The statistical hypothesis that one variable has no association with another variable or set of variables, or that two or more population parameters do not differ from one another.

### **P-VALUE**

The probability that, if a specified null hypothesis is true, the value of some statistic will be at least as extreme as that actually observed. In calculating this probability it will sometimes be appropriate to consider the deviations in only one direction (one-sided significance tests); in other cases, deviations in either direction may be appropriate (two-sided tests). Conventionally, if P (probability) is less than 0.05

“significant at the 5% level”, we take it to be unlikely that the deviation has arisen simply by chance and are inclined to “reject the null hypothesis”, ie. to seek some alternative hypothesis to explain the observations. Similarly, if P is less than 0.01 (significant at the 1% level) we are more persuaded that such an alternative hypothesis is necessary).

### **PLUTONIUM (Pu)**

An element which exists in several different isotopic forms. The five main isotopes are:

$^{238}\text{Pu}$ : alpha emitter, half-life c.86 years

$^{239}\text{Pu}$ : alpha emitter, half-life c.24,000 years

$^{240}\text{Pu}$ : alpha emitter, half-life c.6,600 years

$^{241}\text{Pu}$ : beta emitter, half-life c.13 years which decays to americium-241, which is an alpha emitter with a half-life of c.460 years

$^{242}\text{Pu}$ : alpha emitter, half-life c.379,000 years

### **POISSON DISTRIBUTION**

A mathematical formula which describes the probability of observing each number of events (0, 1, ...) in equal units of time and/or space, where the mean rate of occurrence is low and is known, and events are occurring at random. The Poisson distribution is useful when calculating the number of times a rare event may be expected to occur in a large group of people.

### **RADIOACTIVE CONTAMINATION**

When radioactive substances have mixed with another non-radioactive substance. Or where radioactive materials have spread to areas so that people may be harmed or equipment made unsafe.

### **RADIOACTIVE DISCHARGES**

Some establishments produce radioactive waste as byproducts and this is disposed of, usually to the environment, as radioactive discharge.

### **RADIOACTIVITY**

The property of radionuclides of spontaneously emitting ionising radiation. Measured in becquerels (Bq).

### **RADIONUCLIDE**

A type of atomic nucleus which is unstable and which may undergo spontaneous decay to another atom by emission of ionising radiation (usually alpha, beta or gamma radiation).

### **RBE see RELATIVE BIOLOGICAL EFFECTIVENESS**

### **RED BONE MARROW**

The cellular material found in bones in the axial skeleton (ie. bones excluding the arms and legs) and is the organ responsible for producing cells in the blood. (In infants, because the demand for blood is so great, all bones are used for blood production.) On average, red bone marrow produces 5 million cells every second, or 400 billion every 24 hours.

### **REGISTRATION see CANCER REGISTRATION**

### **RELATIVE BIOLOGICAL EFFECTIVENESS (RBE)**

The relative biological effectiveness of one radiation compared with another is the inverse ratio of the absorbed doses producing the same degree of a defined biological effect.

**RISK**

The probability that an event will occur, eg. that an individual will become ill or die within a stated period of time or age group.

**SIEVERT (Sv)**

The international (SI) unit of effective dose, obtained by weighting the equivalent dose in each tissue in the body with ICRP-recommended tissue weighting factors, and summing over all tissues. Because the sievert is a large unit, effective dose is commonly expressed in millisieverts (mSv), ie. one thousandth of one sievert, and microsieverts ( $\mu\text{Sv}$ ), ie. one thousandth of one millisievert. The average annual radiation dose to the UK population is 2.6 mSv.

**TRITIUM**

A radioactive isotope of hydrogen which emits beta particles, and has a half-life of 12.5 years.

**TUMOUR**

Mass of tissue formed by a new growth of cells, normally independent of the surrounding structures. Can be either benign or malignant.

**URANIUM (U)**

A hard grey metal which exists in seven isotopic forms (uranium-233 to uranium-239) of which the two most important are uranium-235 (the only naturally-occurring readily fissile isotope) and uranium-238. Both isotopes decay through a series of daughter products which emit alpha, beta and gamma radiation. Principal source of fuel for nuclear reactors.



## APPENDIX B

# COMMITTEE ON MEDICAL ASPECTS OF RADIATION IN THE ENVIRONMENT

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National Radiological Protection Board  
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## APPENDIX C

### DECLARATION OF MEMBERS' INTERESTS CODE OF PRACTICE

#### **Introduction**

1 This code of practice guides members of COMARE as to the circumstances in which they should declare an interest in the course of the Committee's work.

2 To avoid any public concern that commercial interests of members might affect their advice to Government, Ministers have decided that information on significant and relevant interests of members of its advisory committees should be on the public record. The advice of the Committee frequently relates to matters which are connected with the nuclear industry generally and, less frequently, to commercial interests involving radioactivity and it is therefore desirable that members should comply with the Code of Practice which is set out below.

#### **Scope and definitions**

3 This code applies to members of COMARE and sub-groups or working groups of COMARE which may be formed.

4 For the purposes of this Code of Practice, the "radiation industry" means:

- (a) companies, partnerships or individuals who are involved with the manufacture, sale or supply of products processes or services which are the subject of the Committee's business. This will include nuclear power generation, the nuclear fuel reprocessing industry and associated isotope producing industries, both military and civil;
- (b) trade associations representing companies involved with such products;
- (c) companies, partnerships or individuals who are directly concerned with research or development in related areas;
- (d) interest groups or environmental organisations with a known interest in radiation matters.

It is recognised that an interest in a particular company or group may, because of the course of the Committee's work, become relevant when the member had no prior expectation this would be the case. In such cases, the member should declare that interest to the Chairman of the meeting and thereafter to the Secretariat.

5 In this code, "the Department" means the Department of Health, and "the Secretariat" means the secretariat of COMARE.

#### **Different types of interest - definitions**

6 The following is intended as a guide to the kinds of interests which should be declared. Where a member is uncertain as to whether an interest should be declared he or she should seek guidance from the Secretariat or, where it may concern a particular subject which is to be considered at a meeting, from the Chairman at that meeting. Neither members nor the Department are under an obligation to search out links between one company and another, for example where a company with which a member is connected has a relevant interest of which the member is not aware and could not reasonably be expected to be aware.

If members have interests not specified in these notes but which they believe could be regarded as influencing their advice they should declare them to the Secretariat in writing and to the Chairman at the time the issue arises at a meeting.

### *Personal interests*

6.1 A personal interest involves payment to the member personally. The main examples are:

- (a) Consultancies or employment: any consultancy, directorship, position in or work for the radiation industries which attracts regular or occasional payments in cash or kind.
- (b) Fee-paid work: any work commissioned by those industries for which the member is paid in cash or kind.
- (c) Shareholdings: any shareholding in or other beneficial interest in shares of those industries. This does not include shareholdings through unit trusts or similar arrangements where the member has no influence on financial management.

### *Non-personal interests*

6.2 A non-personal interest involves payment which benefits a department for which a member is responsible, but is not received by the member personally. The main examples are:

- (a) Fellowships: the holding of a fellowship endowed by the radiation industry.
- (b) Support by industry: any payment, other support or sponsorship by the radiation industry which does not convey any pecuniary or material benefit to a member personally but which does benefit their position or department, eg.
  - (i) a grant from a company for the running of a unit or department for which a member is responsible;
  - (ii) a grant or fellowship or other payment to sponsor a post or a member of staff in the unit for which a member is responsible. This does not include financial assistance for students, but does include work carried out by postgraduate students and non-scientific staff, including administrative and general support staff.
  - (iii) the commissioning of research or work by, or advice from, staff who work in a unit for which the member is responsible.
- (c) Support by charities and charitable consortia: any payment, other support or sponsorship from these sources towards which the radiation industry has made a **specific and readily identifiable** contribution. This does not include unqualified support from the radiation industry towards the generality of the charitable resource.

Trusteeships: where a member is trustee of a fund with investments in the radiation industry, the member may wish to consult the Secretariat about the form of declaration which would be appropriate.

Members are under no obligation to seek out knowledge of work done for or on behalf of the radiation industry within departments for which they are responsible if they would not reasonably expect to be informed.

## Declaration of interests

### *Declaration of interests to the Department*

7 Members should inform the Department in writing when they are appointed of their current personal and non-personal interests and annually in response to a Secretariat request. Only the name of the company (or other body) and the nature of the interest is required; the amount of any salary, fees, shareholding, grant, etc, need not be disclosed to the Department. An interest is current if the member has a continuing financial involvement with the industry, eg. if he or she holds shares in a radiation company, has a consultancy contract, or if the member or the department for which he or she is responsible is in the process of carrying out work for the radiation industry. Members are asked to inform the Department at the time of any change in their personal interests, and will be invited to complete a form of declaration once a year. It would be sufficient if changes in non-personal interests are reported at the next annual declaration following the change. (Non-personal interests involving less than £1000 from a particular company in the previous year need not be declared to the Department.)

### *Declaration of interests at meetings and participation by members*

8 Members are required to declare relevant interests at Committee meetings and to state whether they are personal or non-personal interests. The declaration should include an indication of the nature of the interest.

- (a) If a member has a current (personal or non-personal) interest in the business under discussion, he or she will not automatically be debarred from contributing to the discussion subject to the Chairman's discretion. The Chairman will consider the nature of the business under discussion and of the interest declared (including whether it is personal or non-personal) in deciding whether it would be appropriate for the relevant member to participate in the item.
- (b) If a member has an interest which is not current in the business under discussion, this need not be declared unless not to do so might be seen as concealing a relevant interest. The intention should always be that the Chairman and other members of the Committee are fully aware of relevant circumstances.

9 A member who is in any doubt as to whether he or she has an interest which should be declared, or whether to take part in the proceedings, should ask the Chairman for guidance. The Chairman has the power to determine whether or not a member with an interest shall take part in the proceedings.

10 If a member is aware that a matter under consideration is or may become a competitor of a product process or service in which the member has a current personal interest, he or she should declare the interest in the company marketing the rival product. The member should seek the Chairman's guidance on whether to take part in the proceedings.

11 If the Chairman should declare a current interest of any kind, he or she should stand down from the chair for that item and the meeting should be conducted by the Deputy Chairman or other nominee if he or she is not there.

12 Some members of the Committee may, at the time of adoption of this note, or (in the case of new members) of their joining the Committee, be bound by the terms of a contract which requires them to keep the fact of the contractual arrangement confidential. As a transitional measure, any member so affected should seek to agree an entry for the public record (see para 14) with the other party. If such agreement does not prove possible, the members shall seek a waiver permitting them to disclose their interest, in confidence, to the Chairman and the Secretariat. The Secretariat will maintain a confidential register of such disclosures which will not form part of the public record.

13 On adoption of this note members shall not enter into new contractual obligations which would inhibit their ability to declare a relevant interest.

## Record of interests

14 A record will be kept in the Department of the names of members who have declared interests to the Department on appointment, as the interest first arises or through an annual declaration, and the nature of the interest.

15 Information from the record will be made available by the Secretariat to bona-fide enquirers and published by any other means as and where the Department deems appropriate.

| Member            | Company           | Personal interest   | Company               | Non-personal interest    |
|-------------------|-------------------|---------------------|-----------------------|--------------------------|
| Prof B Bridges    |                   | None                |                       | None                     |
| Prof E Alberman   |                   | None                |                       | None                     |
| Prof K Boddy      |                   | None                |                       | None                     |
| Prof R Cartwright | Various law firms | Medico-legal advice |                       | None                     |
| Prof K Cheng      |                   | None                |                       | None                     |
| Prof K Clayton    |                   | None                |                       | None                     |
| Prof S Darby      |                   | None                |                       | None                     |
| Prof T Dexter     |                   | None                |                       | None                     |
| Dr G Draper       |                   | None                | National Grid Company | Collaborative assistance |
| Prof O Eden       |                   | None                |                       | None                     |
| Prof D Goodhead   |                   | None                |                       | None                     |
| Prof N Haites     |                   | None                |                       | None                     |
| Prof J Little     |                   | None                |                       | None                     |
| Prof P Smith      |                   | None                | BNF plc               | Grant                    |
| Dr M Spittle      |                   | None                |                       | None                     |
| Prof J Thacker    |                   | None                |                       | None                     |
| Dr T Wheldon      |                   | None                |                       | None                     |
| Prof M Whitehouse |                   | None                |                       | None                     |
| Prof E Wright     |                   | None                |                       | None                     |

## APPENDIX D

Apart from its now five full reports and its one joint report with RWMAC, COMARE has produced many other statements on a variety of different issues. They were usually published in *Hansard* and the references are given below.

### **COMARE Statements prior to the publication of the Committee's Fourth Report**

COMARE 1989; Statement from COMARE on the Limitation of Human Exposure to Radon in the Home. Copies available from the Secretariat.

COMARE Statement of advice on the "Case-control study of leukaemia and lymphoma among young people near the Sellafield nuclear plant in West Cumbria", *Hansard*, 2 April 1990 Col 430-434

COMARE Statement of advice on the "Results of a case-control study of leukaemia and non-Hodgkin's lymphoma in children in Caithness near the Dounreay nuclear installation". *Hansard*, 21 March 1991 Col 187-190

COMARE Statement of advice on "Parental occupations of children with leukaemia in west Cumbria, north Humberside and Gateshead". *Hansard*, 3 June 1991 Col 64-66

COMARE Statement of advice to Health Departments *Health effects of ultra violet radiation*. *Hansard* 1 July 1992 Col 637-639

COMARE Statement of advice on the "Study of cancer in young people living in the vicinity of Sellafield". *Hansard*, 14 January 1993 Col 803-804

COMARE Statement of advice on the "Aldermaston and Burghfield case-control study." *Hansard*, 18 May 1993 Col 151-152

COMARE Statement of advice on the "Investigation of the incidence of cancer around Wylfa and Trawsfynydd nuclear installations". *Hansard*, 16 June 1994 Col 655-657

Since the publication of the COMARE Fourth Report in 1996 and the change in the Committee Secretariat arrangements, the Committee has produced three full statements and one interim statement. These statements are reproduced in full on the following pages.



## Introduction

Recommendation 5 of the Black Advisory Group report of 1984 pointed out the need for an independent unit to monitor small area health statistics around major installations producing discharges to the environment that might represent a health hazard to the public, and thus allow early warning of any untoward health effects to be obtained.

The Small Area Health Statistics Unit (SAHSU) was set up at the London School of Hygiene and Tropical Medicine in 1987.

The SAHSU methodology used in these papers involves an examination of health statistics in geographical areas at varying distances from radio transmitter masts. A positive finding is seen as warranting further investigation but does not demonstrate that the health effects were caused by emissions from such sources.

## Background to the SAHSU investigations

In 1992 SAHSU was asked by the Department of Health to investigate cancer incidence around the Sutton Coldfield television/FM radio transmitter in the west Midlands of England after media claims of an increased incidence of leukaemia and lymphoma in the vicinity of the transmitter.

An initial study in 1993 showed an excess of adult leukaemia within 2 km of the Sutton Coldfield transmitter with 23 cases being observed in an area where approximately 13 cases would have been expected. However, further studies around similar TV and FM transmitters in Great Britain showed no independent evidence of an excess leukaemia incidence within a few kilometres of a transmitter. The Department of Health asked COMARE to consider these preliminary studies and COMARE asked NRPB to advise on exposure data.

In 1994 COMARE sought verification of the diagnoses of the cases at Sutton Coldfield and in 1995 asked for further studies of field strength in the vicinity. Also in June 1994, the Committee, having reviewed relevant research data, concluded that there was no firm evidence of a carcinogenic hazard from exposure to very low frequency electromagnetic fields.

## The findings of the final SAHSU reports

### (1) Sutton Coldfield transmitter

A small area study of cancer incidence between 1974-86 was carried out to investigate an unconfirmed report of a "cluster" of leukaemias and lymphomas near the Sutton Coldfield TV/FM transmitter in the west Midlands of England. The study used a national database of postcoded cancer registrations and population and socioeconomic data from the 1981 census. The cancers studied were haematopoietic and lymphatic, brain, skin, eye, male and female breast, lung, colorectal, stomach, prostate and bladder.

The study area was defined as a 10 km radius circle around the transmitter, within which 10 bands of increasing distance from the transmitter were defined as a basis for testing for a decline in risk with distance. An inner area was arbitrarily defined for descriptive purposes as a 2 km radius circle.

There was, as stated above, an excess of adult leukaemia within 2 km of the transmitter and there was a significant decline in risk with distance from the transmitter. However, an increasing trend with distance was found for non-Hodgkin's lymphoma. The authors noted that no causal implications can be made from a single cluster investigation of this kind.

## (2) All high power transmitters

A study of cancer incidence in small areas near 20 high power TV/FM transmitters in Great Britain was carried out to test the hypothesis that the levels of leukaemia in the surrounding areas were associated with distance from these transmitters. The time period, database and areas around the transmitters were the same as those in the first study. Cancers studied were adult leukaemias, skin melanoma, bladder cancer, childhood leukaemia and brain cancer. Statistical analysis was performed for all sites combined, four overlapping groups of transmitters and for all sites separately. There was no observed excess within 2 km of the sites. The authors note that the magnitude and pattern of risk found in the Sutton Coldfield study are not confirmed in the second study.

## COMARE Statement on the SAHSU Studies

Cases of leukaemia are not homogeneously distributed throughout the country. Even quite large areas such as counties can differ to the extent that one county may have only 70-80% of the incidence of childhood leukaemia seen in another. Differences tend to be more extreme when smaller areas are compared. This poses great difficulties when attempting to assess a possible risk factor, the magnitude of whose effect, should it exist, is no greater than that attributable to the variation found between different geographical regions.

In respect of the two SAHSU studies, we note that in no case is there a suggestion of an association of *childhood* leukaemia with proximity to a radio/TV transmitting mast.

In the case of the Sutton Coldfield transmitter, we note that there is a decrease in the incidence of *adult* leukaemia with increasing distance (with a statistically significant excess only in the inner band within 2 km of the mast). This must be contrasted with an increased incidence of non-Hodgkin's lymphoma with increasing distance (with a statistically significant excess in the outer band 2-10 km from the mast). Such opposing trends clearly do not demonstrate a pattern that would be consistent with a particular effect produced by the Sutton Coldfield transmitter.

Around all transmitters other than Sutton Coldfield, there is no evidence of an excess of leukaemia relative to national rates within any of the inner bands (up to 2 km from the mast). For the Crystal Palace transmitter there is a statistically significant decreasing trend with increasing distance but a complete absence of any excess in the innermost three bands (up to 2 km).

These observations and inconsistencies lead us to conclude that, overall, these data do not indicate that residence close to a radio/TV transmitting mast is associated with an increased risk of leukaemia. We also note that there is no experimental evidence that radiofrequency radiation acts as a carcinogen. In our opinion these new data do not change our advice, given in 1994, that there is no firm evidence of a carcinogenic hazard from exposure to very low frequency electromagnetic fields, as far as this advice relates to TV and radio mast emissions. The Committee can see no implications from these studies for the siting of new or existing transmitters nor does it see any need for further epidemiological studies in the areas around TV/radio masts in the United Kingdom.

**Background**

In 1994, COMARE was asked by the Department of Health to comment on the Departmental strategy for research on radiation protection. The Committee broadly endorsed what was proposed, and subsequently commented on the Research Strategy before it was put out to tender. The Department of Health undertook a 2 stage tender process, which involved independent peer review of submitted project proposals. Projects were funded, rejected, or researchers were asked to submit proposals in a modified form on the basis of this review process. A total of 26 projects are currently being funded as a result.

For the June 1996 meeting of COMARE, the Department of Health provided abstracts of the research projects funded within the present programme. A response from COMARE was requested on the following issues:

- (1) No suitable proposals for new research were received in the following areas specified in the research strategy:

Health risks from Auger emitters  
Health risks (measurement, target tissues and epidemiology)  
Risk perception of non-ionising radiation

Members of the Committee were asked if they knew whether any or sufficient work was underway elsewhere covering these areas.

- (2) The Committee was asked whether the funded research projects adequately addressed the priorities in the programme strategy, and whether the issues raised in the recommendations of the COMARE Fourth Report are being adequately addressed.
- (3) COMARE was asked whether there were other areas of research which should be addressed in future within the Department of Health Research Programme.

### **COMARE Statement on the Department of Health Research Programme**

The Committee recommends that the three research areas, identified in the Department's research strategy, for which no suitable proposals were submitted should remain open for future funding by the Department. These areas are: health risks from Auger emitters; measurement, assessment of target tissues and epidemiological evidence for health risks from ionising radiations; risk perception of non-ionising radiation.

The Committee is of the opinion that the current research programme is good, and represents an adequate response to the recommendations of the Fourth Report. However, further areas of research in the areas of genetic instability and minisatellite mutations would be valuable and new proposals should be considered in these areas.

An area of work of particular importance in the light of the COMARE Fourth Report is the interaction between radiation and other environmental and/or infectious agents. In particular, mechanistic studies of interactions would be

valuable. The Committee recommends that research in this area should be extended and that this could be initiated by a directed call for proposals for such mechanistic studies. The Committee suggests that the effects on proliferation, of stem cell interaction and inhibition of apoptosis, could be mentioned as examples of postulated mechanisms. Epidemiological studies of interactions, for example between radiation exposure and infectious diseases, also need to be addressed. The Committee would provide further advice if requested.

The following areas of research were also identified as priorities:

- (1) The genetic basis for differences in sensitivity between individuals, and the differences in sensitivity between somatic and germ cells in the same individual. The possibilities for research in this area are expanding due to the rapid development of cloning techniques and suitable probes.
- (2) The risks associated with exposure to radiations of different quality.
- (3) The importance of the distribution of target cells for lymphoid malignancies, and the effects on the risk model for leukaemia.

### **COMARE Statement on RWMAC**

The safe management of radioactive waste is crucial for the continued use of radioisotopes in the medical and commercial sectors. The Radioactive Waste Management Advisory Committee (RWMAC) provides an important, independent forum for discussing and reviewing radioactive waste management practices in the United Kingdom. The Committee brings together individuals with professional expertise in many disciplines relevant to radioactive waste management, not only health-related, and thus complements the work of COMARE. The two Committees have co-operated effectively together, making use of their complementary expertise, in a joint study on the potential health effects and possible sources of radioactive particles found in the vicinity of the Dounreay Nuclear Establishment. This study led to the publication of a joint report.

The keen public interest in the topic of radioactive waste management, together with the deep rooted opinions held in some areas emphasises the requirement for the RWMAC.

The status and structure of the RWMAC as an independent Committee comprising individuals from diverse backgrounds is appropriate for its function. It is important, if there are any changes to Committee membership in the future, that the RWMAC continues to reflect the wide range of interests in this topic. The membership and structure of the RWMAC enable it to comment authoritatively on the technical and wider issues surrounding radioactive waste management and thus appropriately inform Government Policy. "Contracting out" some or all of the functions of this Committee would be overwhelmingly detrimental, since undertaking the Committee's functions within a privatised framework would compromise the Committee's potential to provide independent opinion. It is essential that such a Committee should be independent of all external influences or pressures and that the public should perceive it as such.

In view of the continuing national and international developments in the area of radioactive waste management, the mode of operation of the Committee, in that it produces an annual summary of its work, continues to be both relevant and appropriate. These annual reports are usefully supplemented by reports on specific topics.

In summary:

- (1) There is a definite continuing requirement for a Committee such as the RWMAC.
- (2) The RWMAC's existing status and function satisfy this requirement.
- (3) The RWMAC's mode of operation is entirely appropriate and should not be significantly altered.

## Introduction

In its Second<sup>1</sup> and Third<sup>2</sup> Reports, the Committee on the Medical Aspects of Radiation in the Environment (COMARE) recommended that studies should be set up to consider any possible effects on the health of the offspring of parents occupationally exposed to radiation. The Department of Health (DH) and the Health and Safety Executive (HSE) provided funding for two major epidemiological studies. Prior to the setting up of these two studies, Gardner et al<sup>3</sup> published a study suggesting that occupational exposure of fathers to ionising radiation prior to the conception of any offspring, raised the risk of the subsequent development of leukaemia or non-Hodgkin's lymphoma (LNHL) in those children and that this raised risk was dose dependent. Gardner's conclusions rested mainly on the observation that there was an increase in the incidence of LNHL in the children of those fathers who received the highest radiation dose (greater than 100 mSv). This association and the possibility that it could be the cause of some cases of childhood leukaemia has come to be known as the "Gardner hypothesis". Following publication of this study COMARE made further recommendations for biological research to address the Gardner hypothesis. COMARE also stated that both of the epidemiological studies already recommended should be designed to test this hypothesis. In 1990, DH and HSE jointly established the Co-ordinating Committee on Health Aspects of Radiation Research (CCHARR) to manage Government-sponsored research to investigate the association suggested by Professor Gardner and his colleagues. The epidemiological studies recommended by COMARE were included in the CCHARR programme.

## Studies of health outcomes in children of radiation workers

The first of these two epidemiological studies to be completed is that of Draper et al<sup>4</sup> and is referred to here as the "Linkage study". This has been considered by COMARE prior to publication. The second is known as the Nuclear Industry Family Study (NIFS), which is due to be published in 1998. A further study by Roman et al<sup>5</sup>, which was funded by HSE and published in 1996, examined the reproductive outcome and health of the children of medical radiographers, who may also be exposed to radiation because of their occupation.

COMARE has considered the results of these two recently published studies<sup>4,5</sup>, which have both examined the health of children whose parents were exposed to ionising radiation in the course of their work. As the Nuclear Industry Family Study has yet to be completed, this statement is the interim view of COMARE. A full statement will be provided when COMARE has seen the results of NIFS and the biological research funded by CCHARR.

## Findings of the studies

### (1) The Linkage study

The objective of this case-control study<sup>4</sup> was to determine whether or not parents who are occupationally exposed to radiation before the conception of their children, have an increased chance of having children who develop cancer and to investigate the radiation dose to which those parents were exposed prior to the conception of their children. The cases were children aged 0-14 years, who were born and diagnosed with cancer between 1952 and 1986 in Britain. Scottish cases of LNHL diagnosed in the period 1987-1990 were also included. The study used the database held by the National Radiological Protection Board (NRPB), on more than 120,000 workers who were registered as being monitored for their potential exposure to radiation. This database, which is known as the National Registry for Radiation Workers (NRRW) and which includes occupational data on doses of radiation, was linked to other databases holding information on childhood cancers.

These childhood cancer databases are held by the National Registry of Childhood Tumours, the Oxford Survey of Childhood Cancers and a database of Scottish childhood LNHL compiled by Professor Kinlen. The aim was to identify children of radiation workers and details of workers preconception radiation doses. The NRRW database was also linked to data on control children matched to the cases by area and time of birth. Information was not available on the children of non-radiation workers employed at nuclear installations.

The main finding of the study was that fathers of children with LNHL were significantly more likely to be radiation workers than were fathers of control children born in the same part of the country. The relative risk for children of fathers who had been radiation workers prior to their conception was 1.77 with 95% confidence limits of 1.05-3.03. However, the Linkage study found no relationship with dose in the preconception period. Indeed, the association was most marked in those with doses below the limit of detection, that is below 0.1mSv and there was no association with preconception doses greater than 100 mSv, the level at which Gardner et al<sup>3</sup> found a high relative risk. There was no increased risk for any other childhood cancers associated with paternal radiation exposure (relative risk 0.94 with 95% confidence limits of 0.56-1.58).

The relative risk for all childhood cancers in the children whose mothers were radiation workers was higher at 5.0 with 95% confidence limits of 1.42-26.94. However, the latter figures are based on very small numbers (15 cases and 3 controls) and must be interpreted with great caution.

The authors discussed possible explanations for their results including population mixing (sometimes known as the "Kinlen hypothesis"<sup>6</sup>). Kinlen and his colleagues and other workers have carried out a number of analyses relating to areas in which there have been high levels of population mixing, particularly between persons from urban and rural backgrounds such as occurs in the construction of remote industrial plants, and have found a significantly increased incidence of childhood leukaemia in such areas. This effect has been attributed to the bringing together of infectious and susceptible individuals in abnormal numbers.

The authors of the Linkage study have concluded that their results do not support the Gardner hypothesis. They have suggested that other factors relating to radiation workers such as exposure to infective or other agents, or chance, may explain the findings.

## **(2) The medical radiographers study**

The study of medical radiographers<sup>5</sup> used a questionnaire technique to investigate the incidence of adverse reproductive outcomes and the subsequent health, including cancer, of the children of medical radiographers, a predominantly female workforce. The frequencies of adverse reproductive outcomes (eg. miscarriage and stillbirth) were similar to those reported in other studies. There were no substantial differences in the risks of major congenital malformations, chromosomal anomaly or cancer in the children of radiographers as compared to the general population. In the age group 0-14 years, 3 cancers were observed in children of male radiographers compared to 1.1 expected. For the children of female workers, the figures were 7 cancers observed to 7.7 expected. Because of the small numbers involved the authors of the study themselves stress that caution needs to be exercised in the interpretation of the results. It should be noted that long-term dose records are not routinely held for medical radiographers. Thus, dose-response analyses could not be performed.

## COMARE Interim Statement on the Studies

COMARE has noted the results of the Linkage study and agrees with the authors that there is no evidence for a dose-related effect between preconception radiation dose to parents and the incidence of LNHL in their children. There was no association with preconception doses greater than 100 mSv and the association was most marked in the children of those workers with occupational doses below the limit of detection. Hence, an increase in LNHL with radiation dose, implicit in the Gardner hypothesis, is not supported by this study and this is in line with the findings of other recently published data<sup>7,8,9</sup>.

One aspect of the Linkage study, however, needs further consideration. That is the finding that male radiation workers were 1.77 times more likely to have children who develop LNHL than the general population. This finding must be interpreted with some caution, but if it represents a real risk and is not due to chance, then the risk must be small in absolute terms. The outcome of the radiographers study also supports this conclusion. This finding is consistent with the possibility that any effect could be due either to being a radiation worker or being employed at an establishment where radiation work is undertaken, whether or not by the individual concerned. The latter interpretation is not unreasonable as an hypothesis because it has been shown that both radiation and non-radiation workers in the nuclear industry have a cancer and mortality profile that differs significantly from that of the general population. Overall mortality and the incidence of all cancers taken together are lower in nuclear workers, but with an increase in one specific group of cancers, namely LNHL. This may possibly be due to the differences in the lifestyle of nuclear workers<sup>10</sup>. There is also some suggestion in the Linkage study that female radiation workers have an increased risk of having children with cancer. However, as the number of female workers included in the study was small, no firm conclusion can be drawn at present.

The authors of the Linkage study suggest that population mixing may play a role in explaining their findings, a possibility that COMARE discussed in its Fourth Report<sup>11</sup> in regard to the rate of LNHL in young people resident in the village of Seascale close to the Sellafield reprocessing plant. If this were to be the explanation for the results of the Linkage study, increased risks due to these factors should also apply to non-radiation workers at nuclear sites, but neither the Linkage study nor other studies as yet published have been specifically designed to address this issue.

We may get a much clearer picture when the results from the Nuclear Industry Family Study (NIFS) become available. We are advised that this study should be completed early in 1998. NIFS will contain information about the health of families of non-radiation workers as well as radiation workers. Consequently, COMARE proposes to reserve further comment until the results of NIFS can be considered in conjunction with the studies described above and the results of the biological research commissioned by CCHARR.

## REFERENCES

1. Committee on Medical Aspects of Radiation in the Environment (COMARE) (1988). Second Report. Investigation of the possible increased incidence of leukaemia in young people near the Dounreay Nuclear Establishment, Caithness, Scotland. HMSO, London.
2. Committee on Medical Aspects of Radiation in the Environment (COMARE) (1989). Third Report. Report on the incidence of childhood cancer in the West Berkshire and North Hampshire area, in which are situated the Atomic Weapons Research Establishment, Aldermaston and the Royal Ordnance Factory, Burghfield. HMSO, London.



3. Gardner M J, Snee M P, Hall A J, Powell C A, Downes S and Terrell J D (1990). Results of case-control study of leukaemia and lymphoma among young people near Sellafield nuclear plant in West Cumbria. *Br Med J*, **300**, 423-429.
4. Draper G J, Little M P, Sorahan T, Kinlen L J, Bunch K J, Conquest A J, Kendall G M, Kneale G W, Lancashire R J, Muirhead C R, O'Connor C M and Vincent T J (1997). Cancer in the offspring of radiation workers: a record linkage study. *Br Med J*, **315**, 1181-1188.
5. Roman E, Doyle P, Ansell P, Bull D and Beral V (1996). Health of children born to medical radiographers. *Occup Environ Med*, **3**, 73-79.
6. Kinlen L J (1995). Epidemiological evidence for an infective basis in childhood leukaemia. *Br J Cancer*, **71**, 1-5.
7. Little M P, Wakeford R and Charles M W (1994). A comparison of the risks of leukaemia in the offspring of the Sellafield workforce born in Seascale and those born elsewhere in West Cumbria with the risks in the offspring of the Ontario and Scottish workforces and the Japanese bomb survivors. *J Radiol Prot*, **14**, 187-201.
8. Little M P (1993). A comparison of the risks of leukaemia in the offspring of the Japanese bomb survivors and those of the Sellafield workforce with those in the offspring of the Ontario and Scottish workforces. *J Radiol Prot*, **13**, 161-175.
9. Little M P, Wakeford R, Charles M W and Anderson M (1996). A comparison of the risks of leukaemia and NHL in the first generation offspring (F1) of the Danish thorostrast patients with those observed in other studies of parental pre-conception irradiation. *J Radiol Prot*, **16**, 25-26.
10. Carpenter L, Higgins C, Douglas A, Fraser P, Beral V and Smith D (1994). Combined analysis of mortality in three United Kingdom nuclear industry workforces 1946-1988. *Radiat Res*, **138**, 224-238.
11. Committee on Medical Aspects of Radiation in the Environment (COMARE) (1996). Fourth Report. The incidence of cancer and leukaemia in young people in the vicinity of the Sellafield site, West Cumbria: further studies and an update of the situation since the publication of the report of the Black Advisory Group in 1984. HMSO, London.





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