IN THE FIRST TIER TRIBUNAL

RESERVED DECISION OF THE WAR PENSIONS & ARMED FORCES COMPENSATION CHAMBER

IONISING RADIATION APPEALS

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References

References to trial bundles and the transcript of evidence use the following format

For the B files the reference is Bundle/Tab/Page.

For the D files the reference is D then the tab number, page number and paragraph number.

For all the other files the reference is File and Page Number.

Core/Tab refers to the core bundle prepared by the Treasury Solicitor for the videoconference with Mr Pasquini.

Transcript T date page and where appropriate line

Quotes from bundle documents – "*in italics*".

Quotes from transcript in smaller font

Representation

1. The appellants Leonard Abdale, Donald Battersby, Darryl Beeton, Trevor Butler, the late Derek Hatton, Ernest Hughes, Brian Lovatt, the late Mrs Dawn Pritchard, Mrs Laura Selby, Denis Shaw and Mrs Mary Williams were represented by Mr Anthony Metzer and Mr Adam Gersch instructed by Hogan Lovells on behalf of the Royal British Legion (RBL).

2. The appellants the late Bert Sinfield and Mrs Anna Smith were represented by Mr James Dingemans QC instructed by Rosenblatt.

3. The Secretary of State was represented by Mr Adam Heppinstall and Ms Hannah Curtain instructed by the Treasury Solicitor.

BACKGROUND AND INTRODUCTION

4. These appeals have been brought under Section 1 of the Pensions Appeal Tribunals Act 1943 (the 1943 Act). They have been made by former Members of the Armed Services or their widows. They are against the rejection of claims for entitlement that disablement or cause of death are attributable to exposure to ionising radiation whilst serving at Maralinga, Australia or on Christmas Island during the British Government's Nuclear Testing Programme in the 1950's.

5. It will also be necessary to consider aggravation but only in those cases where atherosclerosis is the rejected condition.

6. The UK's 21 atmospheric nuclear detonations, two other trials and three clean-up operations conducted between October 1952 and August 1967 are tabulated at Annex A, showing the presence at individual tests of the 14 appellants in these appeals.

7. For many years concern has been expressed by service organisations that the Tribunal was making inconsistent decisions in relation to such claims. A number of appeals were successful – see the list prepared by Sue Rabbitt-Rolfe at B12/163. It is not known how many have been unsuccessful. The lack of consistency was also recognised by the Ministry of Defence and the Service Personnel and Veterans Agency (SPVA). These concerns were raised with the President of the Pensions Appeal Tribunal and subsequently the President of this Tribunal. The Tribunal was also aware that medical and scientific opinion had been changing.

8. In November 2008 following the major re-organisation of Tribunals, new Tribunal Rules came into effect. These provided this Tribunal with much more effective case management powers. It has enabled this Tribunal to arrange for a group of appeals to be heard together. This has addressed another concern of the Tribunal – that there had been an inequality between the parties in single case ionising radiation appeals and that a more balanced hearing was needed out of fairness to the appellants.

9. In late 2009 the Tribunal started this process. It could only do so, however, with appeals which had been received. This therefore has been the major factor in determining the

group of appeals which we have been hearing. It is a principal reason why only one of the test series in Australia has been considered in these appeals.

10. Although the appeals are known collectively as the Ionising Radiation appeals, the Tribunal is very conscious that they involve individual claims. It is therefore right that we should set out below some basic information about the appeals.

Name of appellant	Appeal ref no.	Date of Decision	Rejected Conditions or Cause of Death
Leonard Abdale	ENT/328/2010	10 December 2009	Bladder Cancer, Cataracts
Leonard Abdale	ENT/293/2012	17 March 2010	Blast injury to ears (1953-76)
Donald Battersby	ENT/176/2010	15 October 2009	Chronic Lymphatic Leukaemia
Darryl Beeton	ENT/129/2010	25 November 2009	Atherosclerosis, Myocardial infarction
Trevor Butler	ENT/814/2007	24 April 2007 17 July 2007	Immune System Dysfunction, Staphylococcal Lumbar Discitis, Streptococcal viridans infection, Glomerulonephritis, Klebsiella urinary tract infection and Hypertension
The late Derek Hatton	ENT/723/2008	4 June 2008	Polycythaemia Rubra Vera
Ernest Hughes	ENT/065/2010	13 February 2009	[Tribunal deciding exposure issue only]
Brian Lovatt	ENT/279/2010	22 January 2010	Atherosclerosis, Myocardial infarctions
The late Mrs Dawn Pritchard	ENT/039/2008	13 February 2006	Bronchopneumonia, Cardiorespiratory failure, end stage renal failure, Berger's Nephropathy, Hypertensive heart disease, Arterial Atheroma and Type II diabetes
Mrs Laura Selby	ENT/658/2008	8 March 2006	1(a)Idiopathic Fibrosing Alveolitis, (b)Type II diabetes
Denis Shaw	ENT/054/2010	11 August 2009	Sub-capsular cataract
The late Bert Sinfield	ENT/751/2007	2 March 2007	Large Cell Lymphoma
The late Barry Smith	ENT/680/2008	8 May 2008	Carcinoma Pancreas
Mrs Anna Smith	ENT/088/2010	31 July 2009	1(a) Adeno Carcinoma of Head of Pancreas
Mrs Mary Williams	ENT/768/2008	7 May 2008	1(a) Carcinoma Head of Pancreas

11. The decision by the Tribunal to arrange for a group of appeals to be heard together was also made against the background of the decision by Foskett J in the High Court on the preliminary issue as to whether the personal injury claims made by over 1,000 claimants had been brought out of time. He concluded that the appeals should be allowed to proceed to trial.

12. The Tribunal was also aware that some 690 of the claimants in the High Court were former members of the Armed Services and therefore entitled to make a claim for a war pension under the Service Pensions Order 2006. There are no time limits for making such claims.

This was an additional reason why it was desirable to have a full hearing where all the issues could be considered in greater detail than had been previously possible. The Secretary of State commented on page 180 of his closing written submissions:

"10.3 The aim is for the Tribunal's decision (subject to any appeal) to provide guidance for future nuclear test veteran war pension decisions and appeals, so as to encourage consistency and to provide public confidence in the administration of war pensions and war pensions appeals."

13. A number of appeals have been received since the main Directions for these appeals to be heard together. They have been stayed under Rule 18 of the Tribunal Procedure Rules 2008. This allows, subject to safeguards, for common issues of fact and/or law decided in these appeals to be binding on the parties in the stayed appeals.

14. In the preparation for the High Court hearing very substantial disclosure had been given by the Secretary of State. There has been considerable dispute as to how complete the disclosure was. It was made for the purposes of the limitation issue but in order to decide that issue Foskett J had to form a view about the overall merits of the claims. So the disclosure needed to be extensive.

15. The significance of that disclosure was that it could be used again as the basis for the documentation required by the Tribunal. This was against a background of the wholly inadequate disclosure that had been given by the Secretary of State in appeals previously heard by the Tribunal.

16. In the High Court both the claimants and the Ministry of Defence had filed expert evidence about nuclear physics – ionising radiation, cytogenetics and epidemiology.

17. It is important for readers of this decision to understand that there are major differences between the High Court proceedings and these proceedings. In the High Court the claimants had to prove that the Ministry of Defence acted negligently and they had to show this on the balance of probabilities. In these proceedings the Tribunal is required to decide whether the appellants are entitled to an award under the War Pensions Scheme which is a strict liability Scheme – negligence does not need to be shown. To succeed the appellants have only to show on the basis of raising a reasonable doubt based on reliable evidence that their claims should succeed. This is a much less onerous test than that in the High

Court. We should add that The Secretary of State contends that there is an important exception to this. The appellants disagree. In short the issue is whether the appellants have to prove the injurious or pathological process in relation to their claimed conditions on the balance of probabilities. The issue is more fully described in paragraphs 47 to 59 below.

18. Foskett J decided in a long judgment that the claims should be allowed to proceed to trial. We wish to acknowledge the great assistance that the Tribunal has derived from the very clear descriptions of the scientific and medical background to the claims. The decision is reported at [2009] EWHC 1225(QB). We particularly commend to readers of this decision the following passages in the judgment:

> Section 11: The underlying science, including the essential nuclear physics – ionising radiation.
> Section 12: The effects on health of ionising radiation.

19. The Ministry of Defence appealed Foskett J's decision. In November 2010 the Court of Appeal allowed the Appeal. The claimants appealed to the Supreme Court who disallowed the Appeal. Thus most of the 1,000 claimants in the High Court are effectively precluded from continuing with a negligence claim against the Ministry of Defence.

20. In these appeals Mrs Sinfield is making the appeal on behalf of her late husband Bert Sinfield. Mr Sinfield was one of the ten individual test cases in the High Court. Foskett J found that his claim had been brought in time. It was not struck out. Mrs Sinfield is thus able to take the case of her late husband to trial. However Mr Sampson, the partner at Rosenblatt, told us that the Treasury Solicitor is not going to take any further action about the claims in the High Court until After the Event insurance is in place. This is the subject of proceedings in the European Court of Human Rights. This means that there have been no further developments in the High Court litigation for us to take into account.

21. We have already referred to the extensive disclosure exercise which had taken place in the High Court. Since Rosenblatt were representing two of the appellants the Tribunal considered that the appropriate approach to disclosure was for them to ask for those documents on which they wished to rely to be disclosed in these proceedings. The Tribunal gave specific directions in relation for some undisclosed documents which

Rosenblatt had requested and which were in a schedule placed in the House of Commons Library as a result of a Member's question.

22. Judge Stubbs' reasons for ordering disclosure dated 25 October 2010 (J page 63) explain why the Secretary of State's disclosure in these Appeals had been wholly inadequate. Those reasons also rejected the Treasury Solicitor's excuses for not complying with Rule 23(4) (b) of the Tribunal Rules.

23. The Tribunal made a direction for further disclosure on 17 September 2010 (J page 49) because it had become clear by then that the Secretary of State had failed to disclose either in the High Court or in this Tribunal various documents having very high security classifications. Judge Stubbs inspected 18 documents at the Ministry of Defence and concluded that they were clearly relevant and should be inspected by Rosenblatt subject to complying with the security requirements contained in the Directions for the Inspection of Documents – see paragraph 26 below.

24. The extent of disclosure which has been made in these Appeals is very extensive in comparison with the disclosure made initially in individual appeals and in all previous appeals to this Tribunal. In these Appeals there are over 40 lever arch files of evidence. Having said that the Tribunal recognises that disclosure can never be complete and that documents which are now over 50 years old are difficult to find, may have been quite legitimately destroyed and that the Atomic Weapon Establishment's (AWE) filing system did not readily lend itself to finding individual documents so many years later. Both Rosenblatt and Hogan Lovells have had full opportunity to request disclosure of any documents that they considered relevant. There have been many such requests and the Tribunal has concluded that the extensive disclosure that has been given allows these Appeals to be heard justly and fairly and that the disclosure is proportionate balancing the need to have as full disclosure as possible, the desirability of not delaying the hearing of these Appeals further and the very extensive documentation that is before the Tribunal. We record that no complaint was made on behalf of the appellants at the hearing that there had not been proper disclosure.

25. During the first half of 2010 representation in these Appeals was sorted out with Rosenblatt representing the late Mr Sinfield and Mr Smith whilst The Royal British Legion represented the other appellants. It was later that year agreed that Rosenblatt

would deal with general issues relating to exposure to ionising radiation on behalf of RBL. This was both because of the experience Rosenblatt had gained in the High Court and because disclosure included many highly classified documents which RBL were not able to inspect.

26. Classified documents have caused a number of practical difficulties in preparing these Appeals. The inspection and use of classified documents was the subject of an 11 page Directions for the Inspection of Documents first made in August 2010 (J page 37). A new vetting process had been introduced by the Ministry of Defence for use in relation to very highly classified documents. There were delays whilst Mr Sampson and Mr Evans from Rosenblatt together with their Counsel Mark James, obtained Developed Vetting (DV) security clearance.

27. Practical problems arose because the highly classified documents could only be inspected in special facilities at the Ministry of Defence and could not be read in open court. It was agreed that a gisting exercise should take place with the gists being approved by Professor Regan and Mr Ken Johnston the experts on nuclear physics instructed by the appellants and the respondent respectively. This exercise both delayed the preparation of the Appeals and caused Rosenblatt to incur unexpected expense because Rosenblatt did not arrange for Professor Regan to attend a preliminary meeting with Mr Johnston before Mr Johnston started the gisting exercise as provided for in Direction 18(a) dated 3 May 2011 (J page 79 at 87). However, the exercise has enabled all hearings to be in public which the Tribunal has considered to be important given the public interest in these Appeals.

28. The Secretary of State also objected to Directions made by Judge Stubbs for disclosure of a highly classified document which listed highly classified documents relating to the atomic testing programme. The Secretary of State appealed to the Upper Tribunal but was unsuccessful. The decision dated 27 September 2011 is reported as The Secretary of State for Defence v LA [2011] UKUT 391 (AAC). The decision enabled Rosenblatt and Professor Regan to look at the list and make requests for disclosure of specific highly classified documents.

29. In May 2011 Mr Heppinstall on behalf of the Secretary of State had formulated his contention that the appellants also had to prove the injurious process as well as disablement and service on the balance of probabilities. At a directions hearing on 6 July

2011 (J page 107) Judge Stubbs recommended that RBL should obtain advice from Hogan Lovells about the Secretary of State's contentions about proving injurious process on the balance of probabilities because of the wider implications for appeals which are heard in the Tribunal. He refused to direct that there should be a preliminary hearing on the point.

30. The appeals were due to be heard in July 2011. The hearing had to be postponed for the reasons set out in the Directions dated 6 July 2011. A further hearing date in January 2012 was fixed.

31. On 12 December 2011 Rosenblatt informed the Treasury Solicitor and RBL that they were no longer representing any of the appellants in these appeals apart from Mrs Sinfield and Mrs Smith and that they had terminated the arrangements with RBL for representing other appellants on the general issues about exposure to ionising radiation and particularly in relation to evidence contained in classified documents. They also stated that they would no longer be instructing Mr Mark James of Counsel who had appropriate security clearance but would be represented by Counsel who did not. This placed RBL in an impossible position for a hearing which was due to start on 9 January 2012. The Tribunal concluded that it would not be just or fair for the hearing to be held in January.

32. At the same time Hogan Lovells applied for a hearing of the preliminary issue in January. This was refused by a decision dated 18 December 2012 (J page 129).

33. The tribunal was informed on 28 February 2012 that RBL had arranged for Hogan Lovells and Counsel to represent the appellants whom RBL had hitherto been representing. However this necessitated obtaining both legal aid and security clearance. Both were long drawn out processes. The hearing dates in January and February 2013 were fixed in the autumn of 2012.

34. The Tribunal arranged for three of the expert witnesses (Professor Mothersill, Professor Parker and Dr Braidwood) in these appeals also to give evidence in respect of Mr Nick Simons' appeal. His appeal was originally included with the other appeals being heard together. He served at Maralinga as part of the Hercules V clean up operation. His appeal was removed from the list on 1 November 2011. We have prepared a separate decision in his appeal.

The role of Dr Busby in these appeals

35. When the Tribunal made Directions in early 2010 for the individual appeals to be heard together Dr Busby had already prepared reports in support of appeals by Mrs Pritchard and Mrs Williams. In the Responses in the appeals by Mr Abdale, Mr Beeton, Mr Hatton, Mr Hughes, Mrs Selby, Mr Shaw, and Mr Smith the SPVA included in the Response a document prepared by Mr Ron Brown commenting on Doctor Busby's Research note even though the research note itself was not included in the Response.

36. On 23 July 2010 the Tribunal directed that Dr Busby should produce a composite report. He did so. He subsequently produced five further reports. Mr Ken Johnston, the atomic physics expert instructed by the Treasury Solicitor and Professor Busby have been critical of each other's reports. Professor Regan who was instructed first by Rosenblatt and then by Hogan Lovells disagrees with Dr Busby in significant respects. None of the parties wished to rely on his evidence.

37. The Tribunal were informed on 19 December 2012 (some six weeks before the start of the hearing) by Mr Gersch instructed by Hogan Lovells that they would not be calling Dr Busby as an expert witness. Dr Busby wrote to the Tribunal on 20 January 2013 offering to fly from Latvia at his own expense to give evidence to the Tribunal because he was concerned that the experts instructed by the parties would not deal with his arguments. Dr Busby's request to give evidence was canvassed with the parties. The Appellants were neutral. The suggestion was opposed by the Secretary of State. Following written and oral submissions from the parties the Tribunal decided not to accept Dr Busby's offer. The Tribunal was reinforced in making this decision by the observations about doing this in paragraph 17 of Chandra v Care Standards Tribunal [2008] EWHC 2833 (Admin), paragraphs 30 and 31 of Jeleniewicz v Secretary of State for Work and Pensions [2008] EWCA Civ 1163 and paragraph 11 of Clapson v British Airways [2001] IRLR 184. Dr Busby was informed of the Tribunal's decision by emailed letter dated 31 January 2013.

Oral evidence

38. At the hearing we heard oral evidence from Mr Abdale, Mr Battersby, Mr Beeton, Mr Butler, Mr Hughes and Mr Shaw. We had received written statements of evidence from all the appellants who were alive at the end of 2012 and who were represented by Hogan

Lovells or from their widows or members of their family. We also received written statements of evidence from Mrs Sinfield and Mrs Smith who were represented by Rosenblatt.

39. In addition we heard oral factual evidence from Mr Pasquini who had been a navigator in the Canberra aircraft which flew through the atomic cloud following the Grapple Y and Grapple Z2 detonations.

Expert evidence

40. We heard expert oral evidence from Professor Regan and Mr Johnson about atomic physics and ionising radiation, Professor Mothersill on radiobiology, Professor Parker on epidemiology, Dr Braidwood on the appellants' medical conditions and Mr Stretch and Dr Nicholson on meteorology.

41. We had asked the parties to provide lists of issues which they considered we should address. We received the following:

41.1 List of issues dated 16 January 2013 prepared by Mr Metzer and Mr Gersch.
41.2 Secretary of State's suggested amendments to the above list.
41.3 List of agreed issues in respect of the individual appellants represented by Hogan Lovells.
41.4 List of issues prepared by Adam Heppinstall and Hannah Curtain.

42. We received written submissions at the start of the hearings from Mr Metzer on the change of stance by the Secretary of State on the test to be applied and from Mr Heppinstall on expert evidence.

43. We received the following written submissions on 18 February 2013 following the last day of expert evidence on 14 February 2013:

43.1 appellants' closing submissions on standard of proof – Mr Metzer and Mr Gersch;
43.2 appellants' closing submissions – Mr Metzer and Mr Gersch;

43.3 appellants' closing submissions – Mr Dingemans and Rosenblatt;

43.4 The Secretary of State's submission on the test to be applied updated to refer to the Authorities bundles.

43.5 Secretary of State's closing submissions – Mr Heppinstall and Ms Curtain.

THE LAW

44. Article 41 of the Naval, Military and Air Forces (Disablement and Death) Service Pensions Order 2006 (SPO 2006) applies to and governs all the individual appeals. The effect of that Article in the SPO 2006 is to place the burden of proof on the appellant at least to the extent of requiring him or her to raise a reasonable doubt in his or her favour based on reliable evidence.

45. A number of issues relating to Article 41 SPO 2006 have been raised by the parties and it is therefore necessary for us to consider:

45.1 The contentions about the injurious process put forward by the Secretary of State.
45.2 What the meaning of raising a reasonable doubt based on reliable evidence is.
45.3 How raising a reasonable doubt based on reliable evidence is measured in the context of changing medical and scientific opinion.

46. The relevant provisions of Article 41 SPO 2006 are:

Entitlement where a claim is made in respect of a disablement, or death occurs, more than 7 years after the termination of service.

41*-(1) Except where paragraph (2) applies, where, after the expiration of the period of 7 years beginning with the termination of the service of a member of the Armed Forces, a claim is made in respect of a disablement of that member, or in respect of the death of that member (being a death occurring after the expiration of the said period), such disablement or death, as the case may be, shall be accepted as due to service for the purpose of this Order provided it is certified that-*

(a) The disablement is due to an injury which-
  (a) is attributable to service before 6th April 2005; or
  (b) existed before or arose during such service and has been and remains aggravated thereby; or
(b) The death was due or substantially hastened by
  (i) an injury which was attributable to service; or
  (ii) the aggravation by service of an injury which existed before or

arose during service;

(3) A disablement or death shall be certified in accordance with paragraph (1) if it is shown that the conditions set out in this article and applicable thereto are fulfilled.

(4) The condition set out in paragraph (1)(a)(ii), namely, that the injury on which the claim is based remains aggravated by service before 6th April 2005 shall not be treated as fulfilled unless the injury remains so aggravated at the time when the claim is made, but this paragraph shall be without prejudice, in a case where an award is made, to the subsequent operation of article 2(5) in relation to that condition.

(5) Where, upon reliable evidence, a reasonable doubt exists whether the conditions set out in paragraph (1) are fulfilled, the benefit of that reasonable doubt shall be given to the claimant.

(6) Where there is no note in contemporary official records of a material fact on which the claim is based, other reliable corroborative evidence of that fact may be accepted.

The contentions about the injurious process put forward by the Secretary of State

47. The Secretary of State contends that it is for the claimant/appellant to show that ionising radiation has caused an injurious or pathological process which has led to the claimed disablement and that this must be proved on the balance of probabilities.

48. The issue only arises in the appeals of Mr Battersby, Mr Butler (in respect of Staphylococcal lumbar discitis, Streptococcal viridans infection, Glomerulonephritis, Klebsiella urinary tract infection and hypertension), Mr Hatton, Mr Selby, and Mrs Pritchard (in respect of Bronchopneumonia, Cardio Respiratory failure, end stage renal failure, Bergers Nephropathy, Hypertensive heart Disease and Diabetes Mellitus) because in all the other appeals the Secretary of State accepts that the claimed conditions are radiogenic.

49. The Secretary of State contends that in those appeals the appellants must establish on the balance of probabilities:

49.1 Identification of what the injurious or pathological process is;

49.2 Is the claimed disablement capable of being caused by ("due to") the identified injurious process; and

49.3 Was the claimed disablement in fact caused by the identified injurious process in each individual appellant

50. Both Mr Metzer and Mr Dingemans submitted that the meaning of Article 41 SPO is clear. As a matter of statutory interpretation the conditions referred to in Article 41(5) are those set out in Article 41(1) (a) or 41(1) (b).

51. We agree that the meaning of Article 41 must be decided by statutory interpretation. See the Judgment of Edmund Davies J in Judd v The Minister of Pensions and National Insurance 1965 2 QB 580 at 591 where he said:

"These are all the authorities cited to me and they must naturally be most respectfully considered in interpreting Article 4(2) of the Royal Warrant of 1943 but always one must turn, both primarily and ultimately, to the words of the Warrant itself."

52. We have also reviewed the cases cited to us but we do not find it necessary to use them as an aid to statutory interpretation.

53. The Secretary of State relies on Commissioner Mesher's arguments in R (AF) 1/07. Commissioner Mesher referred to Newman J having restated the Royston principle in Secretary of State for Defence v Rusling [2003] EWHC 1359 QB.

54. It is clear that Secretary of State for Defence v Rusling is not authority for the proposition that the claimant must show that the injurious process on the balance of probabilities.

55. Rusling was an appeal about labelling (a non statutory concept). The expression injurious process comes from the SPVA's internal policy statement. We do not agree with Mr Metzer's and Mr Gersch's closing submission on standard of proof that Secretary of State for Defence v Rusling is simply a case about strike out and thus jurisdiction (see paragraph 33 of the submission). It importantly decides that an appeal can be brought solely on the issue of the label which the Secretary of State decides was appropriate for the claimed condition. This emphasis on labelling is reflected in the heading "The relevance of the diagnostic labelling" above paragraph 22 of the Judgment.

56. We have reviewed Newman J's Judgment in Busmer v Secretary of State for Defence [2004] EWH C29 [Admin] because that is the most recent High Court Decision about ionising radiation and followed on shortly from Newman J's Decision in Rusling. There is no indication in Busmer that Newman J's decision in Rusling had in some way changed the law.

57. The only clarification of Royston which is binding on us is the decision of Alliott J in Secretary of State for Social Security v Mitchell, Williams and Bennett (PA/2/97, PA/5/86 and PA/8/96). He stated:

"Following Denning J (as he then was) I direct myself that it is for the claimant to establish the disablement. Denning J was silent as to the standard of proof, but I direct myself that it must be the balance of probabilities. Paragraphs 4 and 5 of Article 5 come into play when the disablement is established."

58. We do not agree with the Secretary of State's written closing submission (see paragraph 31) that it is logical and following R (AF) 1/07 established as a matter of law (our emphasis) that the Royston requirement to prove disablement "on the balance of probabilities must apply equally to the inter-related second stage of proving "injury", the disablement being necessarily linked ("due to the injury")". Commissioner Mesher was very careful to say in paragraph 22 of R(AF) 1/07:

"What I say in this section is somewhat tentative. It should not be taken as establishing any definitive principles unless approved in future cases."

59. We do not attach any weight to the fact that various public statements had been made on behalf of the Secretary of State to the effect that the test to be applied in Article 41 cases is raising a reasonable doubt based on reliable evidence. We agree with the submission made by the Secretary of State on page 22 of his written closing submissions in which he relies on Mumby J's remarks in R(Beale) v Camden LBC [2004] EWHC6 (Admin).

The meaning of raising a reasonable doubt based on reliable evidence.

60. In these appeals Mr Metzer included the following written submissions about the meaning of raising a reasonable doubt based on reliable evidence.

Reasonable Doubt

The criminal case law

26. In a criminal context Viscount Sankey LC in Woolmington v DPP [1935] AC 462, in recognising that the burden of reasonable doubt has a well established and well recognised meaning, stated:

"Juries are always told that, if conviction there is to be the prosecution must prove the case beyond reasonable doubt." (at 481)

27. The current recommended direction is not to define reasonable doubt more fully but equate it to being "satisfied so you are sure".

*28. It is therefore only if the Tribunal is **sure** that the disease(s) in question did **not** arise as a result of exposure to ionising radiation during service, that the appellant's claim will not succeed.*

61. We do not agree that this is the appropriate test. We consider that the law is well established and binding on us. The leading case is R v Department of Social Security Ex Parte Edwards (CO/2281/990). McCowan LJ stated:

"In considering [Article 41(5)], the wording "reliable" cannot, in my judgement, have been intended to mean "convincing". At most it can be construed as "not fanciful". But in fact I doubt whether the word adds anything to the sentence. The real question is: does the evidence raise a reasonable doubt in the mind of the Secretary of State? If he finds the evidence unreliable, it obviously will not raise a reasonable doubt in his mind."

62. The appellants represented by Mr Metzer relied on three other cases: Minister of Social Security v Connolly [1967] SLT 121, Dickinson v Minister of Pensions [1953] 1QB 228 and Minister of Pensions v Greer [1958] NI 156. We have taken them into account in making our decision.

63. We are setting them out in full because the key issue in these appeals is whether the appellants have been able to raise a reasonable doubt based on reliable evidence that their appeals should succeed. The cases show a very similar approach is taken in Scotland and Northern Ireland where the relevant legislation is also the 1943 Act and SPO 2006.

64. In Minister of Social Security v Connolly, in refusing the appeal, Lord Walker stated *at page 128*:

"Once the tribunal accepted the claimant's evidence of sleeplessness, anxiety and tenseness it was, I think, a reasonable if not an inevitable inference that that mental condition was a continuing effect of his wartime experiences. If so, there was ample evidence in the medical department's opinion that mental stress may precipitate the onset of schizophrenia. It seems to me, therefore, that the Tribunal could without perversity fall on the evidence that the claimant had established a reasonable doubt whether this service experience operating through his continued mental condition precipitated the onset of his disablement"

65. In Dickinson v Minister of Pensions at page 233 Ormerod J stated:

"I agree with [Counsel for the claimant]that the wording of that paragraph [Article 5(4)] is probably unfortunate, but I am satisfied that the intention of that paragraph is that it is the duty of the claimant to produce reliable evidence to establish his claim, but if (after hearing and considering that reliable evidence, and making a comparison between such evidence and other evidence which is called on behalf of the Ministry to contradict, or to controvert it) the Tribunal has a reasonable doubt then, in those circumstances, the plain meaning of that paragraph of the Article is that the benefit of that doubt shall be given to the claimant."

66. The passage above was quoted with approval by Black LJ. in Minister of Pensions v Greer [1958] NI 156 and he then considered the meaning of the phrase "reasonable doubt". He stated:

"I think it is sufficient simply to say that in an Article 5 case the Appeal Tribunal must ask itself whether upon reliable evidence a reasonable doubt in the ordinary acceptation of that term, exists as to whether the conditions set out in paragraph (1) are fulfilled, and if the answer is in the affirmative the benefit of that reasonable doubt must be given to the Claimant."

"In my view the Tribunal applied the proper test, and having found that a possibility existed that the Claimant's – disease originated in an infection which occurred during his service and resulted from service conditions and that this possibility constituted a real and substantial doubt, they were justified in allowing the Claimant's appeal ……. I see nothing inconsistent in holding that notwithstanding the existence of a definite preponderance of probability or even a strong preponderance of probability there may also exist a reasonable doubt within the meaning of paragraph (4) of Article 5 of the Royal Warrant……"

How raising a reasonable doubt based on reliable evidence is measured in the context of changing medical and scientific opinion

67. It was accepted by all parties that the test laid down in the penultimate paragraph R v The Department of Social Security Ex Parte Edwards CO/2281/90 is the basis on which the Tribunal should approach changes in medical and scientific opinion in the context of the appellants having to raise a reasonable doubt based on reliable evidence.

68. The paragraph in that Judgment reads as follows:

"I see no reason why, on the material put before him, the Secretary of State should not be entitled to hold that in 1968, the time of publication of the Brown and Burley study, what has now come to be the generally accepted view was a mere hypothesis based on a limited study which would not have created a "reasonable doubt" within the terms of Article [41]. The stage at which it becomes sufficiently supported to raise such a doubt in his mind is a matter for the Secretary of State. Accepting, however, that the shift of opinion was a gradual process and that by February 1980 it was the general accepted view, there must have been an earlier stage when, asked to consider the matter, he would have found that there was a "reasonable doubt" and failure on his part to do so would have been challengeable on Wednesbury grounds. There are, in other words, in my judgment, three stages: no reasonable doubt, reasonable doubt, and consensus."

69. It is important to note that Edwards was a backdating appeal. Today it would be regarded as a specified decision and decided on the basis of the balance of probabilities but in 1992 it was decided as an entitlement appeal and therefore the test of raising a reasonable doubt based on reliable evidence was applicable.

70. It is of course much less difficult to identify the 'raising a reasonable doubt based on reliable evidence' stage in the process described in a backdating appeal when it is known when a change in scientific or medical opinion has become a generally accepted view.

71. In these appeals we are considering developing medical and scientific opinion not knowing with the benefit of hindsight whether the issue being considered has in fact got to the 'raising a reasonable doubt based on reliable evidence' stage, nor whether such opinion may in the future develop in a different direction altogether. Nevertheless we must attempt to do this and our views are set out below in paragraphs 146 to 356, which summarise the current scientific evidence linking ionising radiation to the development of various types of disease.

72. Two issues arose about expert evidence. The appellants contended that Mr Johnston's and Dr Braidwood's expert evidence was not independent and should therefore not be preferred to the expert evidence presented on behalf of the appellants. The Secretary of State contended that Professor Mothersill and Professor Parker's evidence stepped outside their areas of expertise.

Mr Ken Johnston

73. Mr Johnston's CV is at D3 tab 41. Most of his working life has been spent with AWRE or following its re-organisation in 1988 AWE. He retired in 2001, although he remained as a Director of AWE Pension Trustees Ltd until 30 April 2006.

74. After a year at the Royal College of Defence Studies in 1977, he was appointed to the MOD HQ post of Assistant Director Defence Science 6, with oversight of UK Policy supporting the UN Special Session on Disarmament and of recovery of special nuclear materials and clean-up studies relating to the UK's Maralinga test site in Australia.

75. AWE's relationship with the Ministry of Defence is contractual through a Government-owned/contractor organised arrangement. The Ministry of Defence holds a special share in AWE plc and monitors its operations and performance but otherwise its relationship is contractual. AWE maintains records on behalf of the Ministry of Defence about the

United Kingdom's Atomic Test Programme. When documents have been required for these appeals the Ministry of Defence have paid AWE to make the necessary searches.

76. We have carefully considered Paragraph 18 of Mr Dingemans' written submission and his oral submissions (T 20 February Page 14) about Mr Johnston's evidence. The appellants did not contend that the closeness of his relationship with the Ministry of Defence made him unsuitable, on grounds of public policy, to be called as an expert witness in support of the Secretary of State's case – see Paragraph 14 of Evans-Lombe J's Judgment in Liverpool RC Trustees Inc v Goldberg (No 3). 2001 1WLR 2337 (Ch).

77. In a subsequent short written submission Mr Dingemans referred to Paragraph 45(vii) of Mann J's Judgment in Meat Corporation of Namibia Ltd and Dawn Meats (UK) Ltd [2011] EWHC 474 (Ch).

> *"(vii) If the expert has an interest which is not sufficient to preclude him from giving evidence the interest may nevertheless affect the weight of his evidence."*

78. In Paragraph 18 of his written submissions Mr Dingemans put it this way:

> *"But it is established that the weight to be given to such an expert where there is a relevant contest of evidence will necessarily be diminished. This will be because the expert will (not in any conscious way) be predisposed to support the relevant party, and justify behaviour."*

79. In the appellant's summary Response to Mr Heppinstall's closing submissions Mr Metzer described Mr Johnston's views as being coloured by institutional bias.

80. Mr Johnston confirmed on Page 1 of his Expert Report dated 4 May 2011 (D2 Tab 24) that he understood his duties to the Tribunal and that he had complied with that duty. He also stated that he was aware of the requirements of Part 35 CPR, the Practice Direction thereto and the protocol for the instruction of experts to give evidence in civil claims.

81. Not surprisingly, given his long career with AWRE and AWE, Mr Johnston occasionally referred to "we". However, we agree with Mr Heppinstall (Paragraph 3 of closing written submissions) that Mr Johnston's rejection of AWE's assessed dose in the case of

Mr Battersby is a good indication of his independence. We also consider that his independence is reflected in Paragraph 43 of his first report (D3 Tab 24). Taking into account all his written reports and his overall evidence we have concluded that his evidence was careful and objective. There were several significant instances in written and oral evidence where Mr Johnston on the one hand, and Professor Regan and Dr. Nicholson on the other hand, disagreed. We draw attention to these instances under the 'Local Fallout' section and, where needed, make findings. These disagreements fell mainly into the category of the extent of a particular phenomenon; we find that many of them could be described as unsurprising scientific debate given the differing nature of the witnesses' expertise: Professor Regan in overall nuclear physics, Dr Nicholson in atmospheric particles (T 13 Feb 14:8) and Mr Johnston in "*..the sort of fine particulates that are produced in a high-altitude burst which I have studied for years..*" (T 6 Feb 13 79:13).

82. He stated on page 1 of his report dated 4 May 2011 that his evidence will be based mainly on experimental and theoretical work carried out by him in 1962-1966 as a member of AWRE's team of forensic radio-chemists. He clearly had the necessary qualifications and experience relevant to issues relating to exposure to ionising radiation.

Dr Ann Braidwood

83. Since 2002 Dr Braidwood has been Medical Adviser to the Deputy Chief Defence staff (Personnel & Training) . She is the medical lead on no faults compensation and ill health pensions and veterans issues. Part of her duties are to act as Chief Medical Officer at the SPVA's offices where she works part-time.

84. Under Article 41(1) SPO 2006 it is a requirement of making an award that a claim can only be accepted as due to service if it is certified. The provisions for certification are set out in Article 43 SPO 2006. Certificates are also given when claims are refused. It is common practice in appeals to this Tribunal for medical officers to provide subsequent notes and opinions. We regard Dr Braidwood's reports on individual appellants as being such opinions.

85. Dr Braidwood has also summarised the extensive medical evidence in these appeals. The Tribunal has found that helpful.

Professor Mothersill and Professor Parker

86. Professor Mothersill's qualifications are set out in paragraph 146 and Professor Parker's qualifications are set out in paragraph 157. In both cases references are made to the reports which contain their CVs.

87. Both are clearly experts in their respective fields – namely radiobiology and epidemiology. It is, however, well established that it is only within an expert's area of expertise that the Tribunal should give weight to their evidence. In Meadow v General Medical Council [2007] QB 462 Sir Anthony Clarke MR said:

"It is, in my opinion, of the utmost importance that an expert should only give evidence of opinion which is within his particular expertise and that, where a statement, whether made in writing or orally, is outside his expertise, he should expressly say so."

88. Wherever we find the Professor Mothersill or Professor Parker gave evidence outside their areas of expertise we have said so.

THE RELEVANT NUCLEAR TESTS

89. Thirteen out of the fourteen appellants were present on Christmas Island during the Grapple series of tests. Mr Battersby took part in the earlier Buffalo tests at Maralinga, Australia. These tests are covered in the section of this decision relating to his claim – see paragraphs 369 to 382 below.

90. There are many different ways of measuring radiation. Annex D is an Appendix to the Secretary of State's Policy Statement on claims for Ionising Related Conditions (B6/31) which was originally included in many of the Appeal Responses. The policy Document has been withdrawn pending the outcome of these appeals but we have found the Appendix a helpful and accurate summary of the different types of measurement. We have converted measurements to millisieverts (mSv) wherever possible.

91. We set out below in paragraphs 95 to 145 our findings in relation to the Grapple X, Y, Z1, Z2, Z3 and Z4 tests

OPERATION GRAPPLE

Background

92. The main historical background sources which we have used in making our decision are *'Britain and the H Bomb,* by Lorna Arnold (B7/34) a study commissioned by the MoD; and *'Christmas Island Cracker'* by AVM Wilfred Oulton CB CBE DSO AFC, Commander Task Force GRAPPLE 1956-1957. The Secretary of State relies on this book as background evidence, having copied it to the Appellants' representatives in March 2011.

93. Operation GRAPPLE was a major joint military operation judged by HMG to be vital to the UK's national security interests. It was joint in two ways: first, in that the command structure in the field and the participating forces were from all three services; second, in that it also incorporated a civilian, scientific component. All components worked as a team of up to 4,000 people (B7/34 p142). It had elements too of a combined military operation: Australian, Fijian, New Zealand and US forces and/or facilities acted in important supporting roles but were not involved in the GRAPPLE command structure.

GRAPPLE was headed by the Task Force Commander (TFC), a two-star Royal Air Force Officer (Air Vice-Marshal), assisted and advised by the Scientific Director, a senior AWRE Scientist. The sea, land and air components of the Task Force were each headed by a Task Group Commander at one-star or OF-5 level (Commodore RN, Army Colonel and RAF Air Commodore).

94. The British Armed Forces of the late 1950s and early 60s were very different from those of today. Most branches, corps, regiments and trades were not yet open to women; all the appeals before us have been brought by men (or their widows) but there were at least two uniformed '*ladies of Lady Reading's Women's Voluntary Service'* (Oulton) deployed to Christmas Island. There was still a fairly large National Service component, particularly in the Army; of the fourteen appeals five involve National Servicemen, four Army and one RAF. Non-commissioned ranks, particularly junior servicemen, tended to be told only what they needed to know in order to accomplish the task in hand; our appellants were aged between 18 and 22; the most senior of them held the rank of Corporal at the time. The concept of small teams of informed and empowered professionals being able to achieve a task without detailed supervision was not yet widespread, particularly in the Army. In the RAF, there was still a strong distinction between aircrew and non-aircrew and, amongst aircrew, between those with full wings (pilots) and half wings (such as navigators and aircrew engineers). The RN still had a relatively large number of capital vessels; the Deputy TFC was a Commodore RN. We have no RN appellants.

From Malden to Christmas Island

95. It is clear from the historical records that there was considerable discussion, involving political, scientific, military and safety factors, leading up to the decision to proceed at speed from the GRAPPLE 1, 2 and 3 (G1, 2, 3) detonations at the uninhabited Malden Island (700 Kms to the South of Christmas Island) to a new series of tests, GRAPPLE X, Y and Z1 to 4 (GX, GY, GZ1-4), at the inhabited Christmas Island mounting base itself (B7/34 p152). Personnel involved in the Malden Island tests had been carefully handpicked; this would no longer be the case for the Christmas Island tests (Oulton p367). An AWRE Scaled Map of Christmas Island showing principal locations (A10 p8) is reproduced at Annex B. Details of each detonation are covered under the Local Fallout section below (paragraphs 105 to 138). There has been speculation over the years about the detonation height, location, yield and the local meteorology of the GY detonation, the

UK's first true thermonuclear detonation; these aspects are covered separately in paragraphs 100 to 104.

96. What is clear to the Tribunal is that, having decided on the Christmas Island option, the importance of the meteorological input to the decision to launch a particular detonation became critical. It is not quite so clear that the meteorological and radiological standards and safety procedures were geared up to cater for any unforecast meteorological event. The meteorological arrangements from D-1 to D Day for GY were that predictions were presented at 1200, 1800 and 0645 hours using forecasts made available two hours earlier (AWE Interim Report for GY at Core 8 pt17 p1). These forecasts came from radiosonde balloons, which probably took in the order of one hour plus to reach the tropopause (T 13 Feb 115/11-17). AWE's 1999 radiological safety assurance report observed that radiological safety standards were the same for GX off the South-East point of the inhabited Christmas island as they had been for the three GRAPPLE rounds on the uninhabited Malden Island some 700kms to the South; however a new Personnel safety Plan was prepared (B1/11p37/13.3).

Orders, Instructions and Safety

97. The official records entered in evidence (mainly under the 300 or so B folder tabs) indicate that detailed and comprehensive orders and instructions, including on the safety of participants, were issued for all aspects of Operation GRAPPLE, for example the Personnel Safety Plan for the Forward Area issued in April 1958 prior to the GY detonation (B15/278); this included listing key personnel by name to particular vehicles in unit evacuation plans in the event of a nuclear accident (see under Mr Abdale at paragraph [357] below. However, the degree to which these were strictly and consistently applied and their application supervised would inevitably have been variable. Even the TFC and the Scientific Superintendent were bowled over by the shockwave of the GX detonation as they emerged, somewhat prematurely at H+15 seconds, from the C Site bunker to experience it (Oulton p395). The Secretary of State acknowledged, in his closing oral submission, that keeping discipline was difficult and people did go towards the South of the Island after detonations. However, areas that needed controlling were controlled, including by armed guards, until the Health Physics Teams had given the all-clear (T 20 Feb 80/8 et seq, see also B7/34 p159). This control extended to vehicles as well as personnel, to minimise the risk of fallout being 'trafficked'. So, for example,

'Yellow Area' vehicles remained there as did any 'non-Yellow' vehicles entering the area; this required them to be serviced and maintained there (Arnold B7/34 p185).

98. To quote the late Air Vice-Marshal Oulton:

> *"Possibly over-reacting to the finally successful outcome of a very dicey operation* [i.e. GX] *and to the problem itself, the TFC* [i.e. himself] *boiled with fury as he reviewed the quite unnecessary risks and difficulties which had been imposed on the Task Force"* (Oulton, p396).

99. AWE's 1999 Report does note (B1/11 ps 37-38) that, for GY, although the overall radiological standards and safety procedures would remain the same as for GX, tighter aircraft and personnel safety would be implemented following some minor shock-wave damage to buildings and helicopters in the North of the Island. For the GZ detonations, the Personnel Safety Plan for GZ2 and GZ3, the two subsequent airdrops, was '*very similar'* to the Plan issued for GX; no safety plan for GZ1, the first balloon-suspended round, can be found (B1/11 p39) but one has for GZ4, the second such round (at B1/7). Planning for the balloon-suspended round detonations indicated that, after suitable precautions, work might be possible at ground zero after two days (agreed gist D/43 para 9).

GY – Height, Location, Yield and Meteorology

100. GY was the UK's first true H Bomb and the largest bomb the UK has ever detonated. We find that for many of those who were present for the GY detonation and whose evidence is before us, this was a momentous event. The six appellants who witnessed GY were junior Army and RAF servicemen aged between 19 and 22.

101. As to height and location, we carefully considered all the evidence, including the oral evidence of Flt Lt (Retd) Joseph Pasquini (by videoconference link from New York), Prof Patrick Regan, Dr Kenneth Nicholson and Mr Ken Johnston. It transpired during his oral evidence that Dr Nicholson had relied on official data provided to him as to barometric pressure, which we specifically find was incorrect, to deduce a detonation height of some 5,500 feet (T 13 Feb 43:3 et seq). During his oral evidence, Mr Pasquini agreed, as an experienced 'sniffer' Canberra navigator in the air at the time, that GY detonated at 8000 feet and that the bottom of the plasma ball stayed at about 5000 feet. We accept the Royal Aircraft Establishment's July 1959 analysis (E1/3) as the most

comprehensive; we find that the time-delay [not barometric] fused GY round detonated slightly higher than planned (agreed gist D/43 para 6) at around 8,100 feet, slightly further away from the Island than planned at around 1.5 miles offshore.

102. As to yield, the agreed gist (D/43 p4 no.002342) indicated a yield of some 3.1 Megatons (Mt). Arnold (B7/34 p167) recorded that the planning safety limit would again be 2Mt but that AWE's K.V. Roberts thought it could reach 3Mt; ground zero would have to be moved about ten miles, so reducing the measurement opportunities. This clearly was not done and may well explain why the safety of personnel was then reviewed and thousands of anti-flash hoods, gloves and white nylon boiler suits provided (ibid p171). The agreed gist also recorded:

102.1 Very significant transformation of U238 to other Uranium isotopes, which would decay eventually to Pu239, thus adding to the alpha activity in the debris (para 8).

102.2 That firing conditions were adapted, following the poor sampling of GX, so that material could be sampled at an altitude which the sniffers could reach.

103. As to the local meteorology, the GY Interim Report stated that the actual conditions at the time of the burst were just acceptable allowing no margin for uncertainty (Core/8 part 17 p3).

103.1 The agreed gist noted the wind direction measured from 1900GMT onwards (detonation was at 1905GMT) changing from around 80 degrees at 25-35,000 feet to around 250 degrees at 46-60,000 feet (para 8 and Annex B). In his oral evidence, Mr Pasquini recalled that at H+1 hour, the mushroom cloud covered the whole of the Christmas Island area; he disagreed that the cloud at that time was moving away from the Island due to the prevailing wind. He also found it incredible that he encountered cold rain at 46,000 feet, with water running across the Canberra's skylight and white cloud above; he would normally see black at this altitude. The met Office included in their data the detailed cloud and wind information from *'the recco reports from the low-level Shackletons and the high-level Canberra aircraft'* (B8/50 para 1)

103.2 At ground level half an hour after detonation, a 170 degree [i.e. just short of due Southerly] 7 knot light wind was recorded at the met station (Stretch D45 p15 figure 3.6). Dr Nicholson agreed (T 13 Feb 13 p111 et seq) that this was not so relevant [with the airburst being some 1.5 miles high and surface zero some 22 miles away].

103.3 More worryingly, Annex B also showed the 8-10,000 foot vector as around 120 degrees, thus heading slightly North of West-North-West along the South coast towards the South-West point of the Island.

104. In oral evidence, Mr Johnston summed it up as (T 6 Feb 152:16 et seq):

> *"If you put it this way, you asked me what other reason is there. If you take a holistic view of everything that's been recorded, you have the pre-shot calculations and the predictions of where the material in the stem was going to go. You have Mr Scorgie saying after the event, "Blow me," basically, "the 10,000 vector shifted 30 degrees and came awfully close to the island." There was no room for error. He said it himself and he was clearly somewhat twitched that such a change could have occurred. What he said was basically, "We got away with it. Just."*

LOCAL FALLOUT

Relevant Nuclear Physics

105. Direct Radiation. All parties were now in agreement (T 4 Feb 117: 24) that no appellant was subject to the effects of direct radiation (also referred to as 'prompt' radiation or 'radiation shine'), that is the pulse of ionising radiation emitted at the moment of detonation and absorbed in air over a distance of a few kilometres (B6/31 Annex B para 6). The detonation's intense flash of light could have caused the impression of being able to see the bones in hands covering eyes, as reported by some appellants (e.g. A12/209 para 14) but was definitely not caused by X-rays (T 5 Feb 105: 13). Arnold noted (B7/34 p225) that the Island Hospital had no cases of radiation sickness; their main worries had been dysentery and sunburn.

106. Fireball Entrainment. AWE's unclassified 1993 Report on Environmental Monitoring at Christmas Island (the Clare Report) stated that, for Operation GRAPPLE, each device was detonated at such an altitude to ensure that its fireball did not touch the surface, thus preventing surface material (sea or land) being entrained in the fireball and leading to a greater risk of local fallout (B4/24 para 5). Evidence in the agreed gist (D/43) supported this statement and we so find. Overall, we accept the Clare report as reliable evidence, with the caveats that, whilst comprehensive, it was published as an Unclassified document and is now some 20 years old. Subsequently in this decision, we prefer other, sometimes previously classified, evidence and we also take issue with some of the statements made in the report; we specify each such occasion below.

107. Fallout/Rainout. The Clare report stated (para 6) that radioactive residues arose solely from weapon materials and that such debris, in the form of very small particles, did not fall to earth locally. This is not agreed by the appellants nor by some of the expert witnesses. Fallout did reach the Island and there was a paucity of recording stations to measure it (Regan T 4 Feb 67:20 et seq); Professor Regan felt that it was completely possible that there were 'hotter' spots than the ones recorded (T 4 Feb 87:21 et seq); from a Health Physics point of view, he was surprised that [AWE] did not go over the Island with a fine toothcomb afterwards (T 4 Feb 88:11 et seq). Indeed, Clare itself went on to report, as part of the local monitoring programme, depositions measured on land and in rainwater (paras 119 to 138), see below for details.

107.1 The Main Cloud. It was generally agreed (T 4 Feb 103:3 et seq) that the local fallout risk from the main detonation cloud was very low, with the principal possibility being that of 'rainout' from its edges. Mr Johnston, viewing the GY video (see below) could not see, against a blue sky, any rolling at the edge of the main cloud which might produce precipitation (T 5 Feb 119:15); Dr Nicholson could see 'rollout' but this was in the context of the power of the main cloud hitting the tropopause forcing it to expand rapidly sideways in all directions (T 13 Feb 103: 02).

107.2 The Stem. The experts were also in general agreement that a potential local fallout risk [ie in this hearing a potential risk to the appellants] was posed by the mushroom cloud's rising stem.

107.2.1 The stem itself interchanged nuclear debris with the main cloud and could contain between some 10 (Johnston) and 25% (Regan) of the total debris. For the airbursts, wind vector and raincloud formation at around 10,000 foot and above would be critical; for the balloon detonations, this figure would be much lower: the Met Office refers to the wind being measured at a height of one km [around 3,300 feet] (B8/50 para 4). For GY, the wind between 10,000 and 30,000 feet [i.e. the height band for the wind safety parameters] (T 6 Feb 206:19) did veer from forecast and this did lead to fallout (see paragraph 103 above).

107.2.2 Commenting on the viewing by the hearing of the DVD of the GY detonation (AWE 32 at B10/102), Mr Johnston explained that the reflection of the initial shockwave by the sea surface produced a 'condensation spike' (T 5 Feb 117:23) coming up to join the base of the rising cloud stem (T 5 Feb 118:4). Some time later, the dark stem base apparently moved downwards (T 5 Feb 118:23), then began to be moved to one side by one of the intermediate winds (T 5 Feb 119:13). One could see what looked like smoke and dust thrown up from fires initiated by a thermal pulse**.** (T 5 Feb 122:11). One could get rainout when the condensation spike joined the stem and this was what the safety people were worried about (T 5 Feb 125:20). The stem contained dilute radioactivity in the form of extremely fine

particles; particles from a comparable US DOMINIC detonation were less than one micron in size, with a very, very slow fall speed (T 6 Feb 197:17 et seq). They would not have grown to anything like a hot particle, either in size or concentration (T 6 Feb 150:19 et seq). This was not agreed by Dr Nicholson (T 13 Feb 90:4 et seq): these particles would probably have been brought down by low-level clouds bubbling up to around 10,000 feet, then raining down (T 6 Feb 151:7 et seq) or by self-induced rainout from the stem. Mr Johnston commented that the aerial radiological survey found ionising radiation where it was predicted that the GY stem fallout would go; the Decca Master fallout reading at Vaskess Bay was probably due to the change in wind direction at stem height (T 5 Feb 133:19 et seq).

107.2.3 For the two balloon bursts (GZ1 and GZ4), the aerial survey found that the edge of the radioactive [stem fallout] area had '*overlapped the narrow uninhabited strip of land on the South coast between the freshwater lagoon and the sea'* (agreed gist D/43 p7). Deposition would have been less at ground zero for the high-altitude bursts and, '*incidentally, there would have been no Plutonium'* (T 6 Feb 83:13 et seq)**.** The Main Camp fallout reading after GZ1 could plausibly have been due to a '*wisp'* of fallout going up there (T 5 Feb 137:11); '*it was taken there on the wind'* (T 6 Feb 120:6). Although there was a significant reading at Decca (SPAL), there was no reading at the inhabited Port London.

107.3 The sub-stem. For the balloon bursts, a lot of dust would have been sucked up, would have been neutron induced and did fall out over the coastal strip; this was measured (Johnston T 6 Feb 83:13 et seq). Arnold described this area of the GZ4 detonation as a '*towering column of dirt and sand sucked up into the wake of the rapidly ascending fireball, reaching towards but never touching the boiling cloud of incandescent gas before falling back to earth in a cloud of dust*' (B7/34 p191). We find that, although the sub-stem area did not meet the fireball for any of the GRAPPLE detonations, it did meet the stem for the GZ1 and GZ4 balloon detonations at 450m, when the fireball's radius would have been a minimum of some 225m above ground level

(Johnston T 6 Feb 83:4). Not only was the sub-stem neutron-induced but it also probably received some of the nuclear debris from the 10 to 25% of the total debris in the stem (see above). This debris fell back to ground zero (Arnold) as well as falling out over the coastal strip (Johnston).

108. Particles and Alpha Ionising Radiation. Clare reported that only beta/gamma radiation was measured to monitor the environment, in view of the relative ease of doing so compared with the measurement of alpha radiation (B4/24 para 12). The only scenario where alpha-emitting isotopes might have been present in the absence of beta and gamma emitters would have been in the event of an accident dispersing plutonium without a nuclear detonation; this was contested by the appellants and Professor Regan. Monitoring equipment was held on the Island for such a contingency but was never needed (B4/24 para 13).

109. The principal source of alpha radiation from these tests would have been the Plutonium 239 isotope (Pu239), which has a very long half-life of some 25,000 years (T 4 Feb 13:3) In the order of tens to one hundred kgs of Pu239 would be generated by a nuclear detonation of the size of GY (Regan T 4 Feb 53:9 et seq); the vast majority of it would have been vaporised in the fireball, entered the stratosphere and, in due course, contributed to the global fallout. Professor Regan believed that Mr Johnston's estimates of Pu239 deposition were far too low (T 4 Feb 84:24).

110. Professor Regan stated (T4 Feb 55.15 et seq)

> "You can't say that alpha is not there if you have not got the right equipment to find and measure it"

He tended to agree with Mr Johnston that it was unlikely that Pu239 would be deposited alone (it was more likely to be co-deposited with gamma/beta emitters and thus be detected) but soil sampling for alpha particles did not take place at the time.

111. Professor Regan went on to explain that alpha particles also had a radiation weighting factor some 20 times that of beta or gamma particles; if one put alpha particles of the same energy radiation as gamma rays on the same amount of live [human] tissue, they would do some 20 times the biological damage (T 4 Feb 31:8 et seq). On the other hand, they deposited their energy over a very short space, being stopped by as little as a layer of dead skin cells (T 4 Feb 18:1). They entered the body by ingestion, which could for

example be by eating, drinking, breathing or entering the bloodstream through an open wound (T 4 Feb 20-22). The Carter report states (B3/17 page 81) that ingestion through cuts or wounds is generally considered a relatively low risk and a smaller one than through inhalation. Professor Regan also tended to agree that follow-up surveys of Christmas Island, such as the New Zealand NRL Survey carried out for HMG (ODA) in 1981(B4/23) and the Aspinwall & Co 1998 Survey for HMG (MoD) (B5/27) found very low levels of residual radioactivity: for example, the highest dose rate found by Aspinwall in soil samples was some 0.1 microsieverts per hour [equating to some 0.88 mSv per annum] (B5/27 p30-31). However, the danger with Pu239 was the ingestion at the time [some 23 to 40 years earlier] of very small amounts which then remained with one for life. Although the GRAPPLE series was planned as atmospheric detonations with insignificant levels of local fallout, if planned today the risk of very small amounts of Pu239 particles being ingested would need to be catered for (Regan T 4 Feb 122:6 et seq).

112. The Tribunal asked the parties' nuclear physics experts after they had given their oral evidence, whether a measured activity of one microcurie per square metre (a 'significant' deposition as per the MoD sketch map at D/40, reproduced at Annex C to this decision) could arise from a single fallout particle. Whilst they could not agree on all the detail, their consensus seemed to the Tribunal to be (added on the day to bundles as D/48) that, whilst it can be so shown, such activity was more likely to arise from a very large number of sub-micron particles, particularly when generated by a high-altitude megaton-range airburst, such as GY (see for example B8 B/62).

113. Neutron-induced Ionising Radiation. The initial pulse of radiation after each detonation would have induced some ionising radiation in all that it met: at sea, on the land and in the air. Clare acknowledged this effect at sea with reference to the airdrop detonations (B4/24 para 34), leading to seawater monitoring and fish sampling, and on land (para 46) with reference to the tethered balloon detonations. Clare was silent on the local (within a few kilometres) effect in the air, presumably because an assumption would have been that any results of this effect would have been deposited in some way; Clare was silent on birds and insects.

Relevant Meteorology

114. There was a measure of consensus between the written and oral evidence of two expert witnesses, Dr Kenneth Nicholson and Mr Richard Stretch. During Mr Stretch's oral evidence, attention was drawn to a useful overview of the Christmas Island weather (B2/13 p31). An atoll 2 degrees north of the equator, Christmas Island's climate is tropical marine with a relatively slight variation in temperature (21-32C); rainfall is moderate, with a rainy period in the Spring (nine inches in April to one inch in June); cloud cover correlates with rain showers, with low cumulo-nimbus in the morning; Spring winds are persistently Easterly trade winds below 15,000 feet and steady North to North-West at above that height.

115. AWE's 1999 Woodville report concluded, inter alia, that in no case did hazard from fallout arise due to failure accurately to predict the weather conditions at the time of firing (B1/11 para 19.3). The 1999 Report observed that there was no post-detonation fallout from GX on Kiritimati (the then Christmas Island), winds taking the cloud away from the inhabited areas. The weather background immediately prior to the window of opportunity for the GX operation to be launched on the morning of 8 November 1957 was not encouraging. On the 4th November, the weather was 'so hopeless' that a delay of 24 hours was declared; the same happened on the 5th and the 6th; on the morning of the 7th, after a night with a fair amount of cumulo-nimbus cloud and occasional thunderstorms, it appeared that there should be a clearance for some hours the following morning; at 6am on the 8th, it was pitch black and raining outside the Joint Operation Centre (JOC) but the forecast window did then appear (Oulton ps 385-388). Met Office records state that it rained again (*'light shower'*) just over six hours [8 Nov 57 1510V local time = 9 Nov 57 0010Z GMT] after detonation [8 Nov 57 0847V = 8 Nov 1747Z] (B8/50 Appendix 1).

116. Turning to GY, Dr Nicholson stated in his oral evidence that what was being measured was background wind speed not activity in and around the GY mushroom cloud; the main cloud spillout [when it hit the tropopause] was so powerful that wind direction [at that height] would be irrelevant (T 13 Feb 65:1 et seq). He considered that rain from the GY mushroom cloud was not impossible (T 13 Feb 69:13)**.** Small particles could form condensation nuclei for rain; rainout did occur after Hiroshima and Nagasaki (T 13 Feb 48:16) but these were very different low-yield and low-airburst detonations (Secretary of

State closing written submission 39:41 with which we agree). If one considered that contaminated rain fell on Decca Master, one must also consider the witness reports of rain elsewhere (T 13 Feb 80:23). Mr Stretch stated (D/45 para 4b.6) that the second cumulo-nimbus observed by meteorologists was probably generated by the GY detonation and could have resulted in localised rain. Dr Nicholson stated that the idea of doing a radiosonde ascent was so that one could work out the stability layers in the atmosphere, which was all very well and good if predicting rainfall or circulation patterns, but not so good if looking at the impact of a nuclear detonation (T 13 Feb 96:5 et seq). He opined:

> **"**That is no safety margin at all. They don't have accurate measurements of the wind change. Bear in mind, this is radiosonde data. If they knew it could rain and they went ahead with the test, then that is cause for concern." (T 13 Feb 83:1-4)**.**

117. For GZ1, AWE's E.P.Hicks, responsible for fallout prediction, commented retrospectively that if ground zero had been at the South-West tip of the Island [instead of the South-East point], the plume would have blown away out to sea (B7/34 p185).

118. In summary we find that :

118.1 No appellant was subject to the effects of prompt radiation and no fireball entrainment occurred (all detonations)

118.2 Local fallout was recorded and was probably from the stem area below the main cloud and carried by wind or rainfall from low-level clouds (GY, GZ1 and GZ4).

118.3 The rainfall which did occur over inhabited areas was not rainout from the main cloud or from the stem but from cumulo-nimbus clouds (GY and GZ1).

118.4 Neutron-induced dust and other particles from the sub-stem area did fall back to ground in the vicinity of the balloon-burst sites (GZ1 and GZ4).

118.5 Risks were indeed taken with the meteorological conditions in deciding to proceed with the GY and GZ1 detonations; the wind directions at the

relevant heights, although coming close to the planned safety limits, did not breach them.

118.6 A reasonable doubt based on reliable evidence is raised that particles generating alpha ionising radiation were deposited and that neutron induction did occur in forward areas following the GZ1 and GZ4 balloon detonations.

Monitoring, Measurement and Results

119. The Clare Report (B4/24) described the environmental monitoring programme, both Pacific-wide and local. It stated that the purpose of the local monitoring programme was to confirm that levels of radioactivity in the air, on the land and in the sea, arising from the tests were negligible and did not constitute a radiological danger (para 11). No records whatsoever of any post-detonation measurements of local radiation levels can be found for the GX detonation (see for example Table 3 of AWE's 1993 environmental monitoring report at B/4 T24); we accept that the Secretary of State has made persistent efforts to locate them (T 21 Feb 12:8 et seq and Treasury Solicitors letter of 12 November 2012 (I5, page 2579))**.** The Report did indeed conclude that the purpose of the monitoring programme had been fulfilled: *"there was therefore no danger to personnel from external radiation nor from inhalation and ingestion of radioactivity, including that from rainwater and seawater"* (para 46). This conclusion is contested by the appellants and by Professor Regan. We find that the stated purpose of the local monitoring programme shows signs of 'confirmation bias' which is not best scientific practice.

120. Badges. For Operation GRAPPLE, badges were only issued to personnel who could be expected to receive ionising radiation doses in excess of the badge threshold (i.e. 0.2mSv) (B4/11 para 11.17). Clare described these personnel as: all AWRE members; and those Service personnel working in identified, controlled, active areas (B4/24 para 40). Health escorts, with additional monitoring instruments, accompanied working parties into active areas and managed their movements so as to keep radiation exposures within prescribed limits (Arnold B7/34 Appendix 4 para 15). In other words, there was an acceptance that some armed forces personnel would indeed receive an ionising radiation dose above 0.2mSv. Film badges used were capable of estimating dose from gamma radiation, beta particles and 'slow' neutrons within a dose range of 0.2 to 200 mSv (B1/11 para 4.1). However, the first NRPB Report noted that exposure to neutrons and from internal

contamination by radioactive materials after contamination would not have been recorded on personal film badge dosimeters (B3/14 p9).

121. Results. Clare reported that, for the entire GRAPPLE operation, some 1,000 participants were issued with film badges and some 65% received no exposure above badge threshold (B4/24 p8 para 41). We find therefore that some 350 personnel did. Each appellant's individual badge measurements and assessments is detailed below.

122. Sticky paper and Ground Survey. As part of the Pacific-wide programme, there was one monitoring station for ground deposition at the JOC (Clare B4/24 para 10). Additionally, as part of the local programme, sticky paper collectors were deployed for GY and GZ1 to 4 and radiological surveys using portable monitors were carried out (B4/24 para 11). In oral evidence, Mr Johnston confirmed that sticky paper strips were not part of the safety management system (T 6 Feb 84:17); they were point records of area deposition and *"you don't attempt to radiograph it to see if there is a hot particle"*(T6 Feb 218:8). As already stated (para 109) Professor Regan felt that it was completely possible that there were 'hotter' spots than ones recorded by the small number of recording stations. The possibility is obvious to us but there is no evidence that there were. We do not consider that any inference can be made about 'hotter spots' in excess of the highest levels recorded at the relevant time. The only inference that we can reasonably make is that there were other 'hot spots' at these levels. We specifically refer to this, where relevant, in relation to each appellant**.** No local deposition monitoring took place for GX (B4/24 para 26). There were 10 monitoring locations for GY and a further eight for the GZ series (see sketch map at p206V). For GY, sticky paper trays were laid out immediately after the shock wave had passed (agreed gist D/43 ps4-5).

123. Results.

123.1 Pacific-wide Monitoring Clare reported (B4/24 para 23) that the highest value of deposition of 0.075 microcuries per square metres [equating to some 0.0003 mSv per year] at the JOC Pacific-wide collection site occurred 11 days after the G3 detonation at Malden Island.. Clare then stated (ibid) that the next highest deposition value as part of the Pacific-wide programme there was one day after the detonation of GZ4 but this is not supported by Clare's

tables at page 208V and 209 (figures 6 and 7). We find that it is probable that the Clare report was referring to the local fallout reading at RM2 post GZ4 (see below and Clare figure 8 at page 209V).

123.2 Deposition from sampling aircraft. In answer to a question about the 0.075 microcurie deposition after G3 at Malden Island, Mr Johnston opined that it was most unlikely that ionising radiation particles would have been brought down by sampling aircraft: these were coated in gel paint, which was then hosed off under decontamination (T 6 Feb 212:14 et seq). We understand Mr Johnston to have meant that he felt that it was most unlikely that such particles would have 'dropped off' contaminated aircraft prior to decontamination. The Tribunal records that Main Camp was located a couple of miles North of the normal landing path for aircraft returning to the Main Airfield into a prevailing Easterly wind and that landing manoeuvres include the opening of fuselage surfaces, such as for air brakes, flaps and undercarriages

123.3 Local Monitoring As part of the local monitoring programme, significant fallout depositions on Christmas Island were recorded on sticky paper trays as follows (all in microcuries per square metre, see Annex C, source MoD sketch map at D/40,)

123.3.1 GX, GZ2 and GZ3- none

123.3.2 GY- Decca Master, at the South-West Point, 150. The agreed gist recorded that results were generally very low or below detection except for *'a very real'* fallout at the Decca Master Site on South-West Point and this was confirmed by survey on foot. These levels were, however, within those laid down for an uncontrolled area; the ground survey team was unable to determine whether the contamination was the result of dry fallout or rainout in a light shower (D/43 ps4-5). Clare reported that the ground survey team did not confirm this high figure (B4/24 para 29). We find that that this level of fallout was indeed confirmed by survey on foot, the agreed gist drawing on highly classified documents which Clare would not have been able to draw on in her unclassified report.

123.3.3 GZ1-

- Decca SPAL, in the West, 100

- Target Marker, in the South-East, 38
- RMF, in the South-East, 18
- Main Camp (occupied) in the North, 2.8

123.3.4 GZ4

- RM2, in the South-East, 300
- RM17, in the South-East, 1.7

124. Professor Regan noted that, although the 2.8 microcurie per square metre deposition at Main Camp after the GZ1 detonation was *'tiny'* [it equates to some 0.001 mSv per annum], it was a measurable [by definition 'significant'] amount of ionising radiation that was not there before and therefore was the result of GZ1 (T 4 Feb 175:24 et seq)**.**

125. The Tribunal could find no reference to any monitoring of the local land-based fauna, which included pets and feral dogs and cats. Arnold refers to pets being placed in suitable humane containers and every effort being made to round up stray domestic animals (B7/34 p173); Mr Butler refers to being sent out with a net to round up stray dogs but, when this proved too difficult, resorting to a Bren gun instead (A12 p208 para 10).

126. Results of Induction on Land. The agreed gist noted measured [by subsequent radiochemical analysis of samples at AWRE] induced activities in nine neutron transformation indicators following the GZ detonations. '*Very light'* contamination of vehicles in the forward area from neutron-induced activity in fall-back material was noted post GZ1 and GZ4 (D/43 ps6-7). AWE, in responding to a letter from Mr Shaw, mentioned that a mobile generator (recovered from A Site some three to four months after the last Christmas Island detonation) might have shown residual neutron-induced radiation (A10 p83 et seq).

127. Fresh Water. Frequent rainfall readings were taken at the main meteorological station at the JOC (B4/24 para 10). Drinking water was drawn from long shallow trenches excavated to about 18 inches below the water table. 'Raw' water with a higher salinity was used for domestic purposes (B1/12 ps32-33).

128. Results. No rainwater sampling records are available for GX (B4/24 para 31). Occasional samples in May, July and August 1958 indicated '*detectable traces*' of activity; these

were believed to be associated with global fallout (para 32). There was a '*slightly elevated*' rainwater sample following a '*very light shower*' after GZ1 (B4/24 para 33).

129. Seawater. Seawater was monitored by: instruments carried by low-flying aircraft; samples collected by helicopter in the vicinity of surface zero; and by HM Ships further afield (B4/24 para 35).

130. Results. Levels above the limit of detection were only found immediately following the bursts close to surface zero (para 36) and this induced activity decayed and dispersed very quickly (para 37). Professor Regan agreed that there was no danger from ingestion through swimming (T 4 Feb 53:9 et seq).

131. Marine Animals. Fish were caught at and around Christmas Island, including in the lagoon, a favourite area for swimming and fishing (Clare B4/24 paras 10 and 38-39). Professor Regan agreed that, once ingested via a fish, the amount of ionising radiation would be '*relatively small*' but measurable (T 4 Feb 60:12 et seq). Servicemen also recalled (e.g. Mr Abdale after the GX detonation, see below) being despatched to collect dead fish from the shoreline.

132. Results. In no case was reportable activity found in fish (Clare B4/24 paras 10 and 38-39). However, unsuccessful attempts were made to catch fish inside the fallout area [i.e. from West-North-West to West] after the air balloon detonations. Clams, crab and fish were obtained from the South-East; the only (small) activity was found in two clams-during the GZ series of detonations (agreed gist D/43 p7 and B14/220)**.** Professor Regan agreed that the two clams had short half-life isotopes in them (T 4 Feb 60:18 et seq). A doctor at HMS Resolution (Port London) was worried in around late October 1958 that Port personnel had eaten some 140 crayfish caught in the area AG12-AG13 [ie off the South coast in the sea fallout areas for the balloon detonations] (B16/116). Some more were caught from the same area and tested. The edible parts were found to have maximum recorded levels above background of beta: 1.4 counts per minute; and gamma: nil; the 1413 monitor also recorded nil above background (B10/116). Conversion of monitor counts to exposure dose rates depends on the efficiency and method of use of the detector; taking the 1021 monitor as a yardstick, the maximum beta count of 1.4 counts per minute is roughly equivalent to 0.0205 mSv per annum (Appendix to the Carter Report B3/17) . This equates to some one-fiftieth of the UK's current statutory limits for

the general public on exposure to ionising radiation (see paragraph 140 below). The only appellants who worked at Port London were Mr Beeton and, for some three months, Mr Lovatt, both of whom departed the island by August 1958, i.e. before the balloon detonations.

133. Air. Clare recorded that there was one air sampling point at the JOC (B4/24 para 10). Christmas Island is described as rich in migrant [sea] birds and infested with evil-smelling land crabs and hosts of flies (e.g. Arnold B7/34 p104). There are first-hand accounts (e.g. Mr Butler at A12 p209V para 31) of blinded birds flying around and crashing into each other after balloon detonations and people being sent out to collect the corpses; this seems to have been done for general associated health reasons. There are also first-hand accounts (e.g. Oulton p159) and 49 Sqn RAF operational record book for April 1958 (A7 p96) of an Auster crop-spraying light aircraft being purchased to spray DDT around the inhabited areas every morning to control the flies. The Tribunal could find no reference to any collection and monitoring of airborne fauna, such as birds or insects.

134. Results. The Clare report stated that inspection of the results showed that there was no correlation between the dates of UK detonations and the occasional incidence of low but detectable levels of airborne activity (para 19). However, the tables at pages 207 and 207V do show: a co-incidence between such airborne activity and the Malden Island tests (G1,2 and 3); and an increase in the frequency of such activity between August and October 1958, a period which included the GZ1 to 4 detonations and two US tests.

In summary we find that:

135. The highest record for any form of fallout, the sticky paper deposition of 300 microcuries per square metre in the South-East of the Island following the GZ4 balloon detonations, equates to an annual received human dose of some 0.12 mSv (B4/24 para 28).

136. The highest record for an inhabited area, the sticky paper deposition of 2.8 microcuries per square metre at Main Camp following the GZ1 balloon detonation, equates to an annual received human dose of some 0.001mSv (B4/24 para 28).

137. No appellant was at risk from ionising radiation above local background as a result of their routine activities in and around the inhabited areas of Christmas Island, including:

breathing, eating, drinking, swimming or paddling in the main lagoon, fishing and incurring cuts and grazes from coral.

138. The Tribunal records that two of the Christmas Island appellants received assessed film badge exposures of 0.5 mSv; we discuss this further below.

EXPOSURE COMPARISONS

139. "*As no dose of IR is considered safe, natural background is generally considered the cause of a proportion of the cancers which occur in a population.*" (B6/31 para 16)

140. The UK's current statutory limits on exposure to ionising radiation [i.e. the UK's current assessment of acceptable risk] are (B6/31 Annex A):

140.1 General public- 1.0 mSv per annum over and above local background and medical exposure; medical exposure ranges from some 0.02mSv for a chest X-ray to some 7 mSv for a brain scan.

140.2 Occupational unclassified workers- 6 mSv per annum.

140.3 Classified workers- 20 mSv per annum

141. The Secretary of State's agencies and advisers have sometimes made comparisons, on the one hand, between badge dosimeter returns and/or assessments above background for individuals and, on the other hand, the average annual UK dose from natural background radiation of about 2.2mSv (see for example the Clare Report B4/24 para 42 and the SPVA Medical Adviser's comments dated 25 April 2008 at A4 (1) p248 and 26 April 2010 at A11 p232). We appreciate that such comparisons are illustrative only but find that they are not the best evidential tools in cases, such as these, where there has been short-term exposure to ionising radiation. We prefer the 'like-for-like duration' comparisons made in other AWE and SPVA inputs, such as that from AWE for Mr Butler in June 1990 (A4 (1) p69) and that from SPVA for Mr Butler in April 2008 (A4 (1) p248, backed by SPVA's Annex A to medical appendices on cancers). Professor Parker confirmed that she subscribed to this approach (T 11 Feb 71:12 et seq).

142. The latter approach for the three appellants, Messrs Battersby, Butler and Williams, for whom evidence of exposure has been entered and for whom AWE hold badge dose records which are higher than nil, would lead to the following rough and ready assessments, which are developed further in the sections devoted to each appellant.

143. Mr Battersby-

143.1 Over a period of two months had an assessed exposure of **1 to 5 mSv** (one badge for August and one for September 1956, with BUFFALO 1 detonated on 27 September 1956)

143.2 Compare with two months' worth, **0.367mSv**, of the UK background dose (2.2 mSv per annum)

143.3 In other words, Mr Battersby's assessed exposure equated to some **3 to 14 times** the UK background dose

143.4 Comparison with the current statutory limits on exposure would have placed him **in or above the limit for a classified worker** [two months' worth- 3.333 mSv- of the annual 20 mSv limit].

144. Mr Butler-

144.1 Over a period of two days had an assessed exposure of **0.5 mSv** (two badges: one for 22 and one for 23 August 1958, with GZ1 detonated on 22 August; one read 0.3 mSv, one read nil and was therefore assessed as at the threshold at 0.2 mSv, giving a total of 0.5 mSv)

144.2 Compare with two days' worth, **0.012 mSv**, of the UK background dose (2.2 mSv per annum)

144.3 In other words, Mr Butler's assessed exposure equated to some **42 times** the UK background dose

144.4 Comparison with the current statutory limits on exposure would have placed him above **the limit for a classified worker** [two days' worth- 0.110 mSv- of the annual 20 mSv limit].

145. Mr Williams-

145.1 Over a period of two months had an assessed exposure of **0.5 mSv** (two badges: one for August and one for September 1958, covering the period of the GZ1 to GZ4 detonations; the first read nil and was therefore assessed as at the threshold of 0.2 mSv, the second read 0.3 mSv, giving a total of 0.5 mSv)

145.2 Compare with two months' worth, **0.367mSv**, of the UK background dose (2.2 mSv per annum)

145.3 In other words, Mr William's assessed exposure equated to some **1.6 times** the UK background dose

145.4 Comparison with the current statutory limits on exposure would have placed him **within the limit for an unclassified worker** [two months' worth- 3.333 mSv- of the annual 20 mSv limit].

RADIOGENICITY AND CAUSATION

146. This section deals with how ionising radiation can cause disease, and refers to various epidemiological and other studies that bear upon this topic. Where a particular cancer or other disease process can be caused by exposure to ionising radiation, the concept of the amount of risk for a given amount of ionising radiation exposure is introduced.

147. In their reports Professor Regan (D/2) and Dr Lilley (D/19) have provided detailed explanations of basic nuclear physics, including radioactive decay, the nature of ionising radiation, its measurement and how it can interact with human tissue. A summary (from the Secretary of State's Policy Statement) is also included at Annexe D of this Decision.

148. At page 10 of his report, Dr Lilley states:

'Gamma rays are like X-rays. They are highly penetrating and will affect any part of the body that is exposed to them.

Beta particles are much less penetrating and are stopped in a few millimetres of tissue.

Alpha particles from radioactive decay have the shortest range and are stopped in the outer layers of the skin or a few centimetres of air.

Beta and alpha particles however, are much more dangerous if inhaled or ingested into the body where they can affect internal organs.'

Damage to Cells by Ionising Radiation

149. Cells are made from and depend for their function on large, complex molecules, for example DNA, structural proteins and enzymes.

150. When ionising radiation passes through a cell, it can directly damage these large molecules, or can interact with water molecules to create 'reactive oxygen species' which in turn can cause damage to the large cellular molecules including DNA.

151. The generation of reactive oxygen species occurs not only as a result of ionising radiation exposure, but also occurs in normal cellular metabolism, as part of the inflammatory response (see below) and exposure to some chemicals, for example contained in cigarette smoke (see for example report of Professor Lindahl at D2/15). In other words, potential damage to cells is occurring all the time from mechanisms other than exposure to ionising radiation.

152. Reference will also be made to high and low Linear Energy Transfers (high LET and low LET) radiation. This refers to the amount of energy that is transferred to its surroundings as a ray or particle passes through human tissue or some other material . X-rays and gamma rays are low LET radiations, whereas alpha particles are high LET radiations. Because of its greater energy transfer, high LET radiation is more damaging to tissue than low LET radiation, and reference has been made above (paragraph [113] to alpha particles being 20 times more damaging (a weighting factor of 20) than beta or gamma particles.

153. Cells have the ability to repair damage to themselves, including a number of repair mechanisms for DNA.

154. If the dose of ionising radiation to a cell is sufficiently great, then the extent of damage will be such that the cell dies. Lesser degrees of ionising radiation exposure can cause survivable damage, which can include permanent structural alteration to the cell's DNA, because whilst DNA repair mechanisms are highly efficient, they are not perfect.

155. A distinction is often made between the stochastic and deterministic effects of ionising radiation. A stochastic effect refers to the situation where a given dose of ionising radiation may or may not result in a particular condition, for example a cancer. In other words, stochastic effects provide a probability of a condition occurring. Deterministic effects typically occur at higher exposure doses, for example at a level of several Grays [i.e. Sieverts] which are often encountered in a radiotherapy setting, and describe a situation where a given dose of ionising radiation will usually, if not always, produce a particular result. Examples of deterministic effects of radiotherapeutic doses of ionising radiation would include hair loss and bone marrow suppression.

156. The relationship between the amount of ionising radiation exposure (the dose) and its effect (the response) is described by a model widely accepted by the scientific community (e.g. : see UNSCEAR 2006, BEIR, CERRE, NRPB) as well as the Secretary of State (Closing Submissions section C2, paragraph 5) and by the appellants, which is called the Linear No Threshold (LNT) model.

157. The LNT model describes firstly that there is a linear or directly proportional relationship between the dose and the response; secondly that there is no level of dose above zero for which there is no response, or in other words no threshold of dose below which there is no response. The logical consequence of the LNT model is that any level of ionising radiation exposure above zero must carry some risk.

158. The process whereby ionising radiation passing through a cell causes direct damage to its DNA is known collectively as targeted effects (TE).

159. Professor Carmen Mothersill of the Department of Medical Physics and Applied Radiation Sciences, McMaster University is a radiobiologist with a special interest in non targeted effects (NTE). (Reports at D1/7, 8 and 8a; oral evidence given on 7th February 2013). NTE include what is known as genomic instability, which is the process where following the exposure of a cell to ionising radiation, subsequent progeny of that cell exhibit permanent changes such as translocations in their DNA. In other words, irradiation of a cell can lead to irradiation associated changes in the DNA make-up of progeny cell which were not themselves irradiated.

160. The other principal NTE is known as the bystander effect. In this process, it is observed that irradiated cells produce substances which have an effect on other, non irradiated cells. For example, the growth medium of irradiated cells (after all the irradiated cells have been removed from it) can be shown to have an effect upon unirradiated cells, as well as unirradiated experimental animals. These bystander effects can induce both genomic instability, and produce an effect akin to oxidative stress which in turn has been shown to result in changes to markers for the inflammatory response as well as in immune responses. The characterisation of the substances involved in causing the bystander effect are the subject of ongoing scientific interest and research.

161. Professor Mothersill pointed out (T7Feb, page 15) that NTE firstly can be triggered by doses as low as 2 mGy [i.e. 2 mSv], and secondly that once the effect is induced it is stable, or equivalent to an on/off switch being switched on.

162. In his Closing Submissions, Secretary of State accepted that the following had been proven via in vitro research (section C, paragraph 24).

'a. Radiation induced genomic instability - ie alteration of genome in daughter cells which have not been themselves directly irradiated, and

b Bystander effects - ie irradiated cells can damage adjoining unirradiated cells - and subtypes of these effects such as abscopal effect, ie evidence of damage to tissues far away in the body from the exposed part, and clastogenic effect, where plasma from irradiated sources can cause chromosome damage in unexposed cells.'

163. He continues (paragraph 25)

'SoS does not accept that there is evidence which links these processes to disease or conditions in the human body.'

On the other hand, the Appellants' submission is that there is. This issue is discussed further below [in paragraphs].

The Nature of Cancer

164. It is an inevitable part of being alive that cells in the body die and need to be replaced. This occurs by existing cells dividing to form new cells. Cell division is ultimately under the control of that cell's DNA - its genetic make-up. Hence damage to DNA can sometimes result in uncontrolled cell division which if unchecked will form a 'growth' or 'tumour', in other words what is commonly referred to as cancer.

165. Cancer is a disease that becomes commoner as one ages. In a lifetime, approximately 42 of 100 people will be diagnosed with cancer (BEIR VII Report, page 7; E1/10). There are many different kinds of cancer, and doctors classify them according to their cell or tissue of origin. Such classification is important because it enables doctors to know how to best treat a particular type of cancer, as well as predicting how they will behave - some cancers are more aggressive or malignant than others.

Inflammation and Immunity

166. The inflammatory response is the name given to a complex system of interactions between various sorts of specialised cells, chemical messengers and blood vessel changes which together form the body's response to injury. Injury here is used in its widest sense to include physical injury such as a burn, or infection with bacteria or viruses. Closely linked to the inflammatory response is the immune response, which is the body's method

of distinguishing something 'foreign' (for example a virus) from 'self'. The immune response is itself a system of complex interactions involving various types of specialised cells and chemical substances (notably immunoglobulins).

167. Depending upon the nature of the injurious process, some elements of the inflammatory or immune response may be more involved or active than others.

168. Part and parcel of the inflammatory response to an injury is the process of repair, in other words the return of the injured area to normal as far as possible. Familiar examples will include the formation of a scar after a wound in the skin, or the return of the lining of the nose to normal after one has suffered a common cold.

169. Whilst inflammation and immunity are normal responses to an injurious process, there exists a group of diseases called the autoimmune diseases in which disease results because of a person's immune system reacting inappropriately against their own cells or tissues. Examples include autoimmune thyroid disease, rheumatoid arthritis (but not osteoarthritis) and some forms of glomerulonephritis (see below).

Epidemiology

170. Professor Louise Parker holds the Chair in Population Cancer Research at Dalhousie University, Halifax, Nova Scotia, and is Director of Research for Cancer Care Nova Scotia. (Reports at D4/5/5a; oral evidence at T 8 Feb pages 34 - 180 and T 11 Feb pages 4 - 77).

171. Epidemiology is the study of diseases in a particular population of people to see if they differ from a comparison or 'control' population, who are matched so far as is possible with the study population. Professor Parker outlined in oral evidence a number of problems inherent in epidemiological studies, such as case ascertainment, bias, and confounding factors to name a few. Where there is a relatively small difference in the incidence of a particular disease between the test and control groups, proportionally larger numbers of people need to be studied in order to detect such a difference. To put this another way, depending on the size of the population being examined, an epidemiological study will have a threshold of disease incidence below which it is not

possible to say whether there is in fact a difference between the study and control groups or not.

172. The Tribunal heard written and oral evidence from Professor Mothersill to the effect that NTE operating at low levels of ionising radiation exposure, typically below the threshold of epidemiological detection, may alter the dose response relationship from a linear one. In other words, NTE may be relatively more potent at low doses, in effect posing a greater health risk than the LNT model would suggest. The actual shape of this response curve however remains unknown, and is the subject of ongoing research.

173. This topic is dealt with in UNSCEAR 2006 Annexe C, which concluded (paragraph 162):

'The committee stresses that the direct epidemiological observations and associated quantification of the health effects of radiation incorporate all mechanistic elements, including the targeted (direct) effects of irradiation as well as the non targeted and delayed effects described in this report.'

The subject is further explored in the context of radiological protection by CERRIE, ICRP, and NRPB, which reports are considered in more detail below.

NRPB Study

174. The National Radiological Protection Board (NRPB) has carried out a series of epidemiological studies on UK participants in the UK Atmospheric Nuclear Weapon Tests and Experimental Programmes, with reports being published in 1988 (B3/14), 1993 (B3/15) and 2003 (B3/16). They studied more than 22,000 participants, and a similar number of controls.

175. The 1988 report concluded (Abstract, final paragraph)

'that small hazards of leukaemia and multiple myeloma may well have been associated with participation of the Nuclear Weapons Programme, but that such participation has not otherwise had a detectable effect on the participants' expectation of life or on their total risk of developing cancer.'

176. The 1993 report stated (Abstract, final sentence)

'The suggestion from a previous study that participants may have experienced small hazards of leukaemia and multiple myeloma is not supported by the

additional data, and the excesses observed previously now appear likely to have been a chance finding, although the possibility that test participation may have caused a small risk of leukaemia in the early years after the test cannot be completely ruled out.'

177. The 2003 report stated (Abstract, last paragraph)

'In common with earlier analyses, there is some evidence of a raised risk of leukaemia among test participants relative to controls, particularly when focusing on leukaemia other than CLL. This could be a chance finding, in view of low leukaemia rates among the controls and the generally small radiation doses recorded for test participants. However, the possibility that test participation caused a small absolute risk of leukaemia other than CLL among men cannot be ruled out; the evidence for any increased risk appears to have been greatest in the early years after the tests, but a small risk may have persisted in more recent years.'

178. The Tribunal heard evidence from Professor Parker who was critical of the methodology of the NRPB studies, which thereby cast doubt upon the reliability of the conclusions, which are summarised above. She thought that the NRPB studies underestimated the risks of the development of cancer in the participants. She was not otherwise able to quantify that underestimate.

179. Others felt that the NRPB studies were not significantly flawed, and had recognised and taken into account the various methodological difficulties outlined by Professor Parker (see report of Professor John Kaldor, Professor of Epidemiology at the University of New South Wales, report at D2/20; Dr Anne Braidwood, Medical Adviser to the Deputy Chief Defence Staff,, report at D34a and in oral evidence at T 11Feb pages 95 - 98).

Epidemiological Surveys of Other Nuclear Test Veterans

Australian Test Veterans

180. An epidemiological survey of Australian participants in British nuclear tests in Australia was carried out by Carter and others, with a two volume report being published in May 2006 (E/17 and E/18), dealing with dosimetry, and mortality and cancer incidence respectively. The findings were also published in peer reviewed scientific journals (Crouch et al. Radiation Protection Dosimetry 2009, 136: 3; 158 - 167 at E2/7. Gun et al. Occup Environ Med 2008; 65: 843 - 848 at E1/13). The Tribunal noted discussion

by Professor Parker about possible methodological difficulties. The Abstract of the 2009 paper on dosimetry stated:

'Both the external and internal exposure pathways were considered. Most participants received very small doses: 79% of all participants received less than 1 mSv and less than 4% received greater than 20 mSv, the current internationally recommended annual dose limit to workers. The largest dose recorded was 133 mSv, received by air crew conducting sampling in the nuclear cloud soon after detonation. Most doses greater than 20 mSv were received by groups who entered the near vicinity of the explosions or fallout contaminated areas to collect samples or instruments soon after a detonation.

181. The Study on Mortality and Cancer Incidence noted an increase in some cancers in participants, but concluded (Abstract, 2009 study)

'There is no evidence that the excess cancers and cancer deaths were caused by radiation exposure at the test sites. Possible contributing factors are high smoking prevalence and demographic differences from the Australian population with whom rates were compared.'

US Test Veterans

182. Professor Parker refers to 'The Five Series Study' of the mortality of military participants in the US nuclear weapons tests, published in 2000 (cited at her report D1/5A page 53), which looked at around 70,000 of the total of 200,000 US service personnel involved in the atomic weapons tests. The Tribunal has not seen the original report, but Professor Parker quoted from it (Ibid, paragraph 4.23 at page 67)

'Only the risks of death due to nasal cancer and prostate cancer were significantly higher among participants than referents. Among the haematologic cancers, the risks for all leukaemia (1.15; 95% CI 0.93 - 1.43) and leukaemia minus chronic lymphoid leukaemia (CLL) (1.14; 95%CI 0.90 - 1.44) were both elevated, albeit not significantly, among participants.'

She continues that

'Land series participants were found to have a statistically significant increase in the hazard ratio for death due to leukaemia 1.49 (95% CI 1.04 -2.13).'

She discussed the methodology of this study and gave reasons why she considered that it was *'seriously flawed'* (Ibid page 68, paragraph 4.26).

Dr Braidwood also refers to the US studies, noting the results but not critiquing the methodology.

New Zealand Test Veterans

183. A study of New Zealand participants in British atmospheric nuclear weapon tests in the Pacific was conducted by Pierce et al and published in the British Medical Journal in 1990 (Br Med J 1990; 300: 1161 - 6, B14/235). This study looked at 528 participants, with a control group of 1,504 men who were in the Royal New Zealand Navy during the same period but did not participate in the test. Seven test participants died of haematological cancers compared with six controls (relative risk 3.25) with the relative risk for leukaemia being 5.58. The study did not detect any increase in risks of death for causes other than cancer, and little evidence for an increased risk for non haematological cancers. The report concluded *'These findings should be interpreted with caution as they are based on small numbers.'* Both Professor Parker and Dr Braidwood in written and oral evidence discuss the methodological complexities of this study.

The Rowland Report

184. Rowland et al provided a report to the New Zealand Nuclear Test Veterans' Association in 2007 entitled *'New Zealand Nuclear Test Veterans Study - A Cytogenetic Analysis'*, which was the basis for a publication by Wahab et al in a peer reviewed journal in 2008 (Cytogenet Genome Res 121: 79 - 87 (2008)), which hereafter will be referred to as the Rowland Report and the Wahab Report respectively (both reports at B12/162).

185. The Rowland Report stated (page 1)

'The Grapple Series involved several naval vessels from Britain and New Zealand. Two New Zealand frigates attended the series of detonations: the HMNZS Pukaki and HMNZS Rotoiti. Over the course of these tests a total of 551 New Zealand naval personnel manned these ships. Their duties consisted of witnessing the detonation of the nuclear devices and collecting weather data. During the operation Grapple tests, the New Zealand vessels were stationed at various distances of between 20 and 150 nautical miles upwind from ground zero. The Pukaki was present in all nine of the tests [Grapple 1, 2, 3, X, Y and Z1 - 4]*, while the Rotoiti was present only at the first four tests* [Grapple 1, 2, 3 and X]. ... *The unavailability of data from film badges*

worn by the participants during these tests make it difficult to establish with certainty whether or not these individuals received any radiation dosage, or if they did, to what degree.'

186. The experimental group consisted of 50 personnel who had taken part in Operation Grapple, on either HMNZS Rotoiti or HMNZS Pukaki (Rowland Report page 37), and was compared with a matched control group who were ex-Army personnel except for some ex-Policemen. The study used a technique for examining damage to chromosomes known as mFISH which showed

> *'A very high frequency of total translocations in the veterans' chromosomes as opposed to a matched control group. This result is highly significant and we are faced with answering the question: What unifying factor could give rise to such high translocations amongst the veterans? Our carefully planned case control study leads us to the view that this can be attributed to their participation in Operation Grapple ... we submit the view that the probable cause of the veterans' elevated translocation frequency is radiation exposure. This view is supported by the observation of a comparatively high dicentric chromosome score in the veterans, which is characteristic of radiation exposure.'* (Rowland Report page 44).

187. At page 42 the report stated

> *'An attempt was made in the current study to reconstruct possible radiation dosage in the Operation Grapple veterans. Possible exposure estimates are listed in Table 15* [which showed a range of calculated exposure from 0 - 1.15 Gy]. *We acknowledge that there are many uncertainties surrounding this estimate, which should be used only as a guide.'*

188. The Wahab Report was a reiteration of the same data and, unsurprisingly, came to much the same conclusion stating (page 86)

> *'In summary, a sample group of New Zealand naval personnel who participated in Operation Grapple shows three times the frequency of total chromosome translocations than a group of closely matched controls. Our analysis of potential*

confounding factors leads us to the view that this highly elevated frequency is most likely attributable to radiation exposure.'

189. The Tribunal notes various comments on and criticisms of the methodology of the Rowland and Wahab Reports, including from Professor Parker, Dr Braidwood, Professor Mothersill, Health Protection Agency (B12/157), Professor Brenner (D/1), Dr Lindahl (D/16), Dr Darroudi (D/18), and Professor Kaldor (D/20).

Comments On Test Veterans' Studies

190. The only of the foregoing studies to deal with the UK personnel present at Christmas Island and Maralinga is the NRPB Series. This is a population study which does not take into account individual doses in relation to resultant risk. The LNT model establishes that where there has been an exposure there is a risk. It is accepted that an epidemiological survey has a threshold of detection. The Tribunal notes the possibility as set out by Professor Parker that the NRPB studies underestimate the cancer risks for participants. The studies do raise the possibility of increased risk for leukaemia, but do not identify an increased risk for other cancers.

191. This does not mean that the NRPB studies establish that there was no excess risk of cancer (other than leukaemia) for participants compared to non participants. Any exposure must carry a risk, but for the reasons just stated epidemiology may not be able t identify and quantify it. The Tribunal intends to address this latter point from 'the other direction' so to speak, by taking a view from the wealth of other evidence available to it as to what those present on Christmas Island and Maralinga may have been exposed to, and what other scientific studies tell us about the magnitude of risks related to the amount of ionising radiation exposure. This is dealt with further below.

192. The US and Australian studies only assist the Tribunal to the extent that they illustrate, methodological criticism aside, what may be found in respect of those two groups of people. These studies deal with different personnel present at different tests, and whilst they may give an indication of the dose levels and health consequences for those personnel, they do not otherwise assist the Tribunal so far as UK personnel present on Christmas Island are concerned.

193. The Rowland and Wahab studies deal with New Zealand naval personnel on Pukaki and Rotoiti, the latter deployed only for one test in the vicinity of Christmas Island (Grapple X).

194. The Rowland/Wahab studies conclude only that they consider it likely that the excess in chromosomal translocations was the result of participation in the Grapple trials, and that ionising radiation was the likely cause. Neither mention their study group spending time on Christmas Island. There is no information provided about what these ships were doing throughout their attendance at the Grapple tests with regard to opportunities for ionising radiation exposure during their deployment periods.

195. Statements were provided by John Bristow, Douglas Low and George Cowan (Supplemental Bundle, tabs M, N and O).

195.1 Mr Bristow served on the Rotoiti. He describes going on shore on Christmas Island after Grapple 2, 3 and X, participating in activities such as swimming in the lagoon, soccer and cricket. During one of the visits he was shown two Canberra bombers that had been used to fly through the radioactive clouds during the detonations. He does not say whether or not he was a participant in the Rowland study.

195.2 Mr Low also served on the Rotoiti. He also went ashore after Grapple 1, 2, 3 and X.

'The crew would take shifts of approximately five hours, allowing everyone to go onto the island. Whilst on the island, much of the time was spent in the Camp Mess, but we would also spend time at the cinema on Camp, swimming in the lagoons and having barbecues with fish we had caught on fishing trips.'

He does not state whether or not he was a participant in the Rowland study.

195.3 Mr Cowan served on the Pukaki throughout the entire series of Grapple tests. He spent rest and recreation time on Christmas Island following each of the tests apart from Grapple 1. He does not state whether or not he was a participant in the Rowland study.

196. It is the Appellants' submission that ionising radiation exposure of the New Zealand sailors occurred, at least in part, on Christmas Island (see for example T21Feb page 127).

The Tribunal has been provided with no evidence concerning dosimetry aboard Rotoiti and Pukaki.

197. Wahab's retrospective dosimetry (which appears to use a different method of calculation, as it is different to the figures given by Rowland) estimates exposure in the *'range from 0 - 0.31 Gy in the veterans (mean = 0.170 Gy)*[170 mSv] *and from 0 - 0.22 Gy in the controls (mean = 0.037 Gy).'* [37 mSv].

198. If it were contended that all the New Zealand sailors' exposure arose from their presence on Christmas Island over a total of several days, and engaging in everyday activities similar to those permanently resident on the island, then the latter must have been at risk of exposure to correspondingly greater exposure given their much greater length of time spent on Christmas Island. This would run into numbers of Grays if the sailors' average exposure from Christmas Island was 0.17 Gy [170mSv].

199. The possibility of exposures of this level of magnitude is to be compared with other evidence of exposure on Christmas Island discussed above, as well as the probabilistic implications for cancer and other disease incidence at exposure of this magnitude. In short, the Tribunal does not find it credible that the UK participants on Christmas Island could have been exposed to radiation at the level of several Gys (equivalent to several Sieverts) without it becoming apparent. It follows that the contention cannot be substantiated.

200. If on the other hand it were contended that the New Zealand sailors received only part of their exposure on Christmas Island, then it follows that they must have received the remainder of their exposure somewhere other than on Christmas Island, and presumably whilst they were on board ship. Given exposure on board ship, Christmas Island exposure can only be speculative in the absence of other evidence that they were so exposed (see paragraph 185 above).

201. The Rowland Report assumed great significance in the High Court action for limitation purposes, but Foskett J stressed that any conclusions that he came to for the purposes of the limitation hearing were very much subject to the hearing of the full evidence at trial.

202. All the foregoing is of course based upon the assumption that the Rowland/Wahab findings were the result of ionising radiation exposure during the Grapple series in the first place, and not some other unidentified cause, for example organic chemicals, which have been linked to increased levels of chromosome aberrations (report by Professor Brenner, D/1 page 2).

Studies on Health Risks of Ionising Radiation

203. This section will consider studies which are not in themselves epidemiological reports, but are rather a synthesis of the scientific knowledge available taking into account epidemiological as well as other research data. The studies to be considered are:

203.1 The United Nations Scientific Committee on the Effects of Atomic Radiation Volume 1 (UNSCEAR).

203.2 The Radiation Effects Research Foundation (RERF) and its Lifespan Study (LSS).

203.3 The Board on Radiation Effects Research (BEIR).

203.4 The UK Health Protection Agency (HPA).

203.5 The Committee Examining Radiation Risks of Internal Emitters (CERRIE).

203.6 The International Commission on Radiological Protection (ICRP).

204. Many of the above studies use an estimate of risk called the Excess Relative Risk (ERR). ERR is defined as the ratio of the disease rate to the underlying disease rate in the absence of the relevant exposure minus 1. Thus, an ERR of 1 means that the risk of a particular disease is twice the risk of that disease in the absence of exposure.

205. To put this another way, an ERR per Gray (1000 mSv) of 1 for a particular type of cancer means that in a group of people who had been exposed to 1 Gray and who developed that type of cancer, half the cancers could be attributable to ionising radiation exposure, and the other half would have developed anyway, irrespective of any exposure.

UNSCEAR

206. UNSCEAR was formed by a resolution of the General Assembly of the United Nations in 1955, and the committee has an international membership of distinguished scientists. The committee

'Thoroughly reviews and evaluates global and regional exposures to such sources of radiation and the doses that result from them. It evaluates the evidence of radiation

induced health effects from studies of the health of survivors of the atomic bombings of Japan and of other exposed groups. It also reviews advances in the understanding of mechanisms by which radiation induced health effects can occur. These assessments provide the scientific foundation used, inter alia, by the International Commission on Radiological Protection (ICRP) in developing its recommendations on radiation protection and by the relevant agencies within the United Nations system in formulating International Basic Safety Standards for Protection against Ionising Radiation and for the Safety of Radiation Sources.'

207. Many of the experts in these appeals have referred to work by UNSCEAR, and none have questioned its standing. The Tribunal therefore attaches considerable weight to this international expert view. The Tribunal has been provided with relevant portions of the 2006 report, namely the section entitled *Effects of Ionising Radiation*, and Annexes A, C and D to the 2006 report (D3/11, 12, 13 and 14 respectively).

208. Volume 1 of UNSCEAR 2006 discusses the problems of accurate dosimetry as well as problems in characterising cancer risks for some sites owing to the low statistical precision associated with relatively small numbers of excess cases.

209. The report dealt with the effects of both TE and NTE in respect of both cancer and non cancerous conditions, the latter being dealt with separately below.

210. As well as considering updated data from the LSS, UNSCEAR 2006 also considered a number of other new or updated studies including the Mayak Workers' Study (nuclear workers), Techa River Study (persons exposed to radioactive river effluent), the Semipalatinsk Weapons Test Site Fallout (inhabitants of ten exposed villages near the test site), the International Workers' Study (pooled analysis of workforces from 15 countries working in any of 154 nuclear facilities), United States medical radiologic technologists, Chinese radiologists and technologists, studies of air crew, patients treated with radiation, and worker and public exposure to uranium.

211. Of these, the LSS is the most directly relevant to these Appeals, because it is the only study dealing with the effects of an exposed population following nuclear bomb detonation.

212. UNSCEAR then goes on to consider individual cancers.

213. At paragraph 31 (page 7 of UNSCEAR 2006 Volume 1, with regard to NTE), it states:

> *'In spite of the large body of new information, there continues to be considerable debate regarding the causal relationship between these non targeted effects and the observed health effects attributable to radiation. The committee concludes that at present the available data provides some support for concluding that there are disease associations, but not for causation. In arriving at this conclusion, the committee stresses that the estimation of the health effects of radiation is based on epidemiological and experimental observations where there is a statistically significant dose related increase in disease incidence. These direct observations of adverse health outcomes implicitly take account of mechanistic elements relating not only to the targeted (direct effects) of irradiation but also to the non targeted and delayed effects described in Annex C to the 2006 report.'*

RERF

214. The Radiation Effects Research Foundation (RERF) has conducted a mortality study since 1950 on a fixed population (the Lifespan Study (LSS) Cohort) of about 120,000 subjects including atomic bomb survivors and residents of Hiroshima and Nagasaki who were not in either city at the time of the bombing to determine the late health effects of ionising radiation derived from the atomic bombs in Hiroshima and Nagasaki. Reports have been produced periodically over the years, and the latest, Report 14, produced in 2012 (Studies of the Mortality of Atomic Bomb Survivors, Report 14, 1950 - 2003: An Overview of Cancer and Non Cancer Diseases by Ozasa et al, Radiation Research 177, 229 - 243 (2012). Report at E3/16). This report stated

> *'Importantly, for solid cancers the additive radiation risk (ie excess cancer cases per 10^4 person - years per Gy) continues to increase throughout life with a linear dose-response relationship. The sex averaged excess relative risk per Gy was 0.42 (95% confidence interval: 0.32, 0.53) for all solid cancer at age 70 years after exposure at age 30 based on a linear model.'* It continued *'The estimated lowest dose range with a significant ERR for all solid cancer was 0 - 0.20 Gy, and a formal dose-threshold analysis indicated no threshold; ie zero dose was the best estimate of the threshold.'*

This paper also explained that the ERR was greater at a given attained age for persons exposed at a younger age, and illustrates this in Figure 2 (page numbered 235 in the report).

215. Professor Parker discusses the RERF studies in her report (D/4, paragraph 3.4.1.1), commenting:

> *'The dose estimates have been refined over time but remain an estimate of the external ionising radiation received in the immediate aftermath of the bomb detonations. They do not take into account any ongoing external irradiation from contamination in the environment nor any exposure due to internal exposure due to ingestion or inhalation of radioactive particles [cites paper by Sawada]. Such miscalculations of exposure with have some impact on the accuracy of the dose response estimates for cancer and other outcomes.'*

216. She points out that those in the LSS cohort may have represented 'healthy survivors', ie persons who were more resistant to the effects of ionising radiation than the average.

217. She reproduces (paragraph 3.4.1.2) 'A recent summary of findings for cancer from the Radiation Effects website (http://www.rerf.or.jp/radefx/late e/site.html)' which in summary gives a total number of cancer deaths of 7,310, of which there was an estimated excess of 314 deaths attributable to radiation exposure. This represents an excess of about 5% in the total number of cancer deaths that would have been expected to occur anyway, in the absence of radiation exposure. (These numbers also include cancers for which the evidence for a radiogenic effect is stated in the table to be weak).

218. The point to be taken here is that these figures give an overall estimate of increased cancer risk for the Japanese survivors, a proportion of whom may have ingested radioactive material as well as receiving an external ionising radiation dose. This situation has similarities to that pertaining on Christmas Island, where in particular circumstances some individuals may have ingested radioactive material, and this is discussed further below in respect of individual Appellants who may have had the opportunity for such ingestion.

219. Dr Braidwood (D/33, paragraph 16) referred to 'A 2007 review [Little et al (2007) Are Cancer Risks Associated with Exposure to Ionising Radiation from Internal Emitters

Greater than those in the Japanese A-Bomb Survivors? Radiat. Environ. Biophys; 46: 299 - 310, which] compared data from 20 studies on cancer incidence and mortality in groups who received exposure from predominantly internal emitters and calculated excess relative risks (ERR per Sv). Comparable data were obtained for Japanese atomic bomb survivors and "... the results suggested that excess relative risk in the internal emitter studies do not appreciably differ from those in the Japanese atomic bomb survivors."'

BEIR

220. BEIR is a Board of the US National Research Council of the National Academies Institute. The membership consists of distinguished scientists predominantly from the US but also from other countries, including amongst others Professor Lindhal and Professor Pierce. The Tribunal has been provided with the BEIR 7 Phase 2 Public Summary and Executive Summary sections (B1/10). This report focuses on new information available since the 1990 BEIR 5 report on Low Dose, Low-LET Health Effects.

221. The report states (Public Summary page 2):

'Although this BEIR 7 report is about Low-LET radiation, the committee has considered some information derived from complex exposures that include radiation from High-LET and Low-LET sources. High-LET or mixed radiations (radiation from High-LET and Low-LET sources) are often described in units known as Sievert. The units for Low-LET radiation can be Sievert or Gray. ... For this report, the committee has defined low dose as doses in the range of near zero up to about 100 mSv (0.1 Sv of Low-LET radiation).'

222. The report endorses the LNT model, and presents best risk estimates for exposure to low dose, Low-LET radiation in human subjects. At page 7 of the Public Summary, there is a figure (PS-4) which illustrates the caption

'In a lifetime, approximately 42 (solid circles) of 100 people will be diagnosed with cancer (calculated from Table 12 - 4 of this report). Calculations in this report suggest that approximately one cancer (star) per 100 people could result from a single exposure to 0.1 Sv of Low-LET radiation above background.'

223. Whilst the Tribunal is aware that as well as the received dose, factors such as age at exposure, number of years elapsing, and particular type of cancer suffered can all affect

risk estimates, we find the Report's estimate of the lifetime attributable risk of incidence and mortality for all solid cancers and for leukaemia (Table ES-1 at page 15) helpful in so far as it gives an illustrative or order of magnitude indication for dose and risk.

224. Thus for example it estimates, for males, an excess number of cases of 800 per 100,000 for all solid cancers and 100 per 100,000 for leukaemia, from exposure to 0.1 Gy [100mSv] (number of cases in the absence of exposure 45,500 and 830 respectively).

225. For male deaths, the excess from exposure to 0.1 Gy [100 mSv] are 410 per 100,000 for all solid cancers, and 70 per 100,000 for leukaemia (number of deaths in the absence of exposure 22,100 and 710 respectively).

CERRIE

226. The Report of the Committee Examining Radiation Risks of Internal Emitters (CERRIE) was published in October 2004, with the remit

'To consider present risk models for radiation and health that apply to exposure to radiation from internal radionuclides in the light of recent studies and to identify any further research that may be needed.' The report is at B37.

227. The Committee consisted of a number of eminent scientists, and included Professor Busby, who was a co-author of a separate report dissenting from the Committee's report.

228. The Committee considered a wealth of biological and epidemiological evidence.

229. CERRIE considered a number of matters, including risks of internal emitters, alpha emitters, non targeted effects and epidemiological evidence, and made a number of recommendations, particularly about dosimetric methodologies.

230. The NRPB provided a response to CERRIE published in August 2005 (E2/4). This report concluded:

'All members of CERRIE agree that the epidemiological evidence linking moderate and high levels of exposure to internally incorporated radionuclides with a raised risk of adverse health effects is compelling (page 78, paragraph 67). In addition, NRPB - like most of CERRIE - believes that low level intake of radionuclides will

lead to some increased risk of adverse health effects as a result of the internal irradiation of organs and tissues. However, NRPB also believes that the epidemiological evidence, taken as a whole, does not suggest that the predictions of current risk models are materially in error. This conclusion is based on consideration on the strengths and limitations of the various studies considered, including the impact of various sources of uncertainty and their consistency - or lack thereof - between studies. Whilst two committee members suggested that inconsistent findings would be expected under a 'biphasic' relationship between risk and radiation dose, the epidemiological and experimental evidence cited in support of this hypothesis is very weak. NRPB supports CERRIE's recommendations for further epidemiological research, whilst noting that only well designed and well conducted studies are likely to increase our knowledge of risks from internal radiation exposure.

There was general agreement within CERRIE that new findings on the biological effects of radiation should continue to be included in considerations of health risks at low doses and their quantitative uncertainty. The committee endorsed ongoing national and international radiobiology research programmes, particularly in respect of microdosimetry, induced genomic instability, bystander effects, cancer mechanisms and germline minisatellite mutagenesis (page 53, paragraph 44). NRPB agrees with the majority committee view that there are no immediate implications for current estimates of doses and risks of internal emitters

NRPB endorses ICRP approaches to the estimation of doses and risks from internal emitters and agrees with CERRIE conclusions that these should be best estimates and that associated uncertainties should receive more attention.'

231. The Tribunal has no reason to dispute this view.

ICRP

232. As its name implies, the International Commission on Radiological Protection is primarily concerned with preventative measures, its website (www.icrp.org) stating that its work:

'Helps to prevent cancer and other diseases and effects associated with exposure to ionising radiation, and to protect the environment.

Since 1928 ICRP has developed, maintained and elaborated the International System of Radiological Protection used worldwide as the common basis for

radiological protection standards, legislation, guidelines, programmes and practice.

ICRP is an independent, international organisation with more than 200 volunteer members from approximately 30 countries across six continents. These members represent the leading scientists and policy makers in the field of radiological protection.'

233. The Tribunal therefore has no trouble in accepting their views as authoritative.

234. The Tribunal has been provided with a 2012 publication in the Annals of the ICRP (publication 118) entitled *ICRP Statement on Tissue Reactions and Early and Late Effects of Radiation in Normal Tissues and Organs - Threshold Doses for Tissue Reactions in a Radiation Protection Context.* This report will hereafter be referred to as ICRP 2012.

235. ICRP 2012 is concerned primarily with the non cancer effects of radiation, which are discussed further below. *'The main emphasis of this review was to provide estimates of threshold dose, defined for practical purposes as the dose resulting in only 1% incidence of specified tissue or organ reactions.'*

236. ICRP 2012 deals with not only lower dose levels of ionising radiation (not otherwise defined) but also higher or radiotherapeutic levels, typically involving several Grays.[thousands of mSv]

RADIOGENICITY OF AND EXPOSURE RISK ESTIMATES FOR CANCER

237. By the term radiogenicity we mean a condition for which exposure to ionising radiation can be a cause.

Carcinoma of the Pancreas (Mr Smith and Mr Williams)

238. UNSCEAR 2006 Annex A reviewed a number of studies including the LSS, involving exposure to external Low-LET and internal Low-LET and High-LET. It concluded (page 70)

'There is little, if any, evidence for associations between pancreatic cancer and radiation dose, whether in relation to external or internal Low-LET radiation, or to internal High-LET radiation.'

239. The LSS Report 14 (E3/16) found an ERR of 0.22 per Gy for cancer of the pancreas in males (but this did not attain statistical significance (95 CI minus 0.17, 0.83; P = 0.33).

240. In her report at D/4 (pages 105 and 112), and in respect of Mr Smith and Mr Williams, Professor Parker stated

'There are several reports of increased risk of pancreatic cancer in individuals exposed to ionising radiation, reported in UNSCEAR 2006. While some findings have been contradictory, studying pancreatic cancer as an outcome is exceedingly challenging as it is such a rare disease accounting for example for less than 2% of all cancers in the UK.'

241. She also points out that the young age of Mr Smith and Mr Williams would have greatly increased their radiation sensitivity. Professor Parker did not refer to the UNSCEAR 2006 Conclusion, or the LSS Report 14 summarised above.

242. In her report (E1/8) Professor Mothersill mentioned, in reference to Mr Smith and Mr Williams,

'Two studies showing excess risk of pancreatic cancer in people exposed to low dose/low dose rate ionising radiation. It is probable that the ingestions of fallout proposed is critical in this case.'

She continued that

'It is reasonable to conclude that radiation exposure on Christmas Island did make a contribution to the development of Mr [Smith's and Williams'] pancreatic cancer.'

243. A letter from Mr Smith's Consultant Oncologist Dr Sothi dated 22nd December 2010 (D/11) stated

'Radiation is clearly recognised as a possible aetiological factor for this cancer.'

244. Mr Williams' Consultant Oncologist Dr Wilkins said in a letter dated 21st January 2011 (D/11)

'I note the expert opinion preferred by Professor Carmel Mothersill. It is certainly possible that radiation exposure whilst serving in the RAF increased the risk of this patient developing pancreatic carcinoma.'

245. Professor Kaldor (D/20, 21 and 22) considered that

> *'The following could plausibly be considered to have a link with ionising radiation exposure: anaemia; atherosclerosis; basal cell carcinoma; squamous cell carcinoma; cancers of bone, bowel, brain, bladder, kidney, colon, rectum, liver, oesophagus, pancreas, prostate, stomach, parathyroid, tongue, mouth, pharynx, trachea, bronchus, lung; cataracts; leukaemia; non Hodgkin's lymphoma.'* (D3/20, page 17, paragraph 62).

246. He then goes on to consider a likelihood of occurrence of various conditions, based upon an assumed ionising radiation exposure on Christmas Island. Because the Tribunal has made its own findings of ionising radiation exposure in respect of each individual appellant, Professor Kaldor's assumptions of exposure do not otherwise assist us further.

247. Professor Forbes is a Gastro-enterologist (report at D/26). His opinion is that

> *'An association of ionising radiation with pancreatic cancer is generally thought to be absent or weak.'* (paragraph 7),

and then goes on to discuss the LSS and the two papers cited by Professor Mothersill (Tao et al and Guerin et al), stating (paragraph 9)

> *'The late claimant and his supporters propose two papers favouring a definite link between radiation and pancreatic cancer, but neither paper is uniquely specific to this diagnosis and neither is directly relevant to the postulated exposure in Mr Smith's case. Neither really supports the claimed interpretation.'*

He also describes CT scan evidence of chronic pancreatitis in Mr Smith.

248. Professor Forbes then goes on to consider the medical circumstances of Mr Williams. Apart from noting that Mr Williams was a smoker, which is a risk factor for pancreatic cancer (but he did not have chronic pancreatitis), it is unsurprising that Professor Forbes reaches the same conclusions for Mr Williams as he does for Mr Smith.

249. Dr Braidwood provided a Summary of Expert Evidence on each of the appellants at D/32.

250. Taking into account the foregoing, the Tribunal finds that although the radiogenicity of carcinoma of the pancreas is by no means firmly established, a reasonable doubt based on reliable evidence is raised that it can be, and Secretary of State accepts it as radiogenic. The Tribunal also finds that establishing an excess relative risk for carcinoma of the pancreas cannot be done with precision. The LSS Report 14 found an ERR per Gy of 0.42 for all solid cancer at age 70, after exposure at age 30; Figure 2 at page 235 suggests that this might be increased to 0.6 or 0.7 for exposure at age 20; for carcinoma of the pancreas individually a non significant ERR per Gy of 0.22 was found. Therefore we find that an ERR per Gy of 0.6 to 0.7 [i.e. per 1,000 mSv of 60-70%] would be reasonable, if not generous, for Mr Smith and Mr Williams.

Transitional Cell Carcinoma of the Bladder (Mr Abdale)

251. Following the same sequence of enquiry as for carcinoma of the pancreas above, we note the following:

252. UNSCEAR 2006 confirmed the radiogenicity of bladder cancer.

253. The LSS Report 14 found for male deaths an ERR per Gy of 0.88 (95% CI, 0.02 - 2.3, P = 0.04).

254. Professor Parker (D/4, page 52) stated:

> *'It is widely accepted that bladder cancer can be caused by exposure to ionising radiation. The rate of bladder cancer risk has been reported to be increased in several groups exposed to ionising radiation including; survivors of the detonations at Hiroshima and Nagasaki; those exposed occupationally; those exposed to ionising radiation due to benign or malignant disease (see UNSCEAR 2006, page 96 FF). It is estimated that 16% of bladder cancers in Hiroshima and Nagasaki survivors exposed to > 5 mSv are attributable to radiation exposure. Relative mortality from bladder cancer is highest for those exposed between the age of 20 and 40 years and incidence is highest for those exposed under age 20 and second highest for those exposed aged 20 to 40 years.'*

255. She then reproduces figures 10.1a and 10.1b from UNSCEAR 2006, from which it is noted (inter alia) that there is an average excess relative risk at 1 Sv for incidence of 1.00

if exposed at age less than 20 years, 0.95 if exposed at age 20 to 40 years, and 1.00 if time since exposure greater than 30 years. (Figures originally from LSS).

256. Professor Mothersill discusses NTE in general. She describes Mr Abdale as having developed *'nine tumours'*, and then goes on to discuss how exposure to IR can increase the risk of second cancers. Professor Mothersill is not medically qualified, and appears to assume that the recurrences of Mr Abdale's transitional cell carcinoma of the bladder, a clinically common event, equated to new tumours arising. We do not accept this as reliable evidence as she is expressing an opinion which is outside her area of expertise.

257. A report was provided by Consultant Urologist Mr David Hrouda (D3/28). He confirms the radiogenicity of transitional cell carcinoma of the bladder. He confirmed that

> *'The majority of patients with superficial bladder cancer develop recurrent disease at some stage (62%).'*

258. He confirmed that Mr Abdale did not have other recognised risk factors for bladder cancer such as occupational exposure or smoking.

259. Dr Braidwood summarises the reports of other experts.

260. Based upon the foregoing, the Tribunal finds:

260.1 Transitional cell carcinoma of the bladder can be radiogenic, and is accepted as such by Secretary of State.

260.2 As an order of magnitude, the ERR per Sv for bladder cancer incidence is in the region of 1.0 [i.e. per 1,000 mSv of 100%].

Chronic Lymphatic Leukaemia (synonym Chronic Lymphocytic Leukaemia, CLL) (Mr Battersby)

261. The Secretary of State does not accept chronic lymphatic leukaemia (CLL) as radiogenic.

262. UNSCEAR 2006 discusses the various types of leukaemia and comments (Annexe A, page 113, paragraph 500)

> *'CLL is now thought to be a variety of non Hodgkin's lymphoma.'* It continues (page 120, paragraph 530) *'In particular, these studies and also those of occupational exposures provide far stronger evidence of an association between*

non CLL leukaemia risks and radiation exposure than is the case for CLL risks. Moreover, in view of the clinical and aetiological links between CLL and lymphomas, the conclusion reached elsewhere in this Annexe concerning radiation exposure and lymphoma risk should also apply to CLL risk.'

263. In its section on non Hodgkin's lymphoma (NHL) UNSCEAR 2006 concluded (Annexe A, page 110, paragraph 480)

'Findings from recent studies do not change the assessment made by the committee in its 2000 report. Results from studies of NHL risk among groups exposed to external Low-LET radiation are mixed, with little evidence of an association overall. There is still limited information on NHL risk in relation to either High-LET radiation (external or internal) exposure or internal Low-LET radiation exposure, and interpretation of the available data is difficult.'

264. Professor Parker deals with CLL at page 16 of her report at D1/6, stating:

'Studies of CLL risk in the Japanese population were limited for two reasons; firstly because CLL is very rare in Japan and secondly because it was possible that there was misdiagnosis of some T-cell leukaemia's such as CLL which would reduce the statistical power of any study of CLL. While it was originally concluded that CLL is not a radiogenic leukaemia, recent evidence has opened the position that CLL is not induced by radiation may well be incorrect. In particular, studies of Czech uranium miners and Chernobyl clean-up workers suggest that CLL may be associated with radiation exposure with long latency [cites papers by Richardson et al, Abramenko et al and Rericha et al]. *Reviewing this data, Hamblin has suggested that the position of CLL as a radiogenic cancer should be reconsidered in particular in the light of some of the issues raised above and since at a molecular level CLL shares many of the features of non CLL cancers which can be induced by radiation.'*

265. The editorial by Professor Hamblin (Leukaemia Research 32 (2008) 523 - 525; E3/19) reviewed the scientific evidence (including the Abramenko Paper, Leukaemia Research 32 (2008) 535 - 545; E3/20), and concluded:

'What do these new data amount to? They certainly do not establish that CLL may be caused or even made worse by ionising radiation. On the other hand there is

enough suspicion for the case to be sub-judice. Irradiation may well have been given a clean bill of health with respect to CLL with less than adequate evidence.'

266. Professor Daniel Catovsky (report at D3/25) held the Chair of Haematology and Cytogenetics at the Institute of Cancer Research and was a Consultant Physician at the Royal Marsden Hospital until he retired in 2003. In 2006 he received the Rai-Binet Medal for contributions to chronic lymphocytic leukaemia by the International Workshop on CLL. He considers that

'Genetic predisposition plays a major role in the development of the disease ... the fact that in 20% of cases the IG subsets show identical (or stereotype) structure also strongly suggests a common aetiology or mechanism for disease progression via antigenic exposure. There is significant genetic predisposition (more than in any other type of leukaemia), as documented in case control, cohort and family case studies (reviewed in Yuille et al, 2000). Research at the Institute of Cancer Research in London has now demonstrated ten predisposition gene loci as the basis for this high familial predisposition.' He cites various studies including Abramenko et al 2008.

267. He concludes:

'There are no firm data of any kind to suggest that CLL could be caused or initiated by radiation, based on old or new studies. It certainly does not apply to the majority of patients and is almost impossible to prove in those who may have been exposed. There are enough new data on predisposition genes discovered and the pathogenesis of the disease to make the argument for a role for radiation highly unlikely.'

268. Professor Catovsky provided a supplementary report (D3/25a) in which he reiterates his reasons for saying that *'Chronic antigenic stimulation may drive the development of the disease.'*

269. He explained that:

'CLL was always considered a malignancy of mature B cells and therefore grouped together with the B-cell lymphomas.'

270. The U.S. National Institute for Occupational Safety and Health (NIOSH) considered the radiogenicity of CLL for occupational compensation purposes, and found 'the evidence

offered by epidemiology studies to be non-determinative, but no longer believes that it is possible to state that the probability of causation equals zero'. (E/10, 15271).

271. Having explained that there are different subtypes of CLL, based upon common gene variants where familial disposition is a factor, and the stereotyping of B-cell receptors in about 30% of patients, he explains that the Abramenko study described a more aggressive form of CLL which developed after 15 to 20 years after exposure, in those exposed younger. Mr Battersby's form of CLL, in the opinion of Professor Catovsky, did not fall into this category.

272. Based upon the foregoing, we find that there is insufficient reliable evidence to raise a reasonable doubt that CLL can be caused by exposure to ionising radiation. Such evidence as there may be includes the Abramenko Study which describes a different form of CLL to that suffered by Mr Battersby, as explained above by Professor Catovsky.

Polycythaemia Rubra Vera (PRV) (Mr Hatton)

273. In a document dated June 2003 and entitled *Policy Statement on Claims for Ionising Radiation Related Conditions*, the Secretary of State had accepted as a matter of policy that there was a causal link between ionising radiation exposure and a number of cancers including PRV and non-Hodgkin's lymphomas. Paragraph 4 of that document stated:

> *"Awards can be made for leukaemia (other than chronic lymphatic leukaemia) and PRV if their clinical onset is within 25 years of first visiting the sites, based on presence only at the tests (ie exposure to service-related ionising radiation does not need to be shown)."*

274. Mr Heppinstall informed the Tribunal that that policy has now been withdrawn, and that the Secretary of State does not now accept PRV or NHL (see below) as being radiogenic.

275. UNSCEAR 2006 does not specifically deal with PRV.

276. Professor Parker did not deal specifically with PRV in her report, as she understood that radiogenicity was accepted as a matter of policy by the UK and US governments. In oral evidence (T8Feb page 103 onwards) she considered it '*plausible'* that PRV might be radiogenic, but adduced no specific epidemiological evidence in support of her view. In cross-examination (T11Feb, page 23) she referred to the paper by Caldwell and others

entitled Polycythaemia Vera Among Participants of a Nuclear Weapons Test (JAMA 1984 (252:5; 662 - 664); E2/5), which describes two cases and two suspected cases of PRV among 3,217 US nuclear test participants. The paper itself stated:

> *'However, the small individual whole body doses of radiation reported for these four participants make the association with ionising radiation tenuous, although this was the only known unusual factor.'*

277. Professor Parker acknowledged the difficulties of reaching a firm conclusion.

278. Professor Catovsky describes PRV as a clonal myeloproliferative disorder affecting all the bone marrow cell lines. It occurs sporadically, although familial cases have been reported suggesting a genetic predisposition. There are no known environmental factors and *'A link with ionising radiation has not been demonstrated unequivocally.'*. He cites 12 cases of PRV in participants in the UK nuclear weapons tests, with 13 in the controls (Muirhead et al 2003). He goes on to cite other studies, including Caldwell, and concludes:

> *'The evidence in the literature for a possible association between PRV and radiation is not well documented and I do not consider the evidence that exists to be reliable applying the meaning of 'reliable evidence' given in the case of Edwards.'* He continues *'No excess of PRV was found following the atomic bomb explosions in Nagasaki but a few cases were noted in Hiroshima. ... Epidemiological data on 842 cases of PRV studied by a French group and some cases of familial myeloproliferative disorders but no excess of radiation exposure as a causative factor. The series included 24 cases irradiated for cancer or exposed by their occupation, but this number was considered by the authors as not statistically significant (Najean et al, 1998).*

279. He goes on to point out that the cases reported by Caldwell were diagnosed between 10 and 20 years after exposure, whereas Mr Hatton's PRV *'Did not present clinically until 2001.'* A similar point about length of time between exposure and development of the disease is also made by Professor Kaldor. Professor Parker was of the view that time elapse alone would not exclude radiogenicity for disease in general (T11Feb page 24).

280. Dr Braidwood again summarises the evidence of others.

281. Based upon the foregoing, we find that there is insufficient evidence to raise a reasonable doubt that PRV is radiogenic.

Non Hodgkin's Lymphoma (Mr Sinfield)

282. The Secretary of State does not accept non Hodgkin's lymphoma (NHL) as being radiogenic, in the circumstances explained above in the Section on PRV.

283. NHL is a collection of distinct disease entities that are malignant expansions of lymphocytes. There are a number of different classification systems for NHL.

284. The late Mr Sinfield's claim is in respect of non Hodgkin's lymphoma. We find that Mr Sinfield's particular form of NHL was anaplastic large cell lymphoma (ALCL), as diagnosed on a biopsy in November 2005 (A/31).

285. As stated above for CLL, UNSCEAR 2006 (Annexe A, page 110, paragraph 480) concluded:

> *'Findings from recent studies do not change the assessment made by the committee in its 2000 report. The results from studies of NHL risk among groups exposed to external Low-LET radiation are mixed, with little evidence of an association overall. There is still limited information on NHL risk in relation to either High-LET radiation (external or internal) exposure or internal Low-LET radiation exposure, and interpretation of the available data is difficult.'*

286. LSS Report 14 (Table 3) gives an ERR per Gy for male deaths from malignant lymphoma (not otherwise specified) of 0.70 (95% CI 0.08 to 1.7; P = 0.02). (It was non-significant (P = 0.33) for female deaths.)

287. Professor Parker (D1/6, page 17) cites RERF Report Number 8 - 08 by Richardson et al (Am J Epidemiol 169 (8: 969 - 76), 2009), which investigated two cohorts, namely 20,940 men in the Lifespan Study and 15,264 male nuclear weapons workers. They found

> *'Positive associations between lymphoma mortality and radiation dose under a five year lag assumption were observed in both cohorts (excess relative rates per Sv were 0.79 (90%CI: 0.10 - 1.88) and 6.99 (90% CI: 0.96 - 18.39) respectively.'*

288. A letter from Mr Sinfield's Consultant Haematologist Dr Berney dated 31st January 2011 (D/11) stated

> *'Mr Sinfield's type of lymphoma is rare and the presentation was highly unusual. In 20 years working as a Consultant in Haematology I have not seen a similar presentation. In such cases, we would normally look for some factor which might be implicated in the development of such an unusual lymphoma. When Mr Sinfield mentioned that he had been involved in the Christmas Island atomic bomb tests, both myself and my colleague, Dr Virchis, felt that exposure to radiation at that time was highly likely to have contributed to the development of this aggressive and unusual type of lymphoma which makes up 3% of cases of NHL in adults.'*

289. She continued

> *'It is well known that exposure to excessive radiation can lead to an increased incidence of haematological malignancies, including lymphoma',*
>
> but provides no scientific evidence in support of this view.'

290. Professor Catovsky states (D3/25)

> *'There is no well documented increase in NHL in atomic bomb survivors or in other studies of workers exposed to X-rays. Most NHLs have multiple possible aetiologies or pathogenetic mechanisms, except for ionising radiation ... I am not aware of any single report linking radiation exposure and ALCL. Studies with a long follow-up like the one from Richardson (2009) have not addressed specifically the issue of ALCL. Reports of lymphoma in general are not informative if one considers the many different types of NHL currently known. In fact, 33 are included in the WHO 2008 classification.*
>
> *I have reviewed the supplemental report from Professor L Parker. Although she quotes a number of possible associations, none refers specifically to ALCL, the type of lymphoma that affected Mr Sinfield. Such reports, like the single case report of a Nagasaki survivor, do not provide any additional scientific evidence in this case.'*

291. Based on the foregoing, we find that there is no evidence to raise a reasonable doubt that ALCL in particular is radiogenic, and no reliable evidence for NHL as a whole.

NON-CANCEROUS CONDITIONS AND EXPOSURE

292. There has been developing interest in this topic in recent years, with information coming from epidemiological studies as well as from basic scientific research which has shown that ionising radiation exposure can cause long term modification of inflammatory and immune responses. Given that this is a developing area of knowledge, the Tribunal found the ICRP 2012 Report particularly helpful, because it is authoritative, pulls together much of the knowledge on the subject, and is up to date.

Circulatory Disease and Atherosclerosis (Mr Beeton, Mr Butler, Mr Lovatt and Mr Pritchard)

293. Atherosclerosis is a process of hardening and narrowing of the arteries which begins in childhood and continues throughout a person's life. It involves deposition of lipid material and proliferation of cells in the walls of arteries, and involves chronic inflammatory processes. (See Synopsis of Causation A/286.)

294. Atherosclerosis can manifest itself in a number of forms of disease entity, which include:

294.1 Cardiovascular disease, where the coronary arteries which supply the heart muscle with blood become narrowed, which in turn can lead to myocardial infarction (MI).

294.2 Cerebrovascular disease, where arteries in the brain become narrowed, so that they may become blocked or burst. When this occurs, it is commonly referred to as a stroke.

294.3 Renovascular disease, where small arteries in the kidneys become narrowed. This can lead to a form of raised blood vessel known as renal hypertension. (Other non-atherosclerotic diseases of the kidney can also lead to renal hypertension.)

294.4 Peripheral vascular disease, where arteries in the limbs become narrowed so that it can, for example, become painful and difficult to walk.

295. ICRP 2012 (page 20, paragraph (h)) stated:

'ICRP has not previously listed circulatory disease as a health hazard from radiation exposures to organs and tissues, because it is only in the last few years that there has been greater consolidation of the evidence on this topic. The evidence arises from radiotherapeutic experience and epidemiological studies

following nuclear and other radiation activities. There is no clear pattern across studies regarding whether or not the excess relative risk for cardiovascular disease is greater than that for stroke or cerebrovascular disease. From current evidence, a judgement can be made of a threshold acute dose of approximately 0.5 Gy (or 500 mSv, see note about units below) for both cardiovascular disease and cerebrovascular disease. On that basis, 0.5 Gy may lead to approximately 1% of exposed individuals developing the disease in question greater than 10 years after exposure. This is in addition to the high natural incidence rate (circulatory disease is accountable for 30% to 50% of all deaths in most developed countries).'

296. The Tribunal has also been provided with a number of publications of various prior date, including:

296.1 Circulatory Disease Risk. Documents of the Health Protection Agency, October 2010 (E3/17).

296.2 McGale et al. Low Doses of Ionising Radiation and Circulatory Diseases: A Systematic Review of the Published Epidemiological Evidence. Radiation Research 163, 247 - 257 (2005). E1/18.

296.3 Shimizu et al. Radiation Exposure and Circulatory Risk: Hiroshima and Nagasaki Atomic Bomb Survivor Data, 1950 - 2003. BMJ 2010; 340: B5349. E1/17.

296.4 McGeoghetan et al. The Non Cancer Mortality Experience of Male Workers at British Nuclear Fuels PLC, 1946 - 2005. Int. J. Epidemiol. 2008; 1 - 13.

296.5 Ivanov et al. The Risk of Radiation Induced Cerebrovascular Disease in Chernobyl Emergency Workers. Health Physics 2006; 90: 199 - 207.

297. None of these publications persuade us that the ICRP 2012 view is unreliable.

298. The Tribunal also notes that direct damage to the heart and blood vessels can occur in a deterministic fashion as a result of very high doses, typically in a radiotherapy setting, but do not consider this to be of relevance to these appeals.

299. The LSS Report 14 also considered non cancer diseases. They found an increased number of deaths from circulatory disease (not otherwise defined) but whilst this was significant in females, it was non-significant in males. When combined, the ERR per Gy for circulatory disease was 0.11 (95% CI 0.05 - 0.18; $P < 0.001$).

300. Many of the foregoing studies mentioned hypertension as a risk factor for circulatory disease. None provided evidence that primary or essential hypertension can be caused by ionising radiation exposure.

301. Based on the foregoing, the Tribunal finds that circulatory disease can be a radiogenic condition. The evidence is best for cardiovascular and cerebrovascular disease. Doses above 0.5 Gy [i.e. 500mSv] may lead to approximately 1% of exposed individuals developing the disease.

302. We also find that whilst hypertension as a result of atherosclerotic renovascular disease can be radiogenic, there is no evidence that other forms of hypertension can be caused by ionising radiation exposure.

Cataracts (Mr Abdale and Mr Shaw)

303. ICRP 2012 (page 21, paragraph (i)) stated:

> *'For cataracts in the lens of the eye induced by acute exposures, recent studies, where formal estimates of threshold doses have been made after long follow-up periods, indicate values of approximately 0.5 Gy with 90% to 95% confidence intervals including a zero dose. This is lower by a factor of 10 than deduced in earlier studies.'*

304. Professor Parker also quotes from the ICRP 2012 report, and cites two studies (D1/5a, page 17)

> *'Formal estimates of acute threshold doses have been made in two studies on atomic bomb survivors (Nakashima et al, 2006; Neriishi et al, 2007 (discussed below)). These provided threshold doses of 0.1 - 0.7 Gy with 90% to 95% confidence intervals including 0 Gy. Estimates of threshold doses for protracted exposures were calculated for Chernobyl survivors and these estimates ranged between 0.34 - 0.50 Gy, with 95% confidence intervals 0.17 - 0.69 Gy. There was no dependence of threshold dose on stage or site of the cataract.'*

305. A report was provided by Mr James Acheson, Consultant Ophthalmologist, in respect of Mr Abdale and Mr Shaw (D/27). He reviewed some of the literature relating to cataracts and exposure to ionising radiation (but not including ICRP 2012) noting, in broad terms,

a threshold of about 0.5 Gy [i.e. 500 mSv] below which vision impairing cataracts were not identified.

306. On the basis of the foregoing, the Tribunal finds that cataracts can be radiogenic. There is reliable evidence that cataracts can be caused by exposure in the region of 0.5 Gy [i.e. 500 mSv] and that exposure as low as 0.1 Gy [i.e. 100 mSv] might be so capable. We note the Secretary of State's contention that Mr Shaw's type of cataract was not of radiogenic type.

Immune Dysfunction and Modification of Inflammatory Response (Professor Mothersill's and Professor Parker's generic approach)

307. UNSCEAR 2006 devoted an entire Annexe (Annexe D, E3/14) to the effects of ionising radiation on the immune system. For the purposes of these appeals, the technical details of the way in which ionising radiation can have an effect upon the immune system do not specifically assist us. What is helpful to the Tribunal is encapsulated in section VII, Concluding Remarks (page 171) which stated:

> *'The effects of ionising radiation on the immune system can be assessed by estimating changes in cell numbers or by using a variety of functional assays. The impact of such alterations in immune response depends on factors such as the dose of radiation, its temporal relationship with immune system challenge and individual genetic constitution.*
>
> *High doses of radiation produce immunosuppression mainly through the destruction of cells.*
>
> *Lymphocytes are very radio sensitive, and their reduction is currently used as an early indication of the level of an accidental acute exposure. Radiation induced changes in immune parameters seem to be more dependent on total dose than on dose rate. Persisting effects on the immune system have been observed after exposure to ionising radiation.*
>
> *At low doses and dose rates, the effect of ionising radiation on the immune system may be suppressive or stimulatory. The long term impact of low radiation doses on the immune function in relation to human health needs to be further evaluated.'*

308. At paragraph 464 in section V Final Summary (page 169) it states:

> *'Finally, the question of how radiation induced effects on the immune system may impact on human health remains unanswered. There are many issues that need to*

be more thoroughly investigated before firm conclusions can be reached. Possible future directions for research concerning the effects of ionising radiation on the immune system [are then listed].

309. A paper by Kusunoki et al entitled *'Long Lasting Alterations of the Immune System by Ionising Radiation Exposure: Implications for Disease Development Among Atomic Bomb Survivors'* (Int J Radiat Biol 84: 1 - 14 (2008) (E3/15) detected long lasting alterations in immunological functions associated with atomic bomb irradiation, as well as a persistent change in inflammatory markers. The authors then went on to consider how such changes might result in actual disease development. The paper appears to be written in a spirit of enquiry, with suggestions for further research. It notes, inter alia,

'Prevalence of hepatitis B virus (HBV) carriers appear to be increased among A-bomb survivors ... by contrast, hepatitic C virus (HCV) infections were not influenced by the extent of irradiation.'

'The frequency of finding antibody to Chlamydia pneumoniae but not Helicobacter pylori [two common types of bacteria], *appeared to decrease with radiation dose among A-bomb survivors ... associations between humoral immune responses to these microbial infections and diseases risks among A-bomb survivors remain ill defined and need to be more thoroughly investigated.*

As already summarised in an earlier review (Akiyama 1995), there has been no clinical or epidemiological evidence that supports the idea that there is an increase of autoimmune disease among A-bomb survivors.

... Thus it can be argued that A-bomb irradiation accelerated the natural processes associated with immunological ageing.'

310. Under the heading *'Does A-Bomb Radiation Induced Damage of the Immune System Lead to Disease Development?'*, the authors note an increase in cardiovascular disease, but do not otherwise specifically identify any causal link between alterations in immune or inflammatory function and development of a specific disease, although they hypothesise that such links may exist, stating for example:

'It is therefore possible that the resulting reductions in naive T-cell pool sizes might be related to certain inflammation associated diseases in A-bomb survivors.'

311. This section concludes with the sentence

'Clearly prospective studies will be required to test these hypotheses directly.'

312. In the final section the authors mention

> *'Our preliminary study of a group of A-bomb survivors in Hiroshima suggests the possibility that prevalence of Type II diabetes may be affected by radiation dose in the individuals with a particular human leucocyte antigen (HLA) type but not in individuals with other HLA types (Hayashi et al 2003a). Such an immunogenetic approach would be very likely to provide new insights into determining the mechanisms by which acute, ionising radiation exposure causes disease.'*

313. Both Professor Parker and Professor Mothersill adopt a 'generic approach' to what they perceive as being a causal link between altered immune or inflammatory function and the development of specific diseases (as distinct from any epidemiological evidence they may adduce).

314. Professor Parker uses a similar form of words in respect of a variety of different conditions, for example under the heading *Kidney Disease and Diabetes* (D4, paragraph 10.7.6.2).

> *'Studies have shown that radiation exposure can result in long term perturbation of the immune system. This can result in chronic inflammation, increased autoimmune disease and increased rates of infection.* [Cites Kusunoki 2008 but see above what Kusunoki actually says.] *The evidence on this was also extensively reviewed in UNSCEAR 2006, Volume 2 Annexe D Effects of Ionising Radiation on the Immune System and Annexe C Non Targeted and Delayed Effects of Exposure to Radiation. The evidence supports a dose dependent decrease in cellular immunity and other changes in immune function which may be implicated in chronic inflammation and autoimmune diseases. In particular impacts on the immune system can include lymphocyte apoptosis, modification of Th1 and Th2 balance, shift towards inflammatory profile, acceleration in immunological ageing, modification of antigen presentation, autoimmune reactions and perturbation of immunological homeostasis.*
>
> *Glomerulonephritis is an inflammatory condition of the kidney and the repeated severe infections would be consistent with radiation induced immunological dysfunction. Changes in the risk of diabetes which has an autoimmune and*

inflammatory component, have been reported in the LSS Cohort and is consistent with a late effect of ionising radiation in the induced immune dysfunction.'

315. Professor Mothersill's position is slightly different in that she proposes NTE as a mechanism whereby the immune and inflammatory responses can be modified. However, as with Professor Parker, she goes on to make a causative link between such effects and the development of specific diseases. For example in respect of Mr Pritchard she states (D8):

'Mrs Pritchard is claiming for her husband's kidney disease and diabetes. The conditions listed as the cause of death include a range of conditions including polyarthropathy, cardiovascular disease and arterial atheroma suggesting that the cause was persistent systemic inflammatory disease. This is the subject of intense research in the EU and elsewhere. The mechanism appears to be induction of systemic inflammation by ionising radiation leading to chronic systemic inflammatory disease.'

And on the next page, in respect of Mr Selby:

'Mr Selby died from idiopathic fibrosing alveolitis (cryptogenic fibrosing alveolitis) which is a chronic lung disease characterised initially by the presence of inflammatory cells within the alveoli. This is followed by thickening and fibrosis of the alveolar walls. The aetiology and pathogenesis is as yet unknown but since ionising radiation is known to cause inflammatory disease the development of this condition is entirely consistent with low dose ionising radiation causing genomic instability in the bone marrow which leads to the production of inflammatory cytokines.'

316. Neither Professor Parker nor Professor Mothersill are medically qualified. In order to provide an authoritative opinion on a causal link between an abnormality of immune or inflammatory response and a particular disease entity, the Tribunal would presuppose at least a thorough knowledge of the clinical and pathological basis for the condition, if not special expertise in that particular field of medicine (for example kidney disease or heart disease). We would also expect an iteration of the medical scientific knowledge pertaining to the immunological or inflammatory abnormalities to be found in each condition, with specific reference to whether these were thought to be causal for as opposed to a consequence of the condition in question. This is particularly so because the

current state of scientific knowledge outlined above appears to indicate that whilst the existence of effects upon immunological and inflammatory response resulting from ionising radiation are not in dispute, a causal link between these and specific diseases is at no more than a hypothetical stage.

317. At T 7 Feb page 56 Professor Mothersill said (in answer to a question whether she would be within her expertise discussing Professor Catovsky's clinical report on Mr Sinfield).

'My expertise is radiobiology. My expertise is the ability to say: at the doses that we are talking about, there is - I would almost say a certainty that these mechanisms that I am talking about, the non targeted effects, were turned on. I can say nothing about what the outcome from having that mechanism turned on is, but I can say that it increases the probability of the kind of diseases we are talking about occurring. I mean, as a radiobiologist, really all I can say. I don't know what - .'

318. Professor Parker also accepted that clinical matters were outside her expertise, for example at T8Feb page 99 in answer to the question *Is PRV like a bone cancer?*, she responded:

'You would have to ask a clinical opinion for that.'

319. The Tribunal therefore finds that there is reliable evidence to show that ionising radiation can have a long term effect on immune and inflammatory responses in humans, but that there is no reliable scientific evidence that establishes a causal link between these effects and the development of specific diseases. This area of science is still at the hypothesis stage. The opinions of Professor Mothersill and Professor Parker on such a causal link are outwith their expertise, and the Tribunal attaches no weight to these opinions.

Glomerulonephritis (Mr Butler and Mr Pritchard)

320. Glomerulonephritis is the name given to a number of distinct pathological entities affecting the kidney glomeruli (ie a specific part of the microscopic functional unit of the kidney, the nephron).

321. Different forms of glomerulonephritis have different aetiologies, treatments and outcomes.

322. Mr Butler claimed for glomerulonephritis, the particular type being diagnosed as pauci-immune crescentic glomerulonephritis. (A4(1)/118)

323. Mr Pritchard's type of glomerulonephritis is Berger's nephropathy (also known as IGA nephropathy), which can also be described as a type of autoimmune disease.

324. Both Professor Parker and Professor Mothersill advance their 'generic approach', and for the reasons outlined above, the Tribunal is unable to attach weight to these opinions. Neither present any other scientific evidence of a link between glomerulonephritis and ionising radiation exposure.

325. In the voluminous background literature provided for these appeals, much of which has been referred to above, the Tribunal finds no scientific evidence of such a link.

326. The Tribunal is aware that high doses of ionising radiation can damage the kidney in a deterministic fashion, but such radiation induced injury is not glomerulonephritis.

327. The Secretary of State's position is that glomerulonephritis is not accepted as being radiogenic.

328. The Tribunal finds that glomerulonephritis (and specifically pauci-immune crescentic glomerulonephritis and Berger's disease) is not radiogenic.

Diabetes Mellitus (Mr Selby)

329. Type I diabetes mellitus typically has its onset in childhood, and is insulin dependent. Type II diabetes is typically of maturity onset, is often linked with obesity, and is usually treated by means of dietary control, oral medication (and sometimes insulin as well).

330. UNSCEAR 2006 Annexe D (paragraph 371) noted:

> *'Significant differences in Type II diabetes prevalence were found between heavily exposed (> 1.5 Gy) and low dose or non exposed Hiroshima atomic bombing survivors with different Class 2 HLA DQA1 and DRB1 alleles.* [cites Hayashi et al. Hum. Immunol. 64 (9: 910 - 916 (2003)]. ... *These results suggest that certain Class 2 HLA genes regulate one or more components of the immune system related with the*

risk of diabetes development among the younger and more heavily exposed survivors.' (This was the same research referred to in the Kusunoki paper).

331. Professor Parker referred to a paper by de Vathaire et al, *Radiation Dose to the Pancreas and Risk of Diabetes Mellitus in Childhood Cancer Survivors: A Retrospective Cohort Study* (Lancet Oncol 2012; 13: 1002 - 10). She stated (D1/5A page 13)

'This paper confirms the relation between radiation exposure and occurrence of diabetes in childhood cancer survivors treated by radiotherapy which has been reported previously. In 2,520 survivors, risk of diabetes increased strongly with radiation dose to the tail of the pancreas. The estimated relative risk was 1 Gy was 1.61 (95% CI 1.21 - 2.68). Compared with patients who did not receive radiotherapy, the relative risk of diabetes was 11.5 (95% CI 3.9 - 34.0) in patients who received 10 Gy or more to the tail of the pancreas. Results were unchanged after adjustment for Body Mass Index, despite a strong independent affect (P < 0.0001), and were similar between men and women.'

332. Professor Parker and Professor Mothersill also advanced their 'generic approach' to causation in diabetes mellitus.

333. The Tribunal therefore finds that Type II diabetes mellitus can be radiogenic. The question of dose is less straightforward. In the childhood cancer study these were children who received substantial therapeutic doses of ionising radiation to the pancreas. The development of diabetes in the RERF Study was considerably influenced by an individual's 'tissue type' genetic makeup.

Bacterial Infections (Mr Butler and Mr Pritchard)

334. Staphylococcal lumbar discitis, streptococcus viridans infection, klebsiella urinary tract infection were claimed by Mr Butler; bronchopneumonia was claimed by Mr Pritchard.

335. Other than deterministic immunosuppression by high (typically radiotherapeutic) levels of ionising radiation exposure, the tribunal has received no direct evidence of an increased risk of bacterial infection as a result of ionising radiation exposure.

336. Professor Parker and Professor Mothersill advance their 'generic approach'.

337. The Tribunal therefore finds that the bacterial infections of the types claimed by Mr Butler and Mr Pritchard are not radiogenic in the absence of clinical immunosuppression caused by deterministic levels of ionising radiation exposure.

Idiopathic Fibrosing Alveolitis (Mr Selby)

338. Idiopathic fibrosing alveolitis is also known as cryptogenic fibrosing alveolitis, idiopathic pulmonary fibrosis or usual interstitial pneumonia (UIP). It is a form of chronic fibrosing lung disease in which the underlying cause is unidentified. There are many known causes of chronic fibrosing lung disease including asbestos exposure, some drugs, and connective tissue diseases such as rheumatoid arthritis.

339. Acute radiation lung damage with subsequent scarring (a form of pulmonary fibrosis) is well recognised following substantial doses of IR, typically in a radiotherapeutic context. ICRP 2012 (page 302) gives the threshold values for pneumonitis (i.e. acute lung damage which can lead to subsequent fibrosis) of 6.5 Gy for acute exposures and 18 Gy for highly fractionated exposures.

340. The Tribunal has been provided with a copy of a publication by Parfrey et al, *'Idiopathic Pulmonary Fibrosis in a Christmas Island Nuclear Test Veteran'* BMJ Case Reports 2010; doi: 10.1136/bcr.06.2010.3102). The Tribunal understands that this case report does not refer to Mr Selby.

341. In the Discussion section, this report states:

> *'The incidence of UIP is less certain, although poorly validated reports of 'lung fibrosis' in the Hiroshima bomb survivors have suggested an incidence of 0.8%, equating to an odds ratio of 2.01 over the non exposed population. Plutonium (PU239) inhalation at an annual dose of > 10 mSv is more firmly associated with lung fibrosis ('plutonium pneumosclerosis') and there are similar reports from workers in the USA involved in underground uranium mining during 1942 - 1971.'*

342. It then goes on to discuss lung damage from acute radiation injury, noting

> *'In such cases pulmonary fibrosis is usually well established by 12 months.'*

343. The authors state that there were no dosimetry records for the subject, and conclude:

'We speculate that the close proximity of our patient to three large nuclear detonations and the fact that he has two other conditions well recognised to be associated with radiation injury (bladder carcinoma and atherosclerosis of a major artery), together with the chronicity of his pulmonary fibrosis all support a causal link.'

344. Professor Parker and Professor Mothersill advance their 'generic approach'.

345. The Tribunal has been provided with no other scientific evidence for a causal link between ionising radiation exposure and pulmonary fibrosis in general nor with idiopathic fibrosing alveolitis in particular, other than following acute lung injury, plutonium inhalation or uranium mining. The Parfrey report speculates on a possible link between ionising radiation exposure and idiopathic pulmonary fibrosis in a Christmas Island nuclear test veteran.

346. The Tribunal therefore finds that pulmonary fibrosis, which might conceivably be diagnosed in an individual as idiopathic fibrosing alveolitis, can be radiogenic under certain conditions as just described.

Professor Mothersill's Supplementary Report of 13 Nov 12 (D8A)

347. In this report Professor Mothersill reviews the advances in low dose radiobiology in the previous few years, and cites various publications, which the Tribunal has been provided with, in support of the following:

*'**Summary of Advances:***

1 Recognition that cardiovascular disease (CVD) can be caused by low dose radiation exposure (epidemiological and experimental evidence).

2 Recognition that central nervous system disease (CNSD) is caused by low dose radiation exposure (epidemiological and experimental evidence).

3 Confirmation that non targeted effects of radiation (genomic instability and bystander effects) happen in vivo in mammals as well as most non mammalian animal species.

4 Confirmation that non targeted effects of radiation (genomic instability and bystander effects) are transmissible to offspring and to neighbours.

5 *Confirmation of a central role for inflammatory response and innate immune system following the exposure of mammals to low doses of radiation.*

6 *Mechanistic understanding of the biophysical and biochemical effects of low radiation doses.'*

348. Paragraphs 1, 3, 4 and 6 have been considered above, and are not considered to be an issue so far as this Tribunal is concerned. In paragraphs 2 and 5 however, Professor Mothersill appears to take her generic approach 'a stage further' to the stage of established fact. Because these assertions did not on the face of it appear to be corroborated by the voluminous other scientific evidence with which the Tribunal has been provided, and in the context of Professor Mothersill's acceptance of her lack of clinical expertise, we felt it necessary to explore the issues further.

Paragraph 2 - Recognition that CNSD is [our emphasis] Caused by Low Dose Radiation Exposure (Epidemiological and Experimental Evidence)

349. The reference to CNS disease presumably relates to Mr Simons, in respect of whom Professor Mothersill stated

'Mr Simons is suffering from osteoarthritis, diabetes and a number of conditions which have a neurodegenerative involvement (pins and needles, sleep apnoea and incontinence).' (D1/8).

350. The Tribunal does not accept that Professor Mothersill has the clinical expertise necessary to make this diagnostic categorisation of neurodegenerative involvement.

351. She continues on the same page

'Recent research has also linked neurodegenerative disorder with ionising radiation exposure. Recent research has shown that neural stem cells exist which are exquisitely sensitive to low doses of ionising radiation thus all the arguments about the role of genomic instability and bystander effects cited above can be argued here.'

352. In her supplementary report of 13th November 2012, under the above heading (her paragraph number 2), she states:

'Much of the evidence here comes from experimental studies which were funded by NASA to assess the risks to astronauts to exposure of about 3 mGy over three years

during the Mars Mission. These effects are difficult to study in human cohorts because effects of mental health and wellbeing in irradiated people were dismissed as due to stress and depression about the radiation exposure circumstances, or fear of the consequences. Now however there are experimental studies involving mammals which clearly show impacts on cognitive function (downregulation of critical neural pathways), accelerated ageing and production of Alzheimer's disease like biochemistry and physiology in the cells of animals exposed to low doses of radiation (6 - 9).

Inhibition of neurogenesis and memory impairment have also been documented (10). Of critical importance is the fact that quiescent neural stem cells are highly sensitive to low doses (11) meaning that the repopulation of neural cells as people age could be severely impacted by early exposure to low doses of radiation. Other research documents oxidated damage in the brain leading to apoptosis of neural cells and associated cognitive effects (12, 13). Taken together, these findings provide a causal link between low dose radiation exposure and CNSD and mental health.'

353. We have studied the references:

353.1 Reference 6. Cho-Lim et al. *Satellite Cells Say NO to Radiation.* Radiation Research 175, 561 - 568 (2011). The authors studied the effect of gamma irradiation (0, 1, 2 and 5 Gy) on rat skeletal muscle cells in cell culture, with particular interest in the effect of manipulating nitrous oxide (NO) levels.

353.2 Reference 7. Acharya et al. *Consequences of Ionising Radiation Induced Damage in Human Neural Stem Cells.* Free Radic Biol Med; 49 (12): 1846 - 55. Abstract only provided. This study defined low dose irradiation as less than or equal to 10 Gy, and studied human neural stem cells subjected to '*clinically relevant irradiation (0 - 5 Gy)'* i.e. in the context of cranial irradiation as a treatment for brain cancer. The authors stated *'These data highlight the marked sensitivity of human neural stem cells to low dose irradiation and suggest that long lasting perturbations in the CNS microenvironment due to radiation induced oxidative stress can compromise the functionality of neural stem cells.'*

353.3 Reference 8. Caiozzo et al. *The Radiosensitivity of Satellite Cells: Cell Cycle Regulation, Apoptosis and Oxidative Stress.* Radiat Res. 2010 Nov; 174 (5) 582 - 9. Many of the authors of this paper are shared with Reference

6 above, and this paper appears to cover much the same ground, in which rat skeletal muscle cells in cell culture were either sham irradiated or exposed to 5 Gy.

353.4 Reference 9. Alwood et al. *Heavy Ion Irradiation and Unloading Effects on Mouse Lumbar Vertebral Mycoarchitecture, Mechanical Properties and Tissue Stresses.* Bone; 47 (2: 248 - 55) (2010). Abstract only. Irradiation of mice with heavy ions (0.5 Gy or 2 Gy of 56 iron heavy ion radiation) may accelerate or worsen the loss of skeletal integrity triggered by musculoskeletal disuse.

353.5 Reference 10. Manda et al. *Memory Impairment, Oxidated Damage and Apoptosis Induced by Space Radiation: Ameliorative Potential of Alpha-Lipoic Acid.* Behav Brain Res. 2008: 187 (2): 387 - 9. Mice were exposed to 1.5 Gy of High-LET iron 56 beams, and radiation induced cell damage in the cerebellum was observed, and associated with a decline in certain measures of cognitive function.

353.6 Reference 11. Encinas et al. *Quiescent Adult Neural Stem Cells are Exceptionally Sensitive to Cosmic Radiation.* Exp Neural. 2008; 210 (1): 274 - 9. In this study, mice were exposed to zero or 1 Gy of radioactive iron ionic radiation, and neural stem cell damage observed. The authors intended to simulate a Space radiation environment, where astronauts may be exposed to cosmic rays.

353.7 Reference 12. Lowe et al. *Early Brain Response to Low Dose Radiation Exposure Involves Molecular Networks and Pathways Associated with Cognitive Functions, Advanced Ageing and Alzheimer's Disease.* Radiat Res. 2009 171 (1): 53 - 65. This study exposed mice to what the authors described as low dose exposures (10 cGy) and high dose radiation (2 Gy) and noted that *'The molecular response of the mouse brain within a few hours after low dose irradiation involves the down regulation of neural pathways associated with cognitive dysfunctions that are also down regulated in normal human ageing and Alzheimer's disease.*

353.8 Reference 13. Manda et al. *Space Radiation Induced Inhibition of Neurogenesis in the Hippocampal Dentate Gyrus and Memory Impairment in Mice: Ameliorative Potential of the Melatonin Metabolite AFMK.* J Pineal Res. 2008 45 (4): 430 - 8. The authors observed that radiation exposure (2.0 Gy of 500 MeV/nucleon 56 FE beams, a ground based model of Space

radiation) impaired the spatial memory of mice at later intervals without affecting the motor activities, and observed protective effects from pre-treatment with AFMK.

354. The Tribunal notes from the foregoing that, with one exception, all the foregoing studies relate to studies on mice or rats, either live animals or cell cultures. Many involve irradiation with High-LET ionic particles. Whilst it is of course acknowledged that experimentation of this sort may be a first step on the way to understanding the effects of radiation on humans, we find that a statement that *'Recognition that central nervous system disease is caused by low dose radiation exposure (epidemiological and experimental evidence)'* without further qualification of the nature of the experimentation and radiation type and dose (and the fact that none of these studies were epidemiological ones) is not helpful so far as central nervous system disease in humans is concerned, and the Tribunal does not attach any weight to Professor Mothersill's opinion in this regard.

Paragraph 5 - Confirmation of a Central Role for Inflammatory Response and Innate Immune System following the Exposure of Mammals to Low Doses of Radiation

355. The publications cited in this section describe a number of experiments looking predominantly at cellular responses in a laboratory setting to a range of ionising radiation exposures, and in effect bring up to date the state of scientific knowledge about these mechanisms. None establish a causal link between low dose ionising radiation exposure and specific human disease, and hence can be regarded as further scientific knowledge that underlies Professor Mothersill's 'generic approach' described above.

356. What was unclear to the Tribunal was the phrase *'confirmation of a central role'*, as it was not specified what central role was being confirmed. If it is the contention that low doses of radiation affect the inflammatory response and innate immune system in humans and thereby play a central role in causing specific disease entities, then the Tribunal finds that this latest research does not in fact establish this, and hence cannot be regarded as reliable evidence in support of the contention.

FINDINGS IN RELATION TO INDIVIDUAL APPELLANTS

Mr Leonard Abdale (dob 3 February 1935)

357. Mr Abdale claimed under the SPO 2006 in May and June 2009; the decision under appeal rejecting cataracts both eyes and transitional cell carcinoma of bladder was made on 10 December 2009.

358. His claim for blast injury to his ears was made under the SPO 2006 in November 2009; the decision under appeal was made on 17 March 2010.

Cataracts Both Eyes and Transitional Cell Carcinoma of the Bladder

359. Mr Abdale arrived on Christmas Island in January 1958 as a 22 year-old RAF Leading Aircraftsman with the trade of Wireless Operator. He was a member of the RAF Task Group and was present for the GRAPPLE Y and Z1 to Z4 detonations.

360. Mr Abdale stated that, although he did receive some briefings, he was not aware of the safety plan. The Personnel Safety Plan for the JOC (B15/278 internal p32) shows that he was listed to a particular vehicle in his unit's evacuation plan for Category A personnel in the event of a nuclear accident. We find that, as a junior airman, Mr Abdale may well not have known the details of the safety plan as it affected him but that one was indeed in place. In his oral evidence, Mr Abdale stated that he had gashed his foot on coral twice, adopted a kitten and that he had been allowed to move around freely although he did not go far. On being shown a map of Christmas Island, he indicated that he went mainly to the North-West and to the main lagoon there, catching fish, and that he sometimes went down the road towards C Site, although since he was in the back of a lorry, he could not see if there were any warning signs. In his witness statement (A1 p159 et seq), he recalled that he was on his way back from the JOC to his Mess tent in Main Camp some two hours after the GY detonation when it began to rain heavily (photograph at A1 p165V): the rain was accompanied by wind and had larger blobs in it.

361. AWE hold no record of badge issue to Mr Abdale but he recalled putting badges into a cardboard box (A1 p80). We find that that this may well have indicated that he was issued with badges as a precautionary pre-evacuation measure for Category A personnel

and that these were collected back in when no emergency evacuation was needed. If we assume that Mr Abdale received the same dose as the highest recorded for an inhabited area, Main Camp following the GZ1 detonation, this would only have equated to an annual dose of some 0.001 mSv above local background; this is some one thousand times lower than the UK's current statutory limit on non-medical exposure above local background for the general public (see paragraphs 136 and 140). Even if we generously assume that Mr Abdale encountered an unrecorded 'hot spot' of the same magnitude as the highest recorded for an uninhabited area whilst he was on Christmas Island RM2 in the forward area following the GZ4 detonation, this would only have equated to an annual dose of some 0.12 mSv; this is some eight times lower than the limit for the general British public (paragraphs 135 and 140).

362. For the reasons given above, the Tribunal finds that:

362.1 Cataracts can be radiogenic. There is reliable evidence that cataracts can be caused by exposure in the region of 0.5 Gy, and that exposure as low as 0.1 Gy [100 mSv] might be so capable (paragraphs 303 to 306)..

362.2 Transitional cell carcinoma of the bladder can be radiogenic, and is accepted as such by the Secretary of State (paragraphs 251 to 260)..

363. Thus, although cataracts both eyes and transitional cell carcinoma of bladder can be caused by exposure to ionising radiation, we find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Abdale's activities on Christmas Island led to sufficient exposure to non-background ionising radiation or any other service-related cause for the conditions under appeal to be attributed to service.

Blast Injury to ears

364. In his oral evidence, Mr Abdale stated that he worked in the Joint Communications Centre (JCC) of the JOC, handling morse-code transmissions with the airborne Shackleton and Hastings aircraft, including giving them the ten-second countdown to the Valiant bomber's weapon release**.** He was therefore the last man out of the JCC hut and was still moving towards the muster point when the shock wave arrived; he was knocked off his feet. He then quickly had to resume his duties, as soon as released from the muster, to fire up morse communications with the airborne Shackletons and Hastings. Mr Abdale stated that he had some initial deafness in both ears; he went to see a medical

orderly who advised him that it would go away after a few days, which it did. We accept Mr Abdale's evidence about this and so find.

365. Mr Abdale served for a further 17 years on communications duties in the RAF, then for a further 14 years on similar duties in the Defence Communications Centre in Whitehall. His hearing was recorded as H1 [functional capacity above the average] both on his Fitness for Overseas Special Medical Examination in July 1959 (A1 (a) p38) and on his Release Medical in October 1975 (A1 p52).

366. In the 2008 Synopsis of Causation on Blast Injury of the ear Paragraph 1.2 gives the following definition:

> ***"1.2 Blast injury of the ear*** *(Syn. Blast overpressure injury to the ear) The classification of blast injury of the ear is inconsistent in the literature, but the term encompasses the various effects of explosive forces on the auditory system and the following categorisation is frequently employed:*
>
> *1.2.1 .**Explosive blast injury of the ear This** term refers to otological trauma due to the detonation of explosives.*
>
> *1.2.2 **Non-explosive blast injury to the ear Here**, otological trauma is caused by a blow to the ear that seals the external auditory meatus, causing a shock wave to be transmitted along the auditory canal.*

367. The Secretary of State has applied Royston to the claimed blast injury to his ears. It is therefore for Mr Abdale to show on the balance of probabilities that he suffered the disablement. We find that he did not suffer from blast injury because (a) he did not have the clinical features of explosive blast injury which are set out in paragraph 2.1 of the Synopsis and (b) he did not suffer from non-explosive blast injury to the ear because he did not suffer acute perforation of the tympanic membrane (paragraphs 2.2 and 3.2 of the Synopsis). We find that the most likely medical condition which Mr Abdale suffered was temporary deafness following the post detonation shock wave. We have therefore changed the label from Blast injury to temporary deafness and allow the appeal. We draw attention to our findings in paragraphs 364 and 365 above.

368. Mr Abdale departed Christmas Island in November 1958 and completed his Regular Service in February 1976 having achieved the rank of Sergeant.

Mr Donald Battersby (dob 3 January 1936)

369. Mr Battersby claimed under the SPO 2006 in September 2009; the decision under appeal to reject chronic lymphatic leukaemia was made on 15 October 2009.

370. Mr Battersby arrived at Maralinga, South Australia, in July 1956 as a 20 year-old RAF Senior Aircraftsman with the trade of Aircraft Mechanic.

371. The objective of Operation BUFFALO was to test four nuclear devices (details are at Annex A to this decision); in addition, the opportunity was taken to expose a variety of military equipment and structures of the detonations in order to gather data on nuclear weapons effects (Woodville B1/11 para 10.2). The Radiological Safety Assurance arrangements for BUFFALO are set out (B1/11 p29 et seq) in the August 1999 Harrison Report. In oral evidence, Mr Johnston agreed that the subsequent Australian Royal Commission's Report on BUFFALO (the McClelland Inquiry B14/252) had found that the standards of radiological compliance for the BUFFALO tests had not been the best (T 6 Feb 15:4); all were agreed that there should have been more Health Physics supervision (T 6 Feb 18:16).

372. Mr Battersby was a member of the RAF Task Group. They lived at Maralinga Village, where McClelland noted that the amount of contamination was biologically negligible (B14/252 p347 et seq). He witnessed the four BUFFALO nuclear detonations. He recalled that he did so some four and a half miles away, protected by sandbags. AWE's records (A2 p58) indicated that no personnel were less than seven and a half miles from the points of detonation and we so find.

373. BUFFALO 2 cloud samples indicated that the fission products had been 'scavenged' by the large amounts of vaporised soil and had fallen out locally (agreed gist D/43 para 4); fallout within 25 miles of ground zero was shown to be much more than expected, reflecting the fact that it was a ground burst (D/43 p9).

374. For the BUFFALO Operation, film badges were issued to all personnel, those being required to enter a contaminated area being issued with a second badge. Instructions were that the film badge should be worn on the chest: experiments indicated that if it were

worn elsewhere, the indicated dose might vary by up to 40%. (Woodville B1/11 para 10.14). Mr Battersby recalled wearing a film badge, except when sunbathing, in Maralinga Village and receiving stitches to his hand after cutting it on a tent peg (A2 p74).

375. We find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Battersby's presence alone at Maralinga led to exposure to non-background ionising radiation.

376. However, Mr Battersby also believed, although he could not be sure of this, that he probably was a member of the Active Handling Flight (AHF) involved in the decontamination of the irradiated 'sniffer' Canberras on their return from sampling the nuclear clouds. He described his decontamination duties in detail (A2 p72V et seq) and recalled that he was quite sure that there was no preceding cleaning process before his. He wore his normal work clothes with the addition of a white nylon overall; he did not have gloves or anything to protect his face, sweated, rubbed his face constantly to 'control the perspiration' and took regular drink breaks. At the end of the working day, he went through decontamination, showering sometimes four or five times before he was declared 'clean' [of ionising radiation]. The Secretary of State maintained that, although there are no records currently held of membership of the AHF, one can deduce such membership from affiliation to No 76 Squadron RAF (the Canberra 'sniffer' aircraft) and a recorded badge dose in excess of 10mSv above background; Mr Battersby's name is not on either list. However, there are also references to: members of the AHF at Maralinga having all been involved in such duties for the MOSAIC detonations, which took place at Montebello Island earlier that year (B9/28 p26); and that AHF members would be specially trained at Aldermaston (B7/34 p134). Mr Battersby did not serve at Montebello Island and there is no record of him having trained at Aldermaston. The Secretary of State also noted that all AHF personnel wore protective clothing and were issued with film badges whilst performing their duties; they were however augmented by non-AHF RAF personnel to complete the final wash-down after decontamination had been completed (B9/28 p75). We find that Mr Battersby was attached to the AHF and was involved in the final wash-down stage of the decontamination of 'sniffer' Canberras.

377. Mr Battersby also stated that he went to the forward area once with AWRE personnel to assist in sample collection; he wore a lightweight white suit, with some form of radiation

detector on his belt; we so find. He grazed his leg on the way to the forward area and a scientist in the truck put a bandage over it; the Secretary of State accepts that this injury is not recorded (closing written submission p 153) but did not challenge Mr Battersby about it.

378. His total recorded badge dose has been re-evaluated upwards by the Secretary of State (based on evidence from Mr Johnston at D/40a dated 3 January 2013) from 0.4 mSv to between 1 to 5 mSv.

379. We find that the figure of 1 to 5 mSv does not fully reflect the extent of Mr Battersby's exposure:

379.1 As recorded earlier in this decision (paragraph 143), Mr Battersby's assessed exposure, based on like-for-like duration, equated to some 3 to 14 times the UK background dose and to being in or above the statutory limit for a classified worker.

379.2 In addition, we find that Mr Battersby ingested a small amount of radioactive material at the time and was thereby internally exposed to ionising radiation including alpha particles, the means of ingestion including inhalation (of dust directly from contaminated equipment and areas), orally (through eating and drinking whilst hands, other body surfaces and clothing were contaminated) and entering the bloodstream through an open wound. This exposure would not have been recorded on a personal film badge (see paragraph 120).

380. Mr Battersby departed Maralinga in November 1956 and was discharged from his Regular Service in the RAF in February 1959.

381. For the reasons given above (paragraphs 261 to 272), we find that there is insufficient reliable evidence to raise a reasonable doubt that CLL can be caused by exposure to ionising radiation. Such evidence as there may be includes the Abramenko Study which describes a different form of CLL to that suffered by Mr Battersby, as explained above by Professor Catovsky.

382. Thus although we have found that Mr Battersby was exposed to a significant amount of ionising radiation, we find that a reasonable doubt is not raised that Mr Battersby's claimed condition was caused by service.

Mr Darryl Beeton (dob 9 August 1937)

383. Mr Beeton claimed under the SPO 2006 in July 2009; the decision under appeal to reject atherosclerosis and myocardial infarction (2001) was made on 25 November 2009.

384. Mr Beeton arrived at Christmas Island in August 1957 as a 20 year-old Leading Aircraftsman with the trade of Cook II; he served with 160 Wing RAF. He was present for the GX and GY detonations.

385. Mr Beeton was billeted at Main Camp and worked in the dock area of Port London. His main task was to collect food supplies from the Port and distribute them to the rest of the Island. He watched the sea birds and swam in the lagoon. There were a lot of rats in the food supply depot and the tented living accommodation. He was not issued with a film badge. He stated that he was near the port for the detonations around 20 miles to the south-east; we find that he was mustered there for the GX and GY detonations. In his oral evidence, Mr Beeton confirmed, and we so find, that he was sure that it rained on him there after the GY detonation: the rain was fine, dusty and warm. He stated that he was not aware of any restrictions on his movements on Christmas Island; he did not go towards the forward areas. AWE hold no record of Mr Beeton being issued with a film badge (A3 p10).

386. If we assume that Mr Beeton received the same dose as the highest recorded for an inhabited area, Main Camp following the GZ1 detonation, this would only have equated to an annual dose of some 0.001mSv above local background; this is some one thousand times lower than the UK's current statutory limit on non-medical exposure above local background for the general public (paragraphs 136 to 140) Even if we were generously to assume that Mr Beeton encountered an unrecorded 'hot spot' of the same magnitude as the highest recorded for an uninhabited area whilst he was on Christmas Island, Decca Master in the forward area following the GY detonation, this would only have equated to an annual dose of some 0.06 mSv; this is some sixteen times lower than the limit for the general British public (paragraphs 123 and 140).

387. For the reasons given above (paragraphs 293 to 302), we find that:

387.1 Circulatory disease can be a radiogenic condition. The evidence is best for cardiovascular and cerebrovascular disease. Doses above 0.5 Gy [500mSv]

may lead to approximately 1% of exposed individuals developing the disease.

387.2 Whilst hypertension as a result of atherosclerotic renovascular disease can be radiogenic, there is no evidence that other forms of hypertension can be caused by ionising radiation exposure.

388. Mr Beeton finally departed Christmas Island in August 1958 (he had some Christmas leave in Honolulu in January 1958) and completed his Regular Service in January 1959. He became a publican, retiring aged 52.

389. Although myocardial infarction can be caused and atherosclerosis can be aggravated by exposure to ionising radiation (and thus service) we find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Beeton's activities on Christmas Island led to sufficient exposure to non-background ionising radiation or any other service-related cause for the conditions under appeal to be attributed to or aggravated by service.

Mr Trevor Butler (dob 7 March 1938)

390. Mr Butler's appeal was remitted by the Upper Tribunal [2009] UK UT 170 AAC. A copy of that decision is at A4 (1) (p301). Paragraph 9 of that decision sets out the four issues which the Upper Tribunal directed should be considered by the Tribunal which re-heard Mr Butler's appeal. They are:

(a) "The appellant's evidence about where he was on Christmas Island has been misrepresented". We describe below in paragraphs 396 to 398 the work that he did in the forward area. We accept that he was "significantly more exposed to radiation" than was generally the case on the Island at the time.

(b) "*The* [2008] *Tribunal was not fair in the way it ignored a DVD of a Dispatches programme"*. The Tribunal viewed the DVD – see Paragraph 400 below.

(c)"Internet reports produced by the Tribunal" [at the hearing in 2008]. Neither party wished to rely on these reports – see paragraph (h) of the directions made on 14 December 2009 (A4(1) Page 320).

(d) "The extracts of two books". See Paragraph 400 below.

391. Mr Butler has made the following claims under the SPO:

391.1 In February 1990 for cataract right eye.

391.2 In August 1991 for loss of sight after the cataract operation.

391.3 In March 1996 for back and skin problems.

391.4 In August 2006 for reduced immune system, glomerulonephritis, nightmares and high blood pressure.

392. The decisions under appeal were made on:

392.1 24 April 2007 to reject staphylococcal lumbar discitis, streptococcal viridans infection, glomerulonephritis, klebsiella urinary tract infection and hypertension.

392.2 17 July 2007, to reject immune system dysfunction.

393. Mr Butler is currently in receipt of a 30% war pension for the one accepted disablement of cataract right eye, aggravated by service.

394. Mr Butler arrived at Christmas Island in December 1957 as a 19 year-old Sapper with the trade of Combat Engineer; he served with 61 Squadron, 38 Corps Regiment, Royal Engineers. He was present for the GY, GZ1, 2, 3 and 4 detonations.

395. In his oral evidence, Mr Butler stated that he received no specific safety training but had been excused lectures by his Warrant Officer during the sea passage out, since the latter had placed him on 'extra duties' [i.e. punishment for a minor infringement]. Initially based at Main Camp, he was involved in its conversion from a tented to a hutted camp; he recalled swimming in the main lagoon and shark fishing from shore near the South-East point prior to the detonations in that area (the Z series). He was mustered in the North of the Island for the GY detonation. He recalled looking up at the detonation cloud, which appeared to him to cover the Island. It was cold and raining by the time he got back to Main Camp; he recalled a tot of rum being issued.

396. After witnessing the GY detonation, Mr Butler worked in No 1 Troop of 61 Squadron, attached to Special Group G in support of AWRE scientists in the forward area, at and around B Site and living at the B Site camp, some three miles from ground zero. In his oral evidence, Mr Butler recollected that he was at the B Site Camp for the balloon detonations; he was under ten miles from the detonations and 200 yards South of B Site; he went to a 'designated place' where all members of the Squadron were assembled for roll call. We recorded Mr Arthur Dixon's statement (A4(1) p283) that all members of the Squadron were assembled for roll call at the B Site Camp, which he estimated to be less than 10 miles from ground zero, and that they remained there while the test took place. The Secretary of State recalled that the closest operational manned site to the balloon detonations (see for example A12 p47A) was A Site, some eight miles away from ground zero. Mr Butler stated that he did not know of an A Site but agreed, after being shown a detailed map, that the 'designated place' could well have been in that area.

397. We accept Mr Butler's oral evidence that he drove a Bedford QL truck at up to 50mph for around five to seven miles on the coral dust track to reach the 'designated place', having sandbagged instrument bunkers near B Site, and we find that he was at A Site for the GZ1 and GZ4 detonations. Mr Butler also stated (A12 p209 para 23) that at one point he cut his hand quite badly on a metal drum and had to go to Main Camp to have the wound dressed and we so find.

398. Mr Butler recollected that, within one hour of the detonation, he removed the sandbags protecting the instrument bunkers, only being allowed to remain in this area for some 20 minutes. He was also involved in rebuilding instrument masts and replacing melted reflectors near ground zero, starting some 24 hours after detonation and completing these tasks after some further 12 hours. He wore his normal working clothes (shorts, top, hat and boots); he did not tour or swim whilst deployed to B Site. The Secretary of State noted (A4(2) p519) that, after the GZ1 detonation, a Health Physics team *'cleared the path'* back from A Site to B Site before unprotected personnel were allowed back in to that area. As noted above in paragraph 99, in final planning for the balloon detonations (agreed gist, D/43 p6), it was suggested that, with suitable precautions, work might be possible after two days (at ground zero) but that, in the event (ibid, footnote) *'levels were lower than anticipated'*.

399. AWE's first report in June 1990 (A4 (1) p68 et seq) stated that there was one film badge issued to Mr Butler for GZ which showed 30mRem. After further research, AWE found in April 2008 (A4 (1) p241 et seq) that two badges had been issued: one on 22 August 1958, measured as 0.03r and another for a Blue Area on 23 August 1958 measured as nil. The outermost active area (known as a Blue Area) was defined as having a risk of penetrating radiation during a detonation but not of inhalation, ingestion or injection; no special clothing was required. No person was to enter a Blue Area without the permission of the Health Control Officer in charge. AWE re-assessed Mr Butler's total dose as 0.5 mSv above the local background of 0.61 mSv per annum (A4 (1) ibid).

400. The Tribunal confirmed that the two books ('Deadly Deceit' and 'Wolves of Water'), extracts of which had previously been put in evidence by Mr Butler (A4 (1) p207 et seq), were to be excluded from the Statement of Case: the appellant had not complied with previous directions in December 2009 (A41 p320). The Tribunal viewed the DVD previously put in evidence (1991 Channel 4 Dispatches programme on Operation GRAPPLE). We find that there is no evidence in it that is relevant to our decision in this appeal.

401. We find that the figure of 0.5 mSv does not fully reflect the extent of Mr Butler's exposure:

401.1 As recorded earlier in this decision (paragraph 144) Mt Butler's assessed exposure equated, based on like-for-like duration, to some 42 times the UK background dose and to being above the statutory limit for a classified worker

401.2 In addition, we find that Mr Butler ingested a small amount of radioactive material at the time and was thereby internally exposed to ionising radiation including alpha particles, the means of ingestion including inhalation (of dust directly from contaminated equipment and areas), orally (through eating and drinking whilst hands, other body surfaces and clothing were contaminated) and entering the bloodstream through an open wound. This exposure would not have been recorded on a personal film badge (see paragraph 120).

402. Mr Butler departed Christmas Island in December 1958 and served until June 1960, before transferring to the Regular Army Reserve for a further four years. Mr Butler confirmed that he worked in the building trade, then as a trade instructor in a young offenders' prison, then as Housing Officer for Hull City Council.

403. Mr Butler's claimed infections and glomerulonephritis have already been dealt with as non-radiogenic (paragraphs 334 to 337 and 320 to 328).

404. Mr Butler's other claimed conditions are hypertension and immune system dysfunction.

405. Whilst hypertension can be a complication of glomerulonephritis, the Tribunal notes that in a letter dated 8th March 2005 from Mr Butler's Consultant Cardiologist, Dr Oliver, to his G.P., there is a diagnosis made of essential hypertension (A4(1)/178). We therefore find that Mr Butler's form of hypertension is essential hypertension, for which there is no reliable evidence that ionising radiation can be a cause.

406. Mr Butler associated his infections with "*a breakdown in my immune system caused by exposure to radiation during my time on Christmas Island" (witness statement of November 2012, A4(2) Page 642).* He also mentions that his case was "written up" for a Medical Journal, and what appears to be a draft of this Case Report appears at Page 118 in his Statement of Case. The apparent purpose of this document was to publish in a medical literature a previously undescribed association between Mr Butler's pauci-

immune crescentic glomerulonephritis and lumbar discitis. It makes no reference to any abnormality of functioning of his immune system.

407. Neither is there any reference in the medical records contained in the Statement of Case to indicate that Mr Butler had a primary abnormality of his immune system.

408. A copy of a laboratory report on a blood sample taken on 31st January 2001 (included at A4(2) Page 648) was handed up to the Tribunal. We note that this was a measure of his immunoglobulins (protein electrophoresis), and the report stated that the results showed "*a chronic inflammatory pattern*". Given that this was part of the laboratory workup for what was subsequently diagnosed as bacterial endocarditis and discitis (see, for example, Medical Notes entry dated 21st February 2001 at Page 149 in Statement of Case), the Tribunal finds this laboratory result to be an expected and unsurprising one. It does not indicate a primary abnormality of his immune system.

409. For the avoidance of doubt, the medical term pauci-immune glomerulonephritis means that, compared to some other forms of glomerulonephritis, the amount of immune-complex material deposited in the kidney (glomerulus) was small in quantity. It does not mean or imply "paucity" or insufficiency of the immune system.

410. We find that on a balance of probabilities, Mr Butler has not demonstrated the existence of his claimed condition Immune System Dysfunction.

411. Therefore, although we have found that Mr Butler was exposed to a significant amount of ionising radiation, for the reasons given above, we find that a reasonable doubt is not raised that Mr Butler's claimed conditions were caused by service.

Mr Derek Hatton(dob 4 November 1938)

412. The late Mr Hatton claimed under the SPO 2006 in December 2007; the decision under appeal to reject polycythaemia rubra vera was made on 4 June 2008. Mr Hatton died on 5 July 2009; his appeal is being carried on by his wife.

413. Mr Hatton arrived at Christmas Island in August 1958 as a 19 year-old Royal Army Ordnance Corps (RAOC) Private with the trade of Storeman Technical. He was present for the GZ1, 2, 3 and 4 detonations.

414. Mr Hatton's son Lee recalled (witness statement at A5 p392) his father telling him that he worked at Main Camp, supporting its conversion from a tented encampment, then working from Main Camp, supporting the construction of the main runway. AWE records confirm (A5 p85): his attendance on Christmas Island; and that no badge records for Mr Hatton are held. The parties agreed that Mr Hatton was not listed as working in the RAOC's higher-risk laundry active-handling unit, whose personnel were listed and monitored.

415. If we assume that Mr Hatton received the same dose as the highest recorded for an inhabited area, Main Camp following the GZ1 detonation, this would only have equated to an annual dose of some 0.001mSv above local background; this is some one thousand times lower than the UK's current statutory limit on non-medical exposure above local background for the general public (paragraph 136 and 140). Even if we were generously to assume that Mr Hatton encountered an unrecorded 'hot spot' of the same magnitude as the highest recorded for an uninhabited area whilst he was on Christmas Island, RM2 in the forward area following the GZ4 detonation, this would only have equated to an annual dose of some 0.12 mSv; this is some eight times lower than the limit for the general British public (paragraphs 135 and 140).

416. Mr Hatton departed Christmas Island in August 1959, completed his National Service in December 1959, re-enlisted, then re-engaged and finally completed all forms of Service in December 1967 in the rank of Lance-Corporal. He then worked in a factory, as a Police Officer, at security work and as a cleaning manager.

417. For the reasons given above (paragraphs 273 to 281), we find that there is insufficient evidence to raise a reasonable doubt that PRV is radiogenic.

418. For the reasons stated above, we find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Hatton's activities in and around the inhabited areas of Christmas Island or any other service-related cause led to the condition under appeal being attributable to service.

Mr Ernest Hughes (dob 8 March 1935)

419. It was agreed that the only issue for the Tribunal to consider at the hearing was Mr Hughes' claimed exposure to ionising radiation. See direction 5(1) of the directions dated 22 June 2011 Bundle J Page 99.

420. Mr Hughes claimed under the SPO 2006 in November 2008; the decision under appeal was made on 13 February 2009 to reject: sebaceous cysts, epidermal cysts, pruritis, atherosclerosis, myocardial infarction (1991), and transitional cell carcinoma of the bladder.

421. Mr Hughes arrived at Christmas Island in October 1956 as a 21 year-old Leading Aircraftsman with the trade of Ground Wireless Fitter; he served with 160 Wing RAF. He was on Christmas Island whilst the GRAPPLE 1, 2 and 3 detonations took place at Malden Island, some 700kms to the South.

422. In his oral evidence, Mr Hughes stated that he was billeted at Main Camp. His initial work involved setting up high-powered HF transmitters, which he believed could set up fields which would attract small radioactive particles; no reliable evidence was produced to support this contention. He then worked at the Main Airfield in Air Traffic Control (ATC) and at the RSF (VHF antenna site). He disputed the location shown for the ATC on the AWE plan of the Main Airfield he was shown (B13/196 p13). He claimed that he was exposed, whilst at the RSF, to ionising radiation when the Canberra aircraft which had 'sniffed' the GRAPPLE 1, 2 and 3 detonations were being decontaminated at the nearby Aircraft Decontamination Centre (ADC); he described being within line of sight of the ADC and felt that the high-pressure jets used could re-suspend ionising radiation particles. He confirmed that he did not come into direct contact with contaminated aircraft. The locations shown on the plan for the RSF and ADC were not disputed by the appellant. We find from the official plan of the Main Airfield that the ADC, at its nearest point, was some 1500 feet from the RSF and some 500 feet from the access road along which he would have had to travel to and from the RSF and that this was too far away for any increased ionising radiation risk from the ADC. Mr Hughes also claimed that there had been lots of US tests in the Pacific area, many of them very big. Official records (Core/10) confirm that there were no US tests in the Pacific area prior to the YUCCA detonation, which occurred on the same date as GY (28 April 1958), some seven months

after Mr Hughes had left Christmas Island. Mr Hughes was also asked about his mention of a major fire at Winscale in Cumbria contaminating large areas of England and Wales (Supplemental/D p1); he believed that he had been exposed to ionising radiation from this fire whilst he was stationed at RAF Edelsborough in Buckinghamshire. No reliable evidence was produced to support this contention.

423. AWE hold no record of any badge issue to Mr Hughes (A6 p10). Even if we were generously to assume that Mr Hughes encountered an unrecorded 'hot spot' of the same magnitude as the highest recorded deposition whilst he was on Christmas Island, at the JOC Pacific-wide collection site following the G3 detonation at Malden Island, this would only have equated to an annual dose of some 0.0003 mSv; this is some one three-thousandths of the limit for the general British public (paragraphs 123 and 140).

424. Mr Hughes departed Christmas Island in September 1957 and completed his Regular Service in May 1969, reaching the rank of Chief Technician. He then worked as an electrical engineer, retiring aged 56.

425. We find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Hughes' activities, on Christmas Island and subsequently in the UK, led to any exposure to non-background ionising radiation or any other service-related cause for the conditions under appeal to be attributed to or aggravated by service.

Mr Brian Lovatt (dob 14 April 1937)

426. Mr Lovatt claimed under the SPO 2006 in November 2009; the decision under appeal rejecting atherosclerosis and myocardial infarction (2005) was made on 21 January 2010.

427. Mr Lovatt arrived at Christmas Island in September 1957 as a 20 year-old Leading Aircraftsman with the trade of Aircraft Fuselage Painter and Finisher; he served with the RAF Task Group. He was present for the GX and GY detonations.

428. Mr Lovatt recalled (witness statement A7 p125) being based at Main Camp; he worked at the Main Airfield spray-painting wooden huts, aircraft, vehicles and, for three and a half months, painting fuel pumps at the Main Harbour. He swam and fished in the main lagoon, recalling cutting his knee *'on rocks'* and being hospitalised for three weeks because it wasn't healing. He was mustered at the Main Airfield for the GX detonation, when he wore long trousers, shirts and shoes, and for the GY detonation, when he was issued with paper coveralls and sunglasses; he did not recall being issued with a film badge. After the detonations, he recalled being despatched to collect the dead fish, *'thousands of which had been washed up'*. AWE records show no badge issues to Mr Lovatt (A7 p94). Even if we were generously to assume that Mr Lovatt encountered an unrecorded 'hot spot' of the same magnitude as the highest recorded for an uninhabited area whilst he was on Christmas Island, Decca Master in the forward area following the GY detonation, this would only have equated to an annual dose of some 0.06 mSv; this is some sixteen times lower than the limit for the general British public (paragraphs 123 and 140).

429. Mr Lovatt departed Christmas Island in July 1958 and completed his Regular Service in April 1970, reaching the rank of Corporal.

430. For the reasons given above (paragraphs 293 to 302), we find that:

430.1 Circulatory disease can be a radiogenic condition. The evidence is best for cardiovascular and cerebrovascular disease. Doses above 0.5 Gy [500 mSv] may lead to approximately 1% of exposed individuals developing the disease.

430.2 Whilst hypertension as a result of atherosclerotic renovascular disease can be radiogenic, there is no evidence that other forms of hypertension can be caused by ionising radiation exposure.

431. Therefore, although myocardial infarction can be caused, and atherosclerosis can be aggravated, by ionising radiation, we find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Lovatt's activities in and around the inhabited areas on Christmas Island led to sufficient exposure to non-background ionising radiation or any other service-related cause for the conditions under appeal to be attributed to or aggravated by service.

Mrs Dawn Pritchard (late widow of Mr William Pritchard)

432. Mr Pritchard died on 6 September 2005. The death certificate (A8 page 64) gave the cause of death as I (a) Bronchopneumonia, cardio-respiratory failure end-stage renal failure due to (b) Berger's nephropathy, hypertensive heart disease, arterial atheroma. II Diabetes mellitus.

433. The late Mrs Pritchard (married 11 September 1987) made her claim for a War Widow's Pension under the SPO 1983 in January 2006. The decision under appeal was made on 13 February 2006.

434. The late Mr Pritchard arrived at Christmas Island in January 1958 as a 22 year-old RAF Corporal with the trade of Telegraphist IIa; he served with the RAF Task Group. He was present for the GY and GZ1 detonations; he was at Fanning Island, some 330 kms to the North-West, from August to October 1958, when the GZ 2, 3 and 4 detonations took place at Christmas Island.

435. Mr Pritchard recalled being mustered at the JOC for the GY detonation and at a 'witness point' (claim form dated 28 March 1990 at A8 p434) for the GZ1 to 4 detonations. His Unit's Operational Record Book (A8 p313 et seq) indicated that a number of personnel were allowed to view the GZ1 detonation from the North-East Beacon, some two and a half miles due East of the Main Airfield and 30 kms from the detonation site (A8 p329); we find that Mr Pritchard may well have been amongst these. If we assume that Mr Pritchard received the same dose as the highest recorded for an inhabited area, Main Camp following the GZ1 detonation, this would only have equated to an annual dose of some 0.001mSV above local background; this is some one thousand times lower than the UK's current statutory limit on non-medical exposure above local background for the general public (paragraphs 136 and 140). Even if we were generously to assume that Mr Pritchard encountered an unrecorded 'hot spot' of the same magnitude as the highest recorded for an uninhabited area whilst he was on Christmas Island, Decca Master in the forward area following the GY detonation, this would only have equated to an annual dose of some 0.06 mSv; this is some sixteen times lower than the limit for the general British public (paragraphs 123 and 140). AWE records show that no badge was issued to Mr Pritchard and therefore assessed his dose as zero (A8 p296).

436. Mr Pritchard departed Christmas Island in November 1958 and was medically discharged for depression from his Regular Service in July 1961, having reached the rank of Corporal. He then worked as a clerk, an insurance agent, a warehouseman and a postman.

437. The cause of death given in the Death Certificate (A8/64) mirrors that in the Autopsy Report (A8/74). By convention, conditions put in Ia are "due to" those in Ib; under Part II are listed other conditions contributing to death but not directly related to those in Part I.

438. The Autopsy Report describes Mr Pritchard's Hypertension as central hypertension (i.e. essential hypertension) and states that the diagnosis was made in 1990. The Medical Records contained in the Statement of Case record raised blood pressure at around that time, and he would appear to have been started on blood pressure medication (Adalat) in about 1991. There is no indication in the Medical Records that Mr Pritchard's hypertension was anything other than essential hypertension, although it is noted that hypertension can be secondary to glomerulonephritis (of which Berger's Nephropathy is a form).

439. Whilst bronchopneumonia is technically an infection, it is also a common terminal illness in people who are very ill from other causes, which in Mr Pritchard's case included kidney and heart failure.

440. For the reasons given above (paragraphs 334 to 337, 320 to 328 and 293 to 302) there is no reliable evidence to show that ionising radiation can be a cause of infections (bronchopneumonia), glomerulonephritis (Berger's Nephropathy), or Essential Hypertension (leading to hypertensive heart disease). In certain circumstances Diabetes Mellitus can be radiogenic and Atherosclerosis (Arterial Atheroma) can be aggravated by ionising radiation.

441. Thus, although conditions recorded as causing Mr Pritchard's death can be caused by ionising radiation, we find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Pritchard's activities on Christmas and Fanning Islands led to sufficient exposure to non-background ionising radiation or any other service-related cause for his death to be due to or substantially hastened by service.

Mr Charles Selby (dob 9 June 1935)

442. Mr Selby died on 25 August 2005. The death certificate (A9 page 48) gave the cause of death as I (a) Idiopathic Fibrosing Alveolitis, II Type 2 Diabetes Mellitus.

443. Mrs Selby (married 27 July 1957) claimed a War Widow's Pension under the SPO 1983 in February 2006. The decision under appeal was made on 8 March 2006.

444. The late Mr Selby arrived at Christmas Island in August 1957 as a 22 year-old Sapper with the trade of Electrical and Mechanical Plant Fitter AII; he served with 73 Christmas Island Squadron Royal Engineers. He was present for the GX and GY detonations. Mr Selby's son Andrew recollected (A9 p255 et seq) that his late father said that he would often travel to the South-East point to repair heavy-duty plant vehicles; this was where he was also taken to witness the bombs going off. He wore (photograph at A9 p256) a thick white cotton suit, heavy leather hood, thick blacked glass goggles, cotton gloves with oven-like gloves on top and a radiation badge; he was about 15 miles away from the bomb site. He was ordered to lie flat on his stomach with his feet pointing towards the bomb. They were lying behind a purpose-made mound of earth about 18 inches high. After the blast, when they faced the bomb cloud, the palm trees about five miles ahead of them were on fire.

445. We find that Mr Selby witnessed the GX and GY detonations from C Site, which was some 15 miles from the airdrop detonations and the closest operational manned site to them (A9 p84V). Although AWE hold no records for Mr Selby (A9 ibid), we further find that he was issued with at least one film badge for each detonation; it is possible that these were discarded when they were read as having recorded nil dose above background but we cannot exclude the possibility that they may have recorded a dose and been mislaid in the system. No contemporaneous evidence is available as to whether or not Mr Selby repaired heavy-duty vehicles forward of C Site in any controlled areas. Even if we were generously to assume that Mr Selby encountered an unrecorded 'hot spot' of the same magnitude as the highest recorded for an uninhabited area whilst he was on Christmas Island, Decca Master in the forward area following the GY detonation, this would only have equated to an annual dose of some 0.06 mSv; this is some sixteen times lower than the limit for the general British public (paragraphs 123 and 140).

446. Mr Selby departed Christmas Island in July 1958, completed his National Service in November 1958 and his reserve liability in February 1964.

447. Mr Selby's post service occupational history is summarised at Page 29 of his Statement of Case (A9) in a letter dated 16 January 2003 from his Consultant Chest Physician to his General Practitioner. It stated:

> **"***He worked as a miner for 10 years, he subsequently worked as a maintenance fitter for the Carbon Black factory. He was certainly exposed to asbestos during this time. There were large furnaces burning oil and making the carbon black and his job was to repair the pipework. He subsequently worked for Swansea City Council as a roadsweeper."*

448. Subsequent CT Scan of his chest did not show evidence of asbestosis exposure, and in the absence of any other identifiable medical cause, his lung condition was diagnosed as Idiopathic Fibrosing Alveolitis, which was also the primary cause of death given on his Death Certificate (Page 48).

449. As explained above (Paragraph 338 to 346), Idiopathic Fibrosing Alveolitis is not a radiogenic condition. The timescale and ionising radiation exposure history excludes the possibility that he was in fact suffering from a deterministic form of radiation induced lung fibrosis.

450. For the reasons given above (paragraphs 329 to 333*)*, we find that Type II diabetes mellitus can be radiogenic. The question of dose is less straightforward. In the childhood cancer study these were children who received substantial therapeutic doses of ionising radiation to the pancreas. The development of diabetes in the RERF Study was considerably influenced by an individual's 'tissue type' genetic makeup, and an increased incidence was found only in individuals who were *'heavily exposed (› 1.5Gy)'[1500 mSv]*.

451. We therefore find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Selby's activities on Christmas Island led to sufficient exposure to non-background ionising radiation or any other service-related cause for his death to be due to or substantially hastened by service.

Mr Denis Shaw (dob 17 April 1937)

452. Mr Shaw claimed under the SPO 2006 in March 2009; the decision under appeal to reject left cataract was made on 11 August 2009.

453. Mr Shaw arrived at Christmas Island in December 1958 as a 21 year-old Sapper with the trade of Fitter AIII; he served with 73 Christmas Island Squadron, Royal Engineers. His presence post-dated the GRAPPLE series of detonations. His duties included supporting AWRE in their REPACK operations, which involved limited decontamination work but principally the recovery of equipment and tidying up (A10 p83).

454. In his oral evidence, Mr Shaw stated that he worked mainly at, then from, Main Camp. He went to A Site in December 1958 or January 1959 to recover a five to six-ton towed generator, then went on to see the area of ground zero for GZ1 and 4. Back at Main Camp, he removed the generator's oil filter to send to Aldermaston, then over a period of about a day, cleaned, greased and packed up the generator itself for despatch there. He believed that he had inhaled or ingested irradiating particles during this process.

455. The agreed gist recorded that very light contamination of vehicles in the forward area from neutron-induced activity in fall-back material had been noted post GZ1 and GZ4 (D/43 ps6-7). AWE records show '*no recorded dose*' for Mr Shaw (A10 p83). We note that AWE, in responding to a letter from Mr Shaw, mentioned that the mobile generator [recovered from A Site some three to four months after the last Christmas Island detonation] was checked for loose contamination, post trial, *'which was not likely to be present'* but that it might have shown residual neutron-induced radiation *'which would remain as part of the structure of the metals from which the unit was constructed'* (A10 p83 et seq). AWE also record that, on 6 November 1958, the AWRE Health Physics Adviser declared all parts of Christmas Island safe from ionising radiation above background, apart from four small marked and access-controlled areas: two at the Main Airfield, one at the JOC and one at C Site (A10 p98V). We find that Mr Shaw was not exposed to ionising radiation above background.

456. Mr Shaw departed Christmas Island in December 1959 and completed his National Service in May 1960; his reserve service expired in October 1963. After service, Mr Shaw confirmed that he worked as an engineer, a trade instructor for disabled persons, then ran two pubs before retiring on medical advice re his angina in 1984.

457. In Mr Shaw's further condition claim form (A10/63 onwards) he claims Subcapsular Cataract of the Left Eye, which he says was the result of exposure to radiation at Christmas Island.

458. At page 62 he stated

> "*I am also returning page 55 where it states that I said my subcapsular cataract was caused by the sun and not radiation. I have never made such a statement to you, what I did say was that I thought my bilateral cataracts could have been caused by the sun reflecting from the white coral as we were not issued with any eye protection (sunglasses).*"

459. The Synopsis of Causation for Cataracts (A1/115), Paragraphs 3.6.5 to 7 discusses the possibility that cataracts can be caused by ultraviolet light exposure (UVA and UVB), and states:

> "*The risks associated with UV exposure appear to be limited to the formation of cortical cataracts, which take many years of exposure to develop. For example, a study of 838 watermen in North America, who were exposed to high intensities of direct and reflected UVB over many years (between 37 and 50 years of continuous exposure), showed a significant increase in formation of cortical cataracts. A number of other studies on smaller numbers of persons exposed to high levels of UVB have similarly reported an increased risk.*
>
> *Hats with brims and sunglasses protect against this risk. There is no convincing evidence of a link between UV light exposure and the development of either nuclear or subcapsular cataracts."*

460. Based upon the foregoing, we find that his left cataract was not the type typically caused by UV exposure, and that Mr Shaw was exposed to intense sunlight on Christmas Island for a period of a year, which is not a sufficient period to raise a reasonable doubt that service-related UV exposure was a cause for his left cataract. There is no evidence of any other service-related cause for his claimed condition.

461. We find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Shaw's activities on Christmas Island led to sufficient exposure to non-background

ionising radiation or any other service-related cause for the condition under appeal to be attributed to service.

Mr Herbert Sinfield (dob 9 November 1938)

462. The late Mr Sinfield claimed under the SPO 2006 in December 2006; the decision under appeal to reject large cell lymphoma was made on 24 March 2007.

463. Mr Sinfield arrived at Christmas Island in June 1958 as a 19 year-old Driver BIII; he served with 94 Company, Royal Army Ordnance Corps. He was present for the GZ1, 2, 3 and 4 detonations.

464. Mr Sinfield gave a written account of what he did on Christmas Island when he asked in February 1984 (A12 p50 et seq) to be included in the NRPB survey. He described conveying stores from the Port Area to Main Camp, also carrying asphalt for the Royal Engineers who were building roads and an airstrip. For most of the tests, he was mustered at the Port Area; for one of them, he was put on a landing craft in readiness to move out to a ship if necessary. He recalled that on one occasion it rained as he had to put on his poncho. His release medical noted coral sores from Christmas Island on his right leg (A12 p11).

465. Even if we assume that Mr Sinfield received the same dose as the highest recorded for an inhabited area, Main Camp following the GZ1 detonation, this would only have equated to an annual dose of some 0.001mSv above local background; this is some one thousand times lower than the UK's current statutory limit on non-medical exposure above local background for the general public (see above at paragraphs 136 and 140).

466. However, although there are no person-specific records available, there is reliable evidence (A12 p341) that 94 Company drivers carried building materials forward towards B and D Sites. Asphalting at B site took place between 1 and 6 July, some 2 months after the GY detonation**,** the main road then being asphalted from 10 to 25 July, prior to the GZ1 detonation. On 25 August, three days after the GZ1 detonation, asphalting of the main road resumed towards D Site together with the delivery of mud for the 'new airstrip'. The detailed AWE map of Christmas Island (Annex B) shows the Aeon Field airstrip about half a mile to the West of B Site***;*** we find that this was the airstrip under renovation**.** The road is recorded as having reached B Site on 29 September, six days after the GZ4 detonation; wirelesses were used for the closer control of these drivers from 15 September, four days after the GZ3 detonation, until the completion of the D Site road on

13 October, some three weeks after the GZ4 detonation. We find that Mr Sinfield was engaged in such duties.

467. AWE hold no record of a badge issue to Mr Sinfield (A12 p359).

468. We find that:

468.1 One or more badges may well have been issued to Mr Sinfield for his work in the forward areas after the GZ1 and GZ4 balloon detonations. We also find that the nature of his work would have involved heavy disturbance of the surface coral dust and dried mud, thereby exposing him to ionising radiation above the background level.

468.2 In addition, Mr Sinfield ingested a small amount of radioactive material at the time and was thereby internally exposed to ionising radiation including alpha particles, the means of ingestion including inhalation (of dust directly from contaminated equipment and areas), orally (through eating and drinking whilst hands, other body surfaces and clothing were contaminated) and through entering the bloodstream through any open wound. This exposure would not have been recorded on personal film badge (see paragraph 120 above).

469. Mr Sinfield departed Christmas Island in June 1959, completed his National Service in November 1959 then served in the Territorial Army until March 1961, completing his reserve liability in April 1963**.** He worked for Islington Borough Council, then for the GPO, taking voluntary redundancy in 1992 (witness statement A10 p370 et seq).

470. Mr Sinfield's claimed condition was a form of non Hodgkin's lymphoma of a particular type known as Anaplastic Large Cell Lymphoma. For the reasons given above (paragraphs 282 to 291), we find that there is no reliable evidence to show that non Hodgkin's lymphoma, in general, nor Anaplastic Large Cell Lymphoma in particular, are caused by exposure to ionising radiation.

471. Although we have found that Mr Sinfield was exposed to a significant amount of ionising radiation, for the reasons given above, we find that a reasonable doubt is not raised that Mr Sinfield's Large Cell Carcinoma was caused by service.

Mr Barry Smith (dob 4 May 1939)

472. The late Mr Smith made a further condition claim, under the SPO 2006, for carcinoma of the pancreas in February 2008; the decision under appeal to reject this condition was made on 8 May 2008.

473. Mr Smith died on 20 February 2009. The death certificate (A13 page 174) gave the cause of death as from I (a) Adeno Carcinoma Head of Pancreas.

474. Mrs Smith (married 23 July 1977) claimed for a War Widow's Pension, under the SPO 2006, in June 2009. This decision under appeal was made on 31 July 2009. Mr Smith's appeal also carried on.

475. Mr Smith arrived at Christmas Island in October 1959 as a 20 year-old Aircraftsman 1 with the trade of Catering Assistant; he served with the RAF Task Group. The last of the GRAPPLE detonations had taken place in September 1958; the first US detonation at Christmas Island took place in 1962. He was at the US Hickam AirForce Base (AFB), Pearl Harbour from 28 July to 2 August 1960.

476. A missing witness statement from Mrs Smith dated 19 August 2011 was added to bundles on the day of the hearing at A13 p211. In it, Mrs Smith recalled her late husband telling her that, on arrival, he was employed as the Main Camp barber. He would also help in the clean-up, picking up bits of metal which would disintegrate and replacing his scissors when they rusted quickly. He fished, swam in the lagoon, drank coconut milk and travelled to areas still marked by restricted area signs. He developed stomach cramps and was flown to Hawaii for some hospital treatment. AWE hold no record of a badge being issued to Mr Smith (A13 p103).

477. We find that the 'clean-up' referred to by Mrs Smith was not part of any decontamination effort, all parts of the Island having been declared 11 months previously by the AWRE Health Physics Adviser, as safe from ionising radiation apart from four small marked and access-controlled areas: two at the Main Airfield, one at the JOC and one at C Site (A10 p98V). Any other restricted area signs seen by Mr Smith would have been obsolete.

478. Mr Smith departed Christmas Island in November 1960 and completed his National Service in July 1961. He then worked as a: hairdresser, assembly line worker, shop owner and warehouse supervisor, retiring in 1991.

479. For the reasons stated above (paragraphs 238 to 250) we find that although the radiogenicity of carcinoma of the pancreas is by no means firmly established, a reasonable doubt based on reliable evidence is raised that it can be, and Secretary of State accepts it as radiogenic. The Tribunal also finds that establishing an excess relative risk for carcinoma of the pancreas cannot be done with precision. The LSS Report 14 found an ERR per Gy of 0.42 for all solid cancer at age 70, after exposure at age 30; Figure 2 at page 235 suggests that this might be increased to 0.6 or 0.7 for exposure at age 20; for carcinoma of the pancreas individually a non significant ERR per Gy of 0.22 was found. Therefore we find that an ERR per Gy [1000 mSv] of 0.6 to 0.7 [60 to 70%] would be reasonable, if not generous, for Mr Smith.

480. Although Mr Smith's carcinoma of the pancreas is a condition capable of being caused by ionising radiation we find that there is insufficient reliable evidence to raise a reasonable doubt that Mr Smith's activities at Christmas Island and at Hickam AFB led to sufficient exposure to non-background ionising radiation or any other service-related cause for the condition under appeal to be attributed to service or for his death to be due to or substantially hastened by service.

Mr Alun Williams (dob 13 January 1939)

481. The late Mr Williams made a claim under the SPO 1983 in June 2005; a 'certificate refused' for carcinoma of pancreas, with associated physical and psychological symptoms included as part and parcel, was signed by an SPVA Medical Adviser on 15 February 2006. Mr Williams died on 6 September 2005. The death certificate (A17 page 78) gave the cause of death as Ia Carcinoma Head of Pancreas.

482. Mrs Williams (married 2 March 1963) made a claim for a War Widow's Pension on 18 March 2008. This decision is under appeal and was made on 7 May 2008.

483. Mr Williams arrived at Christmas Island in July 1958 as an 18 year-old Aircraftsman 2 with the trade of Armament Mechanic Assistant; he served with the RAF Task Group. He was present for the GZ1, 2, 3 and 4 detonations.

484. In his claim (A17 p67A et seq), Mr Williams stated that: he was based at C Site, received *' four massive doses of radiation'* ; on decontamination, the geiger counter went off the scale when he was first tested; and that after showers it returned to green. AWE's first report in January 1989 (A17 p27 et seq) stated that there was no requirement for a serviceman with his duties to be issued with a film badge and that consequently no such issue was ever made. In her appeal in September 2008 (A17 p93 et seq), Mrs Williams stated that her late husband was in the forward areas with AWRE cameramen setting up cameras in bunkers to record the bombs and to retrieve them afterwards; no protective clothing or badges were issued to him. After further research, AWE found (A17 p197 et seq) an AC [Aircraftsman] Williams who was formally attached to a group of scientists responsible for '*measuring nuclear transients'* in the Forward Area. He was issued with two film badges, for the periods during which GZ1 and GZ2 were detonated, and his total assessed dose was 0.5 mSv above the local background of 0.61 mSv per annum. The Secretary of State confirmed that he now accepted that the late Mr Alun Williams had performed these duties. We find that Mr Williams was formally attached to Special Group G supporting the AWRE scientists and that, amongst other duties, he assisted in setting up cameras in bunkers and retrieving them after detonations.

485. Cameras forward of C Site were installed at B Site, at two places between B Site and A Site (the two 'point of burst' cameras) and at A Site (RAE report at E1/3). For the Z

series airbursts (GZ2 and GZ3), the highest photographic priority from the forward area would have been to retrieve and process the film from the two point of burst cameras to determine the height of the airburst (E1/3). This information would have been part of the package urgently needed to compile the interim trial report. These cameras were located between 6 and 8 miles from surface zero for the airbursts (between some 4.5 and 6.5 miles from surface zero for the GZ1 and GZ4 balloon bursts). We find that Mr Williams did deploy forward, at least as far as the point of burst cameras, in the immediate aftermath of at least the GZ2 and GZ3 detonations.

486. We find that the figure of 0.5 mSv does not fully reflect the extent of Mr Williams' exposure:

486.1 As recorded earlier in this decision (paragraph 145) Mr William's assessed exposure, based on like-for-like duration, equated to some 1.6 times the UK background dose and to being within the statutory limit for an unclassified worker.

486.2 However, we find the late Appellant's and Mrs Williams' written evidence compelling as to his work in the forward areas shortly after nuclear detonations.

486.3 We find that Mr Williams ingested a small amount of radioactive material at the time and was thereby internally exposed to ionising radiation including alpha particles, the means of ingestion including inhalation (of dust directly from contaminated equipment and areas), orally (through eating and drinking whilst hands, other body surfaces and clothing were contaminated) and through entering the bloodstream through any open wound. This exposure would not have been recorded on his personal film badge (see paragraph 120).

487. Mr Williams departed Christmas Island in July 1959 and completed his Regular Service in April 1970, reaching the rank of Corporal. He then worked as an engineer and a fitter.

488. For the reasons given above (paragraphs 238 to 250), the Tribunal finds that although the radiogenicity of carcinoma of the pancreas is by no means firmly established, a reasonable doubt based on reliable evidence is raised that it can be, and the Secretary of State accepts it as radiogenic. The Tribunal also finds that establishing an excess relative risk for carcinoma of the pancreas cannot be done with precision. The LSS Report 14 found an ERR per Gy of 0.42 for all solid cancer at age 70, after exposure at age 30;

Figure 2 at page 235 suggests that this might be increased to 0.6 or 0.7 for exposure at age 20; for carcinoma of the pancreas individually a non significant ERR per Gy of 0.22 was found. Therefore we find that an ERR per Gy [1000 mSv] of 0.6 to 0.7 [60 to 70%] would be reasonable, if not generous, for Mr Williams.

489. We therefore find that reliable evidence does raise a reasonable doubt that Mr Williams' activities on Christmas Island led to significant exposure to ionising radiation above background (paragraph 486) for his death to be due to or substantially hastened by service.

CONCLUSIONS

490. In these appeals the Tribunal has had the benefit of proper disclosure of relevant documents about possible exposure to ionising radiation at Christmas Island and at Maralinga during the Buffalo Trials. This has never before been given by the Secretary of State. This has enabled the Tribunal to reach its conclusions about exposure with considerable confidence.

491. It is clear to us that there was very limited exposure to ionising radiation on Christmas Island. The Secretary of State has for a long time accepted that the flight crew and decontamination crew for the Canberra sniffer aircraft should be entitled to war pensions if their claimed conditions were included in the list of conditions in the policy document (B6 Tab 31).

492. We consider that if service men served in forward positions on Christmas Island shortly after the detonations it may well have increased their exposure to ionising radiation.

493. As is apparent from what we have said in relation to individual claimed appeals a claimant has to show both that he was exposed to ionising radiation and that such exposure led to his claimed conditions or (in a widow's appeal) were causally linked to a cause of death.

494. We recognise that advances in scientific knowledge may over the years lead to an acceptance that conditions other than those now accepted as being radiogenic may also be so regarded. However, the practical problem is going to be that relatively rare medical conditions require larger epidemiological studies.

495. We emphasise that this decision relates only to servicemen who served on Christmas Island at the time of the Grapple Tests or at a subsequent period prior to the American DOMINIC Tests.

496. We have only heard one appeal about the Buffalo Test at Maralinga although we have had very extensive disclosure of relevant documents. We consider that what we say about Mr Battersby's claim should be taken into account by the Secretary of State when

considering any subsequent claims in relation to exposure to ionising radiation during the Buffalo Trials but recognise that another claimant's individual circumstances may differ from those of Mr Battersby.

497. In the light of our findings the Tribunal will be serving notices in relation to a number of other ionising radiation appeals which have been stayed under Rule 18 of the Tribunal Procedure Rules 2008.

RECOMMENDATIONS

498. If other claims for exposure to ionising radiation are received we do not consider it satisfactory for the SPVA merely to send a request to AWE to write a report in similar terms to the ones that they have provided in all these appeals. The Secretary of State's obligations to give disclosure are set out in Secretary of State for Defence v LA [2011] UKUT 391 (AAC). The SPVA may also wish to consider using findings made by this Tribunal when deciding other claims.

499. The Tribunal has also heard appeals by ground crew serving with 543 Squadron who decontaminated and serviced detachments of sniffer aircraft used to take samples following the French and Chinese atomic testing detonations. We consider that it is important that our detailed findings should be taken into account if similar claims are made by other ground crew in the future.

500. We consider that the conditions which are accepted by the Secretary of State as being radiogenic should be kept under review and the list amended as necessary about every two years.

ACKNOWLEDGEMENTS

501. We wish to acknowledge the great assistance which the Tribunal received from Counsel before and during the hearing. Counsel instructed by the appellants were either wholly or partly acting pro bono as were their instructing solicitors. An immense effort went into the production of written submissions. These were very helpful for the Tribunal. We are also grateful to The Treasury Solicitor's office for preparing the bundles for the hearing.

502. The Tribunal also wishes to acknowledge the great assistance which it derived from all the experts who gave evidence and from Mr Pasquini who gave oral evidence from New York by video conference.

503. Finally, these appeals have been heard over a period of over three years. During most of that time Mrs Evelyn Jarvis has been the member of the Tribunal staff who has had responsibility for organising the extensive paperwork and dealing with the many queries which have arisen over that long period. We are very grateful to her for all that she has done.

Signed…….. **Date: 7 May 2013**

H. STUBBS : Tribunal Judge

(Signed on original.)

Signed…….. **Date: 7 May 2013**

DR A. ANSCOMBE : Medical member

(Signed on original.)

Signed…….. **Date: 7 May 2013**

MR G. MESSERVY-WHITING : Service Member

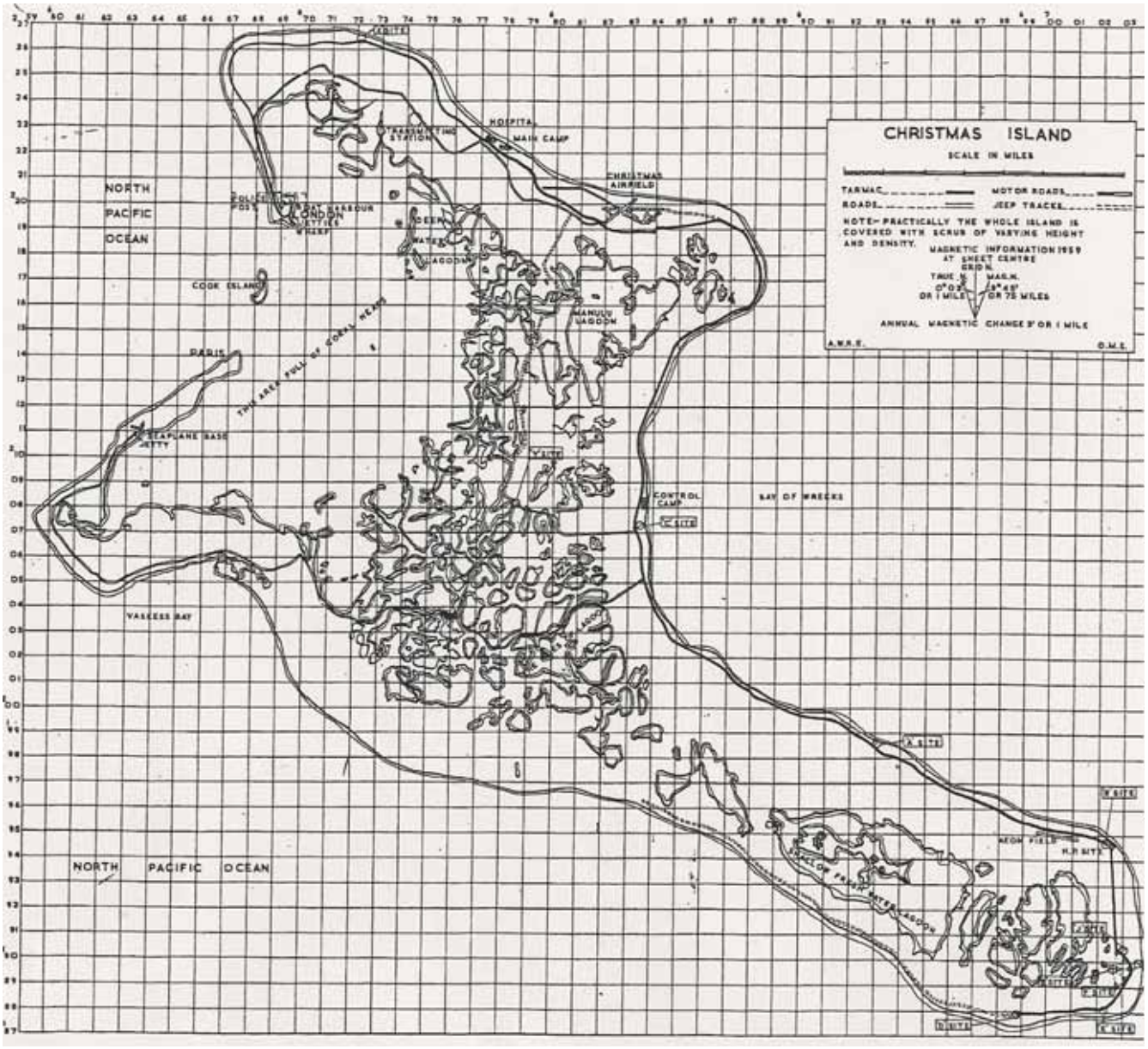
(Signed on original.)

Annex A- Tests, Trials, Clean-Ups and Appellants

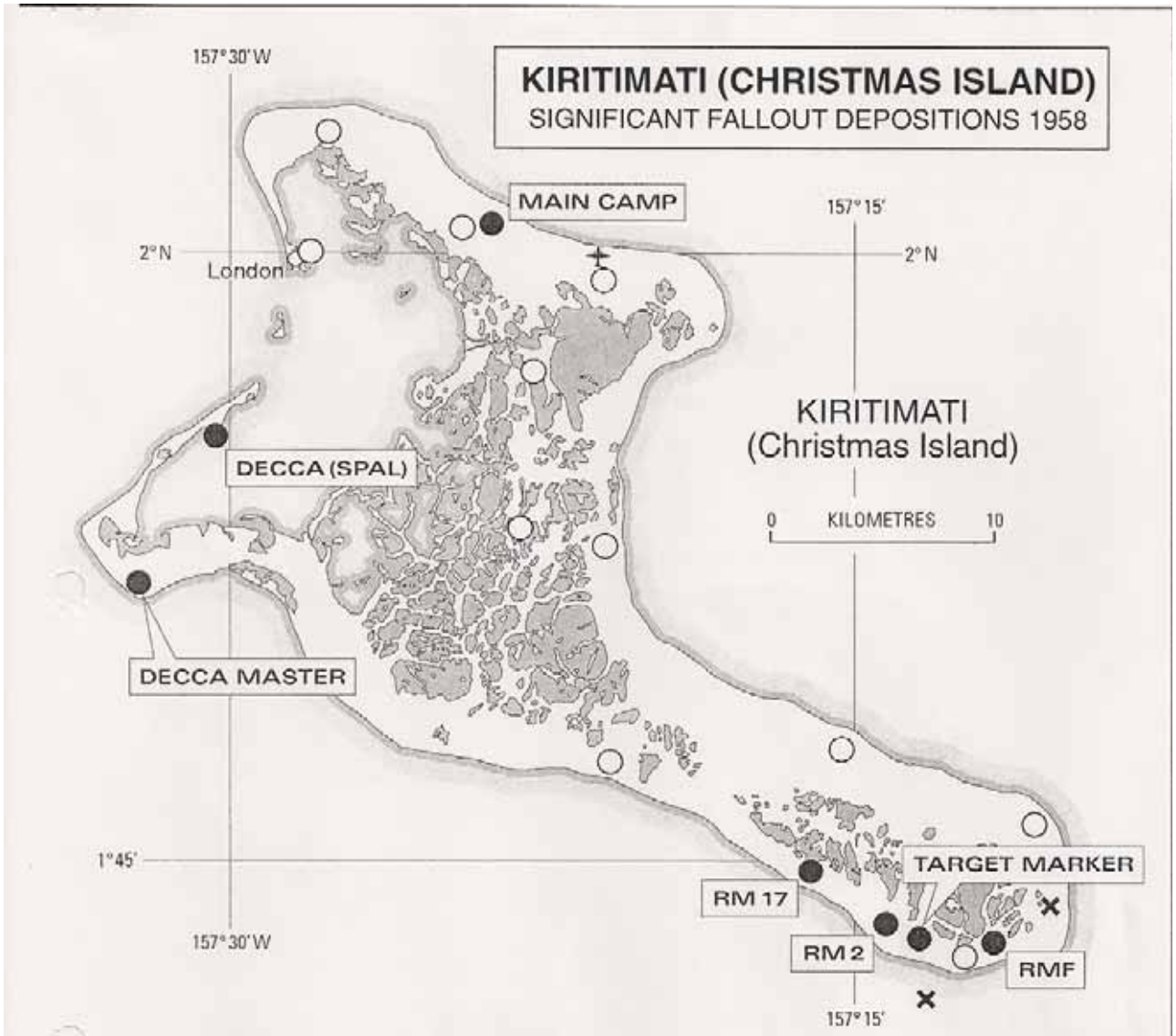
Date/time (Local/Zulu)	Area	Location	Name	Type	Height (m)	Yield (Kt)	Appellants
3 Oct 52 0929L	Monte Bello Is (W Australia)	Trimorille Is	HURRICANE	ocean surface (HMS Plym)	-3	25.0	
15 Oct 53 0700L	Woomera	Emu Field	TOTEM (1)	tower	31	10.0	
27 Oct 53 0700L	Woomera (S Australia)	Emu Field	TOTEM (2)	tower	31	8.0	
?1953	Woomera (S Australia)	Emu Field	minor trials: KITTENS				
16 May 56 1151L	Monte Bello Is	Trimorille Is	MOSAIC G1 (GIRAFFE)	tower	31	15.0	
19 Jun 56 1014L	Monte Bello Is	Alpha Is	MOSAIC G2 (FLASHLIGHT)	tower	31	60.0	
27 Sep 56 1700L	Maralinga (S Australia)	One Tree	BUFFALO (1) (THETA)	tower	31	15.0	Battersby
4 Oct 56 1630L	Maralinga (S Australia)	Marcoo	BUFFALO (2)	ground (concrete emplacement)	0	1.5	Battersby
11 Oct 56 1527L	Maralinga (S Australia)	Kite	BUFFALO (3)	airdrop over land (Valiant)	150	3.0	Battersby
21 Oct 56 0005L	Maralinga (S Australia)	Breakaway	BUFFALO (4)	tower	31	10.0	Battersby
15 May 57 1937Z (3) (Table 1)	Christmas Is	Malden Is (700kms to South)	GRAPPLE (1) (SHORT GRANITE)	airdrop over sea (Valiant)	2200	250.0	Hughes
31 May 57 1941Z	Christmas Is	Malden Is (700kms to South)	GRAPPLE (2) (ORANGE HERALD)	airdrop over sea (Valiant)	2400	750.0	Hughes
19 Jun 57 1940Z	Christmas Is	Malden Is (700kms to South)	GRAPPLE (3) (PURPLE GRANITE)	airdrop over sea (Valiant)	2400	220.0	Hughes
14 Sep 57 time n/k	Maralinga (S Australia)	Tadje	ANTLER (1)	tower	31	1.0	
25 Sep 57 time n/k	Maralinga (S Australia)	Biak	ANTLER (2)	tower	31	6.0	
9 Oct 57 time n/k	Maralinga (S Australia)	Taranaki	ANTLER (3)	balloon array over land	300	25.0	
8 Nov 57 1747Z	Christmas Is	off SE tip, C site 24.6kms nearest manned	GRAPPLE X	airdrop over sea (Valiant with BLUE DANUBE))	2200	circa 1800	Beeton, Lovatt, Selby

28 Apr 58 1905Z	Christmas Is	off SE tip, C site 24.6kms nearest manned	GRAPPLE Y	airdrop over sea (Valiant)	2500	3150.0	Abdale, Beeton, Butler, Lovatt, Pritchard, Selby
22 Aug 58 1800Z	Christmas Is	at SE tip, A site 13 kms nearest manned	GRAPPLE Z (1) (PENNANT)	balloon array over land	450	24.0	Abdale, Butler, Hatton, Pritchard, Sinfield, Williams
2 Sep 58 1724Z	Christmas Is	off SE tip, C site 24.6kms nearest manned	GRAPPLE Z (2) (FLAGPOLE)	airdrop over sea (Valiant)	2800	1000.0	Abdale, Butler, Hatton, Pritchard, Sinfield, Williams
11 Sep 58 1748Z	Christmas Is	off SE tip, C site 24.6kms nearest manned	GRAPPLE Z (3) (HALLIARD)	airdrop over sea (Valiant)	2600	800.0	Abdale, Butler, Hatton, Pritchard, Sinfield, Williams
23 Sep 58 1759Z	Christmas Is	at SE tip, A site 13 kms nearest manned	GRAPPLE Z (4) (BURGEE)	balloon array over land	450	25.0	Abdale, Butler, Hatton, Pritchard, Sinfield, Williams
[Apr-Jul 62]	Christmas Is	off SE tip	DOMINIC 24x US detonations	airdrop over sea (B-52)	n/k	n/k]	Shaw, Smith (post GZ, pre US)
?1955-May 63	Maralinga (S Australia)		minor trials': KITTENS, TIMS, RATS, VIXEN A, VIXEN B	to gather data on behaviour of fissile materials in fires & nuclear assemblies in fires/accidental detonations			
?1964	Christmas Is		clean-up				
Aug- Nov 64	Maralinga (S Australia)		HERCULES V clean-up	burial of some contaminated equipment & fencing of contaminated test areas			Simons
Mar-Aug 67	Maralinga (S Australia)		BRUMBY main clean-up	intended to be final decontamination & restoration of range area			

Annex B Scaled Map Christmas Island showing principal locations



Annex C. Sketch Map, showing significant fallout depositions.



Annex D – Exposure Technology

Appendix 1 to Policy Statement on claims for ionising radiation related conditions

Radiation dose

1. The first definition of a unit of radiation dose was made in 1928 by the International Congress of Radiology. The rontgen (R) was defined as that quantity of radiation which produces in 1cm of air one unit of charge of either sign, thus defining a unit of exposure. Units of **absorbed dose**, the actual energy absorbed in the tissue being irradiated are now used. The radiation absorbed dose or **rad** is now cited in SI (System Internationale) units – joules per kg – of absorbing material. The fundamental unit – 1 joule/kg is 1 gray (1Gy) equivalent to 100 rads (R).

2. Different radiation types have greater or lesser effect per unit dose so they are all expressed relative to the effects of X-rays, i.e. a unit equivalent dose is used. To calculate the rontgen equivalent in man (**rem**) – the absorbed radiation dose is multiplied by a radiation weighting factor – dependent on type and energy of the radiation. The current SI unit of equivalent dose is the **sievert**. For X-rays and gamma rays the equivalent dose in sieverts and the absorbed radiation dose in grays are the same. The relationship between the different dose units is:-

   1 gray (Gy) = 1 joule/kg = 100 rads (R) = 100 rems (r) = 1 sievert (Sv) = 1,000 millisieverts (mSv) = 1,000,000 microsieverts (microSv). Typical doses of radiation include:-

   Chest X-ray – 0.02 mSv
   Brain scan – 7 mSv
   Bone scan – 4 mSv
   Average annual UK dose from cosmic rays – 0.26 mSv
   Average annual UK dose from gamma rays – 0.35 mSv
   Average annual UK dose natural background radiation – 2.2 mSv

Radiological protection

3. Since the days of Marie Curie it has been appreciated that ionising radiation exposure may be hazardous to health. Radiation dose limits were first recommended for ionising radiation exposure in 1928. The statutory limit on the amount of radiation to which the general public may be exposed in excess of natural background radiation and excluding medical exposure is set, from 1 January 2000 at 1 mSv per annum.

4. The most important source of man made exposure is medical investigation which accounts for 90 per cent of man made exposure. Average natural background radiation is raised to 2.6 mSv by all man made exposure. UK estimated experience excluding medical investigation is 0.04 mSv. Other statutory limits include occupational dose limits. From 1 January 2000 these are 20 mSv per annum for classified workers and 6 mSv per annum for unclassified workers.

Health effects of ionising radiation

5. Adverse health effects of ionising radiation are independent of the source of radiation and are of 2 types. Early and late.

Early effects (also called deterministic)

- These effects usually arise shortly after exposure, usually within hours or weeks.
- There is a threshold dose, beneath which no effects are seen.

- This threshold is relatively high, exceeding natural background radiation levels at all parts of the planet by several hundred fold.
- The severity of the effect varies directly with dose.
- Duration of exposure is also important and for a given total dose, acute exposure is more harmful than a protracted dose.
- The tissues affected are those whose cells have a high turnover rate, ie bone marrow – skin – gastro-intestinal tract.

Late effects – also called stochastic/probabilistic

- These effects arise years (2-40 or more) after exposure and the probability depends on the level of the dose.
- There appears to be no threshold and the severity of the effects is not dose dependent.
- This means that there is a finite risk even from low level natural background radiation. At the same time persons exposed to high dose may suffer no ill effects.
- The 2 main late effects are induction of cancer and hereditary disease in subsequent generations.
- All diseases which can be radiation induced can also occur naturally or in relation to other exposures – cigarette smoke, alcohol, diet (both excesses and deficiencies), occupational exposures – and are not distinguishable on the basis of cause.
- Current best evidence is that radiation of all types gives rise to less than 2% of all cancers worldwide. The most important carcinogenic type of radiation is in fact ultra-violet light (UVB) not ionising radiation.
- Not all types of cancer have been shown by evidence to be caused by ionising radiation.
- Hereditary effects have not been demonstrated in humans but there is such evidence in some types of animals.

Effects of total body irradiation

Equivalent dose (Sv)	**Effect**
Sublethal to man	
0.0001 (0.1 mSv)	Around 2 weeks' natural background radiation, no detectable effect.
0.001 (1 mSv)	Around 6 months; natural background radiation, no detectable effect.
0.01 (10 mSv)	No detectable effect.
0.1 (100 mSv)	Minimal decrease in peripheral lymphocyte count, no clinical effect.
1 (1000 mSv)	Mild acute radiation sickness in some individuals (nausea, possible vomiting), no acute deaths, early decrease in peripheral lymphocyte count, decease in all WBC and platelets at 2-3 weeks, increase in late risk of leukaemia, solid tumours.

Equivalent dose (Sv)	**Effect**
Lethal to man	
10(10,000 mSv)	Severe acute radiation sickness, severe vomiting, diarrhoea, death within 30 days of all exposed individuals. Severe depression of blood cell and platelet production, damage to gastrointestinal mucosa.
100 (100,000 mSv)	Immediate vomiting, disorientation, coma, death within hours.
1000 (1,000,000 mSv)	Death of some micro-organisms, some insects within hours.
10,000 (10,000,000 mSv)	Death of most bacteria, some viruses.
100,000 (100,000,000 mSv)	Death of all living organisms denaturation of proteins.