Nuclear New Zealand:

New Zealand's nuclear and radiation history to 1987

A thesis submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy in the History and Philosophy of Science in the University of Canterbury

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Abstract

New Zealand has a paradoxical relationship with nuclear science. We are as proud of Ernest Rutherford, known as the father of nuclear science, as of our nuclear-free status. Early enthusiasm for radium and X-rays in the first half of the twentieth century and euphoria in the 1950s about the discovery of uranium in a West Coast road cutting was countered by outrage at French nuclear testing in the Pacific and protests against visits from American nuclear-powered warships.

New Zealand today has a strong nuclear-free identity – a result of the New Zealand Nuclear Free Zone, Disarmament and Arms Control Act of 1987 that prohibited nuclear weapons and nuclear warships in the country's land, air and water – that can be traced back to the first protests against nuclear weapons in the 1940s. This thesis is based on the supposition that the "nuclear-free New Zealand" narrative is so strong and such a part of the national identity that it has largely eclipsed another story, the pre-1980s story of "nuclear New Zealand". New Zealand's early embracing of and enthusiasm for nuclear science and technology needs to be introduced into our national story. This thesis aims to discover and reveal that history: from the young New Zealand physicists seconded to work on the Manhattan Project; to the plans for a heavy water plant at Wairakei; prospecting for uranium on the West Coast of the South Island; plans for a nuclear power station on the Kaipara Harbour; and the thousands of scientists and medical professionals who have worked with nuclear technology. Put together, they provide a narrative history of nuclear New Zealand.

Between the "anti-nuclear" voices, already well told in many histories of nuclear-free New Zealand, and the "pro-nuclear" voices revealed in this thesis, options were considered and decisions made. This thesis shows that the people with decision-making power tended to make practical decisions based on economics and national interest when it came to deciding whether or not to adopt a certain piece of nuclear technology or whether or not to participate in projects or ventures with international agencies. This eventually led to a nuclear-free policy – focused on weapons, nuclear-powered ships and waste – that since the legislation was enacted in 1987 has been interpreted ever more widely by politicians and the public to include nuclear power, uranium prospecting and many other applications of nuclear technology.

Acknowledgments

First thanks go to the two organisations whose support has been essential to the writing of this thesis. Thanks to the University of Canterbury whose doctoral scholarship provided vital funding over the first few years of this thesis, and to my supervisors at the University of Canterbury: Dr Philip Catton (philosophy), Professor John Hearnshaw (physics and astronomy) and Professor Philippa Mein Smith (history). History of science was a new discipline for me and the support and guidance of my supervisors has been crucial. Second thanks go the Stout Research Centre for New Zealand Studies at Victoria University of Wellington, and its director, Professor Lydia Wevers, for giving me a peaceful haven in which to complete my thesis. Thanks also to the staff and residents at the Stout Research Centre, for stimulating conversation and constant encouragement.

Many individuals have assisted me over the nine-year course of this thesis, either by providing personal anecdotes or sharing photographs, diaries and papers. Particular thanks go to Jim McCahon, Robin Williams, Lloyd Jones and Rob Aspden who shared their personal stories with me. Thanks also to Jock Brathwaite, Simon Nathan and the family of Tas McKee for sharing their photographs. Thanks also to the staff at Archives New Zealand and the National Library of New Zealand, where I spent many weeks researching this thesis.

Final thanks go to my family, my husband Jonathan, and my children, Pippi, Hazel and Huck, all of whom were born during the nine-year course of this project. Thanks also to my mother and step-father Ruth Brassington and Chris Peace and to the nannies whose assistance helped me to achieve this goal: Jade, Janine, Marnie, Miriam and Jess.

Chapter 1

Nuclear-free New Zealand: Reality or a myth to be debunked?

" … our nuclear free status … has become a defining symbol of our national identity."

Prime Minister Helen Clark, 28 November 2007[1]

"New Zealand's nuclear-free status is a myth …"

Act MP Ken Shirley, 27 July 2005[2]

New Zealand today is internationally recognised as being "nuclear-free". The New Zealand Nuclear Free Zone, Disarmament and Arms Control Act of 1987 created a nuclear-free zone that prohibited nuclear weapons and nuclear warships in the country's land, air and water. In the years that followed, government and the New Zealand public began to interpret the nuclear-free policy more widely. In 1996 a Minerals Programme issued under the Crown Minerals Act prohibited uranium mining, and prospecting for uranium. And in 2005, in response to calls for nuclear power to meet New Zealand's future electricity needs, the Labour Government stated their clear policy of no nuclear power stations. This nuclear-free status, initiated by a Labour Government in the 1980s, is now recognised by both major political parties, and is a reflection of a strong nuclear-free national identity.

This thesis is based on the supposition that the "nuclear-free New Zealand" narrative is so strong and such a part of the national identity that it has largely eclipsed another story, the pre-1980s story of "nuclear New Zealand". New Zealand's early embracing of and enthusiasm for nuclear science and technology needs to be introduced into our national story. This thesis aims to discover and reveal that history: from the young New Zealand physicists seconded to work on the Manhattan Project; to the plans for a heavy water plant at Wairakei; prospecting for uranium on the West Coast of the South Island; plans for a nuclear power station on the Kaipara Harbour;

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[1] From the Prime Minister's address on 'New Zealand and Peaceful Conflict Resolution' in Cairo, Egypt, at www.beehive.govt.nz/speech/new+zealand+and+peaceful+conflict+resolution downloaded 23 June 2010.

[2] A statement made when presenting his New Zealand Nuclear Free Zone, Disarmament, and Arms Control (Nuclear Propulsion Reform) Amendment Bill to Parliament on http://www.parliament.nz/mi-NZ/PB/Debates/Debates/7/c/1/47HansD_20050727_00001577-New-Zealand-Nuclear-Free-Zone-Disarmament.htm, downloaded 23 July 2008.

and the thousands of scientists and medical professionals who have worked with nuclear technology. Put together, they provide a narrative history of nuclear New Zealand.

In attempting to write an alternative history – that of "nuclear New Zealand" rather than the already told story of "nuclear-free New Zealand" – I hope first to show the extent of use, over time, of radiation and nuclear science and technology in New Zealand; second, to reveal attitudes (of the scientists and engineers involved and of the public, as reflected in the media, and of the governments of the time) to all aspects of nuclear science and technology before New Zealand's current nuclear-free policy was adopted; and third, to show how recent an addition the nuclear-free status is to national identity.

New Zealand's nuclear-free identity is strong, and most New Zealanders are fiercely proud of it. Perhaps this is why New Zealand's nuclear history (as compared with its "nuclear-free" history) has been neglected – it does not fit with established identity. But this is not the only reason. As the following literature review shows, many books have been written about New Zealand's nuclear-free story and most general histories of New Zealand reference New Zealand's nuclear-free status. Science history in New Zealand, however, is a sorely neglected field. Although Ross Galbreath's history of the Department of Scientific and Industrial Research (DSIR) was published in 1998 and there has been a proliferation of (mostly amateur) biographies of New Zealand scientists published in the last decade, there is little published material on New Zealand's science history – let alone its *nuclear* science history – and almost none that comes from an academic source.[3] In contrast, New Zealand's social and political history is well covered; there are many books, theses and academic articles describing the work of politicians and the peace movement and the build-up to the adoption of New Zealand's nuclear-free policy.

This thesis argues that while being nuclear-free is an important part of New Zealanders' national identity, it is different from other national traits, like a talent for ingenuity or a passion for rugby, in that it is a relatively recent addition to collective identity. History reveals that, apart from New Zealand's public and Governmental opposition to nuclear bomb testing in the Pacific, a broad

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[3] Ross Galbreath, *DSIR: Making Science Work for New Zealand*, Victoria University Press, Wellington, 1998. Recent biographies of New Zealand scientists include Graham Bishop, *The Real McKay: The Remarkable Life of Alexander McKay, Geologist*, Otago University Press, Dunedin, 2008; Veronika Meduna and Rebecca Priestley, *Atoms, Dinosaurs & DNA: 68 Great New Zealand Scientists*, Random House, Auckland, 2008; Christine Cole Catley, *Bright Star: Beatrice Hill Tinsley, Astronomer*, Cape Catley, Auckland, 2006; Simon Nathan, *Harold Wellman: A Man Who Moved New Zealand*, Victoria University Press, Wellington, 2005; Colin J. Burrows, *Julius Haast in the Southern Alps*, Canterbury University Press, Christchurch, 2005; Mary McEwen, *Charles Fleming, Environmental Patriot: A Biography*, Craig Potton, Nelson, 2005; Ross Galbreath, *Scholars and Gentlemen Both: G.M. & Allan Thomson in New Zealand Science & Education*, Royal Society of New Zealand, Wellington, 2002; John Campbell, *Rutherford: Scientist Supreme*, AAS Publications, Christchurch, 1999; Ross Galbreath, *Walter Buller: The Reluctant Conservationist*, GP Books, Wellington, 1989.

all-encompassing “nuclear-free” ethos was not strongly apparent before the events of 1985, when Prime Minister David Lange refused to allow the USS *Buchanan* access to New Zealand ports and French agents bombed the Greenpeace ship *Rainbow Warrior* while it was berthed in Auckland. By examining New Zealanders’ consideration of aspects of nuclear science and technology, like nuclear medicine, nuclear power, and uranium prospecting, and examining the reasons why they were or were not adopted or accepted, this thesis shows that pragmatism and national interest has dominated public and official attitudes and decision-making when it comes to things nuclear. This suggests that had pragmatism (mostly in the form of economic considerations) suggested different decisions be made, New Zealand might not today have had such a strong nuclear-free identity. In the late 1970s, less than a decade before becoming so proudly nuclear-free, New Zealand was considering nuclear power to meet growing electricity demand in the North Island. In 1978, a Royal Commission of Inquiry rejected the immediate development of nuclear power for New Zealand, not in response to anti-nuclear sentiment, which did exist, but because a reduction in projected electricity demand and the recent discovery of the Maui natural gas field meant New Zealand had sufficient indigenous resources to meet electricity needs to the end of the century. This thesis also reveals a previously untold story of the history of uranium prospecting in New Zealand and argues that while New Zealand has never mined uranium, it is not because of a moral decision not to provide materials for the international nuclear power and weapons industries. Rather, as chapter six shows, it is because no economic deposits of uranium were ever found, despite 35 years of uranium prospecting initiated by the DSIR and supported by the New Zealand and British governments.

There are other reasons why introducing the story of nuclear New Zealand into our history will be valuable. There have been challenges to New Zealand’s nuclear-free policy in recent years and there will be more challenges in the future. Human-induced climate change and the need for new sources of energy with a low carbon footprint have led (rightly or wrongly) to calls for nuclear power to be revisited as an option for New Zealand. Both former National Party leader Don Brash and former Prime Minister Geoffrey Palmer have suggested in recent years that New Zealand revisit the question of allowing nuclear-powered ships into ports. But many of the voters who might be considering these options in the future are from younger generations unaware that we ever considered nuclear power in the past or who do not know why we banned nuclear-armed and nuclear-powered ships from our ports. This is why it is important to introduce into our national story New Zealand’s early enthusiasm for things nuclear, as well as the often pragmatic rather than ideological reasons why, for example, nuclear reactors as a source of research materials and electricity generation were rejected by our scientists and engineers while medical and scientific uses of radioactive isotopes were widely accepted, and why we rejected visits from nuclear-armed or nuclear-powered warships.

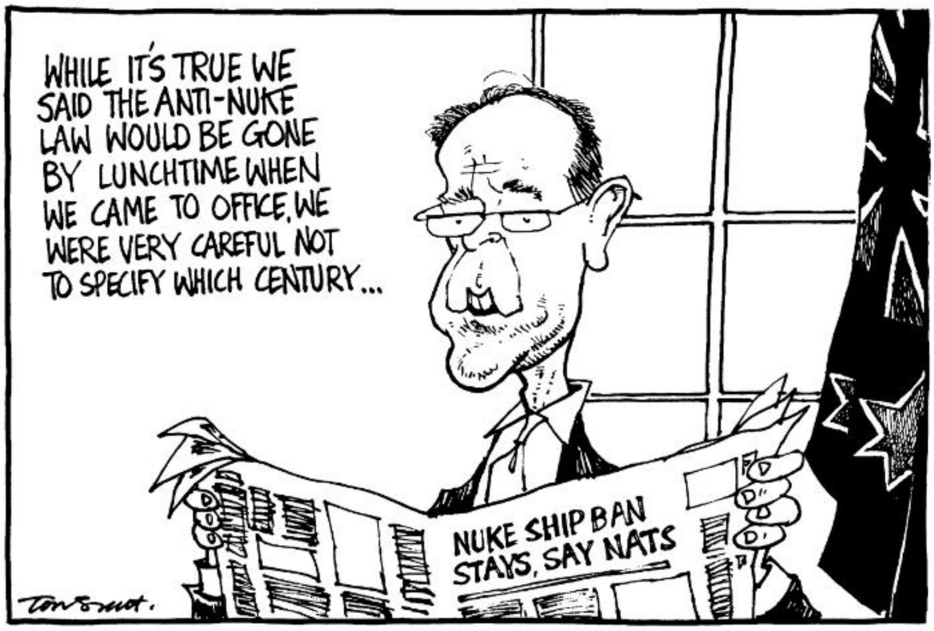

Figure 1.1: After public and media response to Don Brash's comments that under a National Government New Zealand's nuclear ships ban would be "gone by lunchtime", he quickly tried to backtrack on this policy. Cartoon by Tom Scott, *The Dominion Post*, 24 June 2004, ID: A-312-4-023, Alexander Turnbull Library, Wellington, NZ.

Figure 1.2: This Malcolm Evans cartoon from 21 April 2010 illustrated former Prime Minister Geoffrey Palmer's suggestion that New Zealand might revisit the issue of visits from United States nuclear warships. Downloaded from www.evanscartoons.com/image.php?id=1271825710

While New Zealand's nuclear-free policy refers to nuclear weapons, nuclear propulsion, and nuclear power, other practices associated with radiation or nuclear science have been tainted in the eyes of the public with the "nuclear" association. In 1995 Hutt City mayor Glen Evans proposed that the Hutt City Council declare its city a nuclear-free zone as had the former Lower

Hutt City Council in 1984. An NZPA report declared Hutt City could not do this "because of the nuclear reactor at the Gracefield nuclear physics research centre".[4] Evans and the NZPA were not the only people confused. It was a common misconception that there was a nuclear reactor at the DSIR's Institute of Nuclear Sciences, by now part of the Crown Research Institute the Institute of Geological and Nuclear Sciences. In the early 1990s when I was working for the Institute (now known by the less provocative moniker of GNS Science) in Lower Hutt, taxi drivers would call it "the bomb factory" and warn me about the nuclear reactor on the Gracefield hill site (actually a particle accelerator used for radiocarbon dating). When Jools Topp, of the Topp Twins country music duo, was offered radiation therapy as part of treatment for breast cancer, she refused it, recalling to Radio New Zealand's Kathryn Ryan in 2009 she had told the doctors "I'm a lifelong member of Greenpeace, why would I let you irradiate me?"[5] But New Zealand society relies on nuclear technology much more than most people realise, with more than 3,000 shipments of radioactive material entering the country each year for use in medicine as well as industrial and environmental applications. More information about our nuclear history and nuclear present will help people make informed choices in the future.

Scope

In revealing New Zealand's "nuclear history", this thesis examines the consideration of, and subsequent introduction or rejection of, all aspects of radiation and nuclear science and technology in New Zealand. It also examines concerns about their introduction and use, and concerns about the impact on New Zealand of other countries' uses of nuclear technology, for example, with regard to nuclear bomb tests, nuclear power and nuclear waste. With regard to radiation and radiation technologies this thesis is concerned only with ionising radiation – high energy and potentially harmful radiation that is capable of removing electrons from substances it passes through, thereby forming ions – including X-rays, alpha, beta and gamma radiation and neutrons.

The start point for the thesis is a series of interrelated European discoveries in the last years of the nineteenth century: Wilhelm Röntgen's 1895 discovery that a penetrating radiation, that he called X-rays, could be produced by electromagnetic means was followed by Henri Becquerel's observation that similar rays were spontaneously generated by uranium-bearing compounds, and Marie and Pierre Curie's announcement that uranium ores contained the more highly-radioactive

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[4] NZPA, 'Reactor Tempers Hutt City's Nuke Free Declaration', www.rsnz.govt.nz/archives/news_pre_oct99/news/y_1995/m__09/d_18/a_3.php, downloaded 12 January 2000.
[5] The Topp Twins interview, Nine to Noon, Tuesday 31 March 2009, www.radionz.co.nz/national/programmes/ninetonoon/20090331 downloaded 21 March 2010.

elements polonium and radium. These scientific advances led to worldwide applications in medicine, industry and general science, including in New Zealand.

Further investigations, including some by New Zealander Ernest Rutherford, led to the discovery that in addition to the electrons recently discovered by J.J. Thomson, atoms contained a proportionately miniscule positively-charged “nucleus” comprised of protons and neutrons. These advances led to the genesis of the entirely new discipline of nuclear science. By the end of the Second World War this new science had been used to manufacture and unleash upon human beings a devastating new type of bomb, to create new isotopes for application in industry and medicine, and to accomplish new means to generate electricity. By the mid 1980s eight nations were declared or suspected holders of nuclear weapons (which had been tested in the air, underground and underwater), more than 300 nuclear power stations were being used to power homes and businesses in Europe, the Americas and parts of Asia, and nuclear materials and technologies were being used in industry and medicine throughout the world. From a movement that began with opposition to the testing of nuclear weapons in the South Pacific, New Zealand in 1985 declared its nuclear-free intentions, rejecting any associations with nuclear weapons or nuclear-propelled warships.

Method and sources

A review of existing literature reveals a significant gap in New Zealand’s history that this thesis aims to fill. While little-known aspects of New Zealand’s nuclear history have been recently uncovered by Ross Galbreath and John Crawford and are canvassed in books about New Zealand’s nuclear-free history, and institutional histories – of the DSIR, universities, hospitals and the Ministry of Works – reveal that New Zealand scientists and medical professionals have been using radiation and nuclear technologies since they were first available, many aspects of New Zealand’s nuclear history have been forgotten or never told. This thesis supposes there is an untold “nuclear history” of New Zealand to tell and aims to uncover new information and connect the already revealed details to create a narrative history of the scientific and popular use – or rejection – of radiation and nuclear science and technology in New Zealand.

While the thesis is broadly organised according to chronology and themes, a person who features throughout much of this narrative is Ernest Marsden. He was a student of Rutherford’s who, with Hans Geiger, conducted the experiment that led to Rutherford’s determination of the structure of the atom. Ernest Marsden was secretary of the DSIR from 1926 to 1947 and the Department’s scientific advisor to the United Kingdom, positioned in London, from 1947 to 1954. Inspired by his early career in nuclear physics, Marsden had a post-war vision for a nuclear New Zealand, where scientists would create radioisotopes and conduct research on a local nuclear reactor, and industry would provide heavy water and uranium for use in the British nuclear energy and weapons programmes, with all these ventures powered by energy from nuclear power stations. During his retirement, however, Marsden conducted research into environmental radioactivity and the impact of radioactive bomb fallout and began to oppose the continued development and testing of nuclear weapons. It is ironic, given his early enthusiasm for all aspects of nuclear development, that through his later work and influence Marsden may have actually contributed to what we now call a "nuclear-free" New Zealand.

A biographical focus in the history of science in some cases overlooks the institutional and wider social context of science. In the case of the present study, however, which concerns both the very small country of New Zealand and a field as focused as nuclear science, the reverse is true. In this case, as will be shown, one person significantly shaped both the institutional setting and the wider social environment for his science. Therefore we can learn much about the context precisely by examining his influence. Ernest Marsden's wide experience, outspokenness and apparent capriciousness towards nuclear weapons development makes him a compelling study that provides insight into the changing attitudes to nuclear technology in the nation of New Zealand as a whole. For these reasons, Marsden's role, and his attitude towards things nuclear, are followed and analysed closely in this thesis, from his work with Rutherford in 1909, to his death in New Zealand in 1970. Marsden and his role in New Zealand's nuclear history was the subject of a 2006 article by this author and this work is drawn on over several chapters of this thesis.[6]

Ernest Rutherford is also closely followed in this thesis. As the New Zealand-born scientist known as the "father of nuclear physics", Rutherford played a significant role in the development of nuclear science as a discipline and, while uptake of new technologies associated with the discovery of radiation and X-rays progressed in New Zealand independently of Rutherford's influence, his continued contacts with New Zealand reveal much about the times he lived in and the role of science in New Zealand society. Another scientist, Jim McCahon, is also followed as his changing career and concerns – from making Geiger counters for a wartime uranium search, to working for the Department of Health's Dominion X-Ray and Radium

[6] Rebecca Priestley, 'Ernest Marsden's Nuclear New Zealand: from Nuclear Reactors to Nuclear Disarmament', *Journal and Proceedings of the Royal Society of New South Wales*, 139 (2006), pp23-38.

Laboratory, to a lifelong involvement with the Campaign for Nuclear Disarmament – help to highlight some of the trends and issues at work in New Zealand in the 1950s, 1960s and 1970s.

To uncover this history, and reveal the decisions and the motives behind the decisions of the scientists, engineers and officials considering nuclear options for New Zealand, this thesis draws extensively on the records of the DSIR, State Hydro Electricity Department, Department of Health, New Zealand Atomic Energy Committee and External Affairs Department, held at Archives New Zealand in Wellington. More than 90 files are referenced, most of which (to the best of my knowledge) have not been cited in any academic or other works to date. Other primary sources include the *New Zealand Parliamentary Debates*, the *Appendices to the Journal of the House of Representatives*, articles from the popular press and trade and academic journals, personal interviews with active participants, and manuscripts and letters from the Alexander Turnbull Library in Wellington. A wide range of secondary sources are also consulted to provide background and context to the issues.

Literature review

During the nine-year course of this thesis, two books on aspects of New Zealand's nuclear history were published. Both can be seen as insider histories as they were written by people who were to some extent involved in making that history. In 2004, retired health physicist Andrew McEwan launched the argument that New Zealand is not "nuclear free" in a book that covered some aspects of New Zealand's nuclear history but mostly served to meet McEwan's goal of clearing up "public" misconceptions about nuclear and radiation issues in New Zealand.[7] While McEwan's book was not a history it did cover many events in New Zealand's nuclear and radiation history, mainly with the purpose of asking "Is New Zealand 'nuclear-free'?" and "Has it ever been?" McEwan described it as a "double standard" that New Zealand purports to be nuclear-free yet its people are surrounded by natural forms of radiation, and have a health system that depends on radioisotopes made in overseas reactors. McEwan's answers to the questions he posed is no. He saw "nuclear-free" as a warm, fuzzy "feel good" expression and danger that "national antipathy to things nuclear will limit options New Zealand should be examining as it considers future decisions on its development". McEwan had previously written a history of the National Radiation Laboratory, the organisation he worked at for 40 years and one of two major public institutions involved in New Zealand's nuclear history.[8]

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[7] Andrew McEwan, *Nuclear New Zealand*, Hazard Press, Christchurch, 2004.
[8] Andrew McEwan, *Radiation Protection and Dosimetry in New Zealand: A History of the National Radiation Laboratory,* New Zealand Department of Health, Wellington, 1983.

In his 2006 book Malcolm Templeton, a retired diplomat, approached New Zealand's nuclear history from 1945 to 1990 as a foreign policy issue, focusing on international relations and public policy decisions leading up to New Zealand's declaration as a nuclear-free country. Templeton described his book as a "factual account of the development of governmental policy and the conduct of intergovernmental negotiations". Templeton was a senior official in the Foreign Ministry when, in 1973, New Zealand sent a protest frigate to Moruroa and initiated an International Court case against France. He has written a very thorough and factual account of New Zealand in the nuclear age from the perspective of the Foreign Affairs officials and department. One of Templeton's conclusions was that that "New Zealand's antipathy to all things nuclear has become embedded in their collective psyche": he suggested that while this was derived from apprehension about nuclear weapons testing in the Pacific, it has become "a national obsession to keep all things nuclear, power generation as well as weapons, well clear of New Zealand territory". Templeton's other conclusions were about national defence and security measures, ANZUS in particular, but this thesis is most concerned with that first conclusion, and seeks to retrace attitudes to things nuclear back in New Zealand's history, with a focus on scientists and the general public as opposed to foreign affairs officials and the government.

International nuclear histories

The science and technology of radiation and the nucleus is recent; radiation was discovered at the end of the nineteenth century and nuclear science emerged as a discipline in the mid-twentieth century. During the Second World War scientists developed the technology to build nuclear reactors to produce isotopes for scientific research, to generate power, and, most significantly, to create the raw materials for nuclear weapons. Nuclear technology by then had important ramifications for foreign policy and the peace movement. There is a growing body of literature about the development of nuclear weapons, starting with official institutional histories of the British nuclear programme written by Margaret Gowing in the 1960s and 1970s, and Richard Rhodes' Pulitzer Prize-winning account of the United States nuclear programme published in 1986, and expanding into a post-Cold-War proliferation of books about the nuclear age.[9] New Zealanders' involvement in the British nuclear programme at Chalk River, Canada, is

[9] Margaret Gowing, *Britain and Atomic Energy 1939-1945*, Macmillan and Co Ltd, London, 1964; Margaret Gowing, *Independence and Deterrence: Britain and Atomic Energy 1945*-1952*: Volume 1 Policy Making*, Macmillan, London, 1974; Margaret Gowing, *Independence and Deterrence: Britain and Atomic Energy 1945-52, Volume 2, Policy Execution*, Macmillan, London, 1974; Richard Rhodes, *The Making of the Atomic Bomb*, Touchstone, New York, 1986; Lawrence Badash, *Scientists and the Development of Nuclear Weapons*, Humanity Books, New York, 1995.

also covered in Gowing's books as well as in other books about the British and Canadian programmes.[10]

When the British were ready to test their own nuclear weapons they looked first to Australia and then to the rest of the Pacific for testing grounds. Lorna Arnold's books provided detailed factual accounts of the British atomic weapons trials in Australia and the Pacific and included some mention of New Zealand connections.[11] Australian scholars such as Alice Cawte, Wayne Reynolds and Richard Broinowski have also written about this topic from an Australian perspective, revealing the nuclear ambitions that encouraged Australia's support for the British nuclear programme.[12] Like Templeton's book on New Zealand's nuclear story, these books focused on the issues from a foreign affairs perspective and concentrated on Australia's relationship with the United Kingdom. Cawte documented Australia's post-war pursuit of nuclear technology, linking Australia's hunger for nuclear technology to the drive to find significant uranium deposits and the decision to allow the British to use Australian territory to test its nuclear bombs in the 1950s. Cawte's focus was on the political deals and decisions related to the Australian pursuit of a nuclear future, and on the international contracts, treaties and agreements that impacted on Australia's pursuits. Broinowski also focused on issues of foreign affairs in his examination of the likelihood of Australian uranium exports finding their way into clandestine nuclear weapons. Reynolds showed that several Australian leaders cooperated with the British nuclear programme in the hopes of securing information for the development of their own nuclear weapons. He argued that desire for its own nuclear weapons shaped many of Australia's post-war priorities, and even led to the establishment of major institutions like the Australian National University.

Histories of nuclear-free New Zealand

New Zealand's nuclear-free status is seen as an important part of New Zealand's national identity and it has been given prominence in general and specialist histories of New Zealand. In general histories of New Zealand published in the 1990s and 2000s, James Belich, Michael King, David McIntyre and Philippa Mein Smith each covered New Zealand's emergence as a

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[10] See, for example, Robert Bothwell, *Nucleus: The history of Atomic Energy of Canada Limited*, University of Toronto Press, Toronto, 1998; Robert Bothwell, *Eldorado: Canada's National Uranium Company*, University of Toronto Press, Toronto, 1994.
[11] Lorna Arnold, *A Very Special Relationship: British Atomic Weapon Trials in Australia*, HMSO, London, 1987; Lorna Arnold, *Britain and the H-bomb*, Houndmills, New York, Palgrave, 2001; Lorna Arnold and Mark Smith, *British Atomic Weapons Trials in Australia*, 2nd edition, Palgrave Macmillan, Basingstoke, 2004.
[12] Alice Cawte *Atomic Australia, 1944–1990*, New South Wales University Press, Kensington, 1992; Wayne Reynolds, *Australia's Bid for the Atomic Bomb*, Melbourne University Press, Melbourne, 2000; Richard Broinowski, *Fact or Fission: The Truth About Australia's Nuclear Ambitions*, Scribe Publications, Melbourne, 2003.

nuclear-free nation, but only Mein Smith paid any attention to other aspects of New Zealand's nuclear history, documenting events such as the 1950s search for uranium, the University of Canterbury's acquisition of a research reactor, and New Zealand's plans for nuclear power.[13] This thesis argues that the focus on this aspect of national identity is unfairly excluding another story, that of nuclear New Zealand. The story of nuclear New Zealand has been suppressed furthermore by the lack of resources for general historians to draw on. This is partly because the history of science is at yet a far underdeveloped subspecialty of New Zealand history. Writers of general history rely, to an extent, on published specialist histories. Therefore the general lack of material on any aspects of New Zealand's science history holds back scholarly reflection on New Zealand's radiation and nuclear history.

There are, however, a proliferation of books about aspects of New Zealand's nuclear-free policy, many of which are written by peace activists and politicians. These "insiders" have documented aspects of New Zealand's nuclear-free movement and status in a series of books published in the decade after New Zealand declared its nuclear-free status. For example, in 1992, peace activist Elsie Locke looked at New Zealanders' response to perceived nuclear threats in the context of a history of peace activities. She covered New Zealand response to the bombing of Hiroshima and Nagasaki, the Stockholm Peace Appeal, New Zealand response to British, American and French nuclear testing in the South Pacific, the origins and activities of the New Zealand Campaign for Nuclear Disarmament, and progress towards the development of a nuclear-free New Zealand, but her narrative ends in 1975, before New Zealand's nuclear-free policy was adopted.[14]

Kevin Clements' 1988 book is one of the major publications on the lead-up to New Zealand's nuclear free policy. Like Templeton, Clements covered events from 1945 onwards, examining them as to how they lead up to New Zealand's nuclear-free policy, and the implications of this policy for New Zealand's defence arrangements – but with more of an emphasis on the perspective of the peace movement. Clements, a peace activist and pacifist, was a member of the 1986 Defence Review that followed the implementation of Labour's nuclear-free policy. In *Back from the Brink* he "traces the evolution of public and political concern about nuclear weapons, the convergence of nuclear anxiety and the desire for a greater degree of political independence

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[13] James Belich, *Paradise Reforged: A History of the New Zealanders from the 1880s to the Year 2000*, Penguin, Auckland, 2001; Michael King, *The Penguin History of New Zealand*, Penguin, Auckland, 2004; Philippa Mein Smith, *A Concise History of New Zealand*, Cambridge University Press, Cambridge, 2005; David McIntyre, 'From Dual Dependency to Nuclear Free'. In Geoffrey W. Rice (ed), *The Oxford History of New Zealand, 2nd edition,* Oxford University Press, Auckland, 1992, pp520-538.

[14] Elsie Locke, *Peace People: A History of Peace Activities in New Zealand*, Hazard Press, Christchurch, 1992.

from nuclear allies".[15] Clements' observations that there was early enthusiasm for peaceful uses of nuclear technology and little or no opposition to activities like uranium prospecting are picked up and built upon as one of the major themes in this thesis.

Stuart McMillan focused his 1987 book entirely on the nuclear ships debate, canvassing the events up to and immediately following New Zealand's 1985 refusal of the USS *Buchanan* into port on the grounds that it would neither confirm nor deny whether it was carrying nuclear weapons. McMillan's focus on this issue is on the relationship between the peace movement and the New Zealand Government, and the relationship between New Zealand and the United States, and the implications of the 1985 decision for New Zealand.[16]

David Lange wrote about the birth and implementation of New Zealand's nuclear-free policy in his 1990 memoir. Lange's was a personal account focusing on his time first as leader of the Labour Party from 1983, and then as Prime Minister from 1984 to 1989. Lange gave extensive coverage to the ANZUS debate that arose over the Labour Government's policy of closing New Zealand's ports to nuclear-powered or nuclear-weapon carrying craft, focusing on behind-the-scenes political and bureaucratic matters including individual meetings and conversations and examining the attitude of Foreign Affairs and Defence officials to the nuclear-free policy.[17]

The 1985 bombing of the Greenpeace flagship *Rainbow Warrior* spurred the publication of many articles and a few books, which told the story of the French agents' act of terrorism in Auckland and illustrated how this act served to cement New Zealander's support for the nuclear-free policy.[18]

Histories of nuclear New Zealand

In introducing the subject of New Zealand's "nuclear history" this thesis refers to ways in which New Zealand uses or has considered using, nuclear and radiation science and technology, and ways in which New Zealand has supported, or considered supporting, international nuclear projects including nuclear power and nuclear weapons tests. New Zealand has long been considered not to have much of a nuclear history – in fact, the most common response to telling

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[15] Kevin Clements, *Back from the Brink: The Creation of a Nuclear-free New Zealand*, Allen & Unwin/Port Nicholson Press, Wellington, 1988.
[16] Stuart McMillan, *Neither Confirm Nor Deny: The Nuclear Ships Dispute Between New Zealand and the United States*, Allen & Unwin/Port Nicholson Press, Wellington, 1987.
[17] David Lange, *Nuclear Free: The New Zealand Way*, Penguin Books, Auckland, 1990.
[18] Michael King, *Death of the Rainbow Warrior*, Penguin Books, Auckland, 1986; John Dyson, *Sink the Rainbow!: An Enquiry into the 'Greenpeace Affair'*, Reed Methuen, Auckland, 1986; Richard Shears and Isobelle Gidley, *The Rainbow Warrior Affair*, Irwin Publishing, Toronto, 1986; Robin Morgan and Brian Whitaker, *The Sunday Times Insight Rainbow Warrior*, Arrow Books, 1986.

people this thesis topic is a guffaw and the comment "it must be a very short thesis" – but this thesis aims to correct that misconception. In the last two decades independent historian Ross Galbreath, defence historian John Crawford and peace activist Owen Wilkes have spearheaded the academic investigation of new aspects of New Zealand's nuclear history.

Science historian Ross Galbreath was the first person to write about the New Zealand scientists seconded to the wartime Manhattan Project and the post-war establishment of a nuclear sciences team within New Zealand's DSIR. In a 1995 article Galbreath provided an account of New Zealand scientists' involvement on the Manhattan and Montreal Projects, and asked and answered the question "who were the New Zealanders and how did they become involved?" Galbreath put the New Zealanders' role in the context of British wartime cooperation with other Dominions and the United States, as well as in the context of other New Zealand war-focused scientific activities (for example, radar). He also looked at the motives of the different players, in particular, the British, the New Zealanders and the Australians, and examined the British support for a post-war atomic energy project in New Zealand, linking it to New Zealand's "Rutherford connection" and British security concerns about Australia. For details of the New Zealand scientists and his work, Galbreath referred to several DSIR files from Archives New Zealand and to Ernest Marsden's papers at the Alexander Turnbull Library.[19]

In a 1998 article defence historian Crawford revealed, from previously classified documents, some previously unreported New Zealand connections with the British Pacific nuclear testing programme. In his article about New Zealand's involvement in the British hydrogen bomb tests of 1957-58 Crawford identified Ernest Marsden as advising Prime Minister Sidney Holland against allowing the United Kingdom to test hydrogen bombs on New Zealand territory. Crawford also revealed the joint United Kingdom-New Zealand plans for the establishment of a heavy water plant to provide raw materials for the British nuclear energy and nuclear weapons programmes. Crawford's other research for internal defence force publications has looked at New Zealanders involvement in the British nuclear tests in New Zealand and the Pacific.[20]

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[19] Ross Galbreath, 'The Rutherford Connection: New Zealand Scientists and the Manhattan and Montreal Projects', *War in History* 2, 3 (1995), pp306-19; Ross Galbreath, 'The Atom Bomb Effect: Nuclear Science in War and Peace'. In *DSIR: Making Science Work for New Zealand,* Victoria University Press, Wellington, 1998.
[20] John Crawford, ' "A Political H-Bomb": New Zealand and the British Thermonuclear Weapon Tests of 1957-58', *The Journal of Imperial and Commonwealth History* 26, 1 (1998), pp127-150; John Crawford, The Involvement of the Royal New Zealand Navy in the British Nuclear Testing Programmes of 1957 and 1958, New Zealand Defence Force, Wellington, 1989; John Crawford, New Zealand Observers and Indoctrinees at Nuclear Weapon Tests: 1956-1958, unpublished New Zealand Defence Force article, 2001.

Historian and peace activist Owen Wilkes took a different perspective on some of the same information as Galbreath in his 2002 essay “New Zealand and the Atom Bomb”.[21] Wilkes profiled the contributions of nine New Zealand scientists to the teams in the United States and Canada working towards the development of the atomic bomb and nuclear reactors. Wilkes was interested in the extent to which the New Zealanders played a part in the bombing of Hiroshima and Nagasaki, and suggested – almost playfully – that perhaps the kiwis did play a crucial role and given that timing was so critical perhaps if the kiwis hadn’t been there the bomb deployment would have been delayed another week or two. He also examined the scientists’ motives and attitudes to the project before and after the bombs were dropped, showing that while most of them found it an “exciting job” during the war, after the war they, like most United States scientists, were involved in a movement to put nuclear weapons under international control. Wilkes also covered Ernest Marsden’s 1944 and 1945 uranium surveys, emphasising the key role that Marsden played in advancing New Zealand’s atomic energy project within the DSIR. Wilkes’ essay drew extensively on Ross Galbreath’s paper ‘The Rutherford Connection’ and an unpublished history of New Zealand’s wartime involvement with the atomic bomb.[22]

In 2006, this author contributed to two academic articles to the field. Marsden’s role in the wartime uranium survey, as reported on by Galbreath and Wilkes, and in advising Holland against the use of New Zealand island territory for British bomb tests as uncovered by Crawford, was elaborated on, along with Marsden’s other contributions to New Zealand’s nuclear history in this author’s 2006 article on Ernest Marsden.[23] A second article revealed the previously unreported history of uranium prospecting on New Zealand’s West Coast.[24] These articles are elaborated on in this thesis.

Ernest Rutherford and the birth of a new science

Ernest Rutherford, often referred to as the father of nuclear physics, is the subject of numerous biographies, including John Campbell’s 1996 biography, which focused on Rutherford’s early life and studies in New Zealand and his visits to New Zealand once his career in the United Kingdom was established.[25] The body of work on Rutherford, as well as some writings by

[21] Owen Wilkes, ‘New Zealand and the Atom Bomb’. In John Crawford (ed), *Kia Kaha: New Zealand in the Second World War*, Oxford University Press, Auckland, 2002.
[22] Held as Narrative 9 of the DSIR War History Narratives, Archives New Zealand AAOQ, Acc W3424, box 16
[23] Rebecca Priestley, ‘Ernest Marsden’s Nuclear New Zealand’, *Journal of the Royal Society of New South Wales*, 139 (2006) pp23-28.
[24] Rebecca Priestley, ‘The Search for Uranium in ‘Nuclear-free’ New Zealand: Prospecting on the West Coast, 1940s to 1970s’, *New Zealand Geographer* 62 (2006), pp121–134.
[25] Campbell 1996. See also David Wilson, *Rutherford: Simple Genius*, Hodder and Stoughton, London, 1983; Mark Oliphant, *Rutherford: Recollections of the Cambridge Days*, Elsevier Publishing Company, New York, 1972;

Rutherford himself, show his key role in revealing the nature of radioactivity and the structure of the atom through which he pioneered the field of nuclear science, in which the atomic nucleus became the subject of an entirely new field of physics.

Radiation technologies in medicine

New Zealand's early responses to the new technology have been covered in institutional histories of medical schools and hospital boards, as well as in short historical articles in professional journals, usually by retired or active participants in the field. No attempts have been made, however, at a more general enquiry into the New Zealand scientific community's response to the new science.[26]

One of the most wide-ranging publications in this area is a 1996 history of Australasian radiology, which includes a chapter entitled "Diagnostic Radiology in New Zealand".[27] This illustrated chapter introduces New Zealand's early pioneers of X-rays, providing details of the radiographers and hospitals involved. It continues with information about radiotherapy, radiation injuries and the establishment of the National Radiation Laboratory and systems of radiological protection in New Zealand. As well as referencing published medical histories, such as histories of New Zealand hospitals and hospital boards, this chapter draws on a 1966 paper by Colin Anderson, an Invercargill radiologist, who in turn drew on hospital board records and papers published in the *New Zealand Medical Journal* to write his paper on the early uses of diagnostic and therapeutic radiology in New Zealand. Anderson traced the first uses of X-rays in New Zealand, the medical practitioners and lay-people who pioneered the field, and the early incidence of radiation injuries. He also recorded the establishment of New Zealand's radiological societies, the National Radiation Laboratory, the Radiological Service Committee, and the

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Norman Feather, *Lord Rutherford*, Blackie & Son Limited, London, 1940; Ivor B. N. Evans, *Man of Power: The Life Story of Baron Rutherford of Nelson*, Stanley Paul & Co Ltd, London, 1939.

[26] See, for example: J. F. Borrie, 'A History of Training for the Diploma of the Society of Radiographers (London)', *Shadows* 16, 1 (1973), pp15-27; Derek Dow, 'Electricians Left to Run Early X-ray Machines', *New Zealand Doctor*, 30 September 1998; John Angus, *A History of the Otago Hospital Board and its Predecessors*, The Otago Hospital Board, Dunedin, 1984; F. O. Bennett, *Hospital on the Avon: The History of the Christchurch Hospital 1862-1962*, North Canterbury Hospital Board, Christchurch, 1962; Diane J. Campbell, 'A Brief History of Dental Radiography', *New Zealand Dental Journal* 91 (1995), pp127-133; P. C. Fenwick, *North Canterbury Hospital and Charitable Aid Board*, Andrews Baty and Co., Christchurch, 1926; Sir Charles Hercus and Sir Gordon Bell, *The Otago Medical School under the First Three Deans*, E & S Livingstone Ltd, Edinburgh and London, 1964; Jo Kellaway and Mike Maryan, *A Century of Care: Palmerston North Hospital 1893-1993*, Focus Books, Double Bay, 1993; G. E. Roth, 'Radiation Protection: Historical Aspects and Radiographer Responsibilities', *Shadows* 16, 4 (1973), pp6-14.

[27] James Ryan, Keith Sutton and Malcolm Baigent, *Australasian Radiology: A History*, McGraw-Hill Book Company, Sydney, 1996.

Radiological Advisory Committee. Anderson's paper has been used as a significant source of information for subsequent works in this area.[28]

A 1995 book, written by a group of former hospital physicists, documented the history of medical physics at Auckland, Wellington, Palmerston North, Waikato, Christchurch and Dunedin hospitals and focused on the people involved and the equipment and technologies they used. Much of the book took the form of personal reminiscences though there were also references to earlier histories, medical journals and lectures.[29]

Another source of literature on the scientific background to radiation and nuclear science in New Zealand comes from publications associated with the National Radiation Laboratory of the Ministry of Health. In 1983 the Department of Health published a history of the laboratory, written by Andrew McEwan.[30] While McEwan, who worked for the National Radiation Laboratory from 1963 to 2002 and was director for 13 years, was sometimes criticised for what some people interpreted as a pro-nuclear attitude, this was a largely dispassionate account. In the epilogue, however, he commented on "increasing concern about risks which are conjectural or stochastic and individually of very low probability" arising from "popular misunderstanding or ignorance of the effects of low-level radiation exposure … fuelled by the commonly sensational approach to news reporting on radiation and radioactivity topics".

Concern about misconceptions about nuclear science extended beyond McEwan. A 1998 report on *Radiation and the New Zealand Community*, prepared by a group of scientists (including McEwan), was published by the Royal Society of New Zealand to "give information and perspective on the risks associated with the widespread use of radiations of different types in modern society", partly in response to misconceptions about what it meant for New Zealand to be "nuclear free".[31] In presenting information for public discussion it touched on aspects of the history of nuclear science, though its coverage of New Zealand's nuclear history was limited to a few paragraphs dispersed throughout the document to provide background to the issues discussed. The report outlined the various applications of nuclear science in New Zealand and included chapters on food irradiation safety and the "system of controls on radiation sources in

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[28] C. C. Anderson, 'The Development of Radiology in New Zealand', *Australasian Radiology* 10 (1966), pp296-307.
[29] H. D. Jamieson (ed), *The Development of Medical Physics and Biomedical Engineering in New Zealand Hospitals: Some Personal Overviews for the Period 1945-1995*, H. D. Jamieson, Dannevirke, 1995.
[30] Andrew McEwan, *Radiation Protection and Dosimetry in New Zealand: A history of the National Radiation Laboratory*, New Zealand Department of Health, Wellington, 1983.
[31] Academy Council of the Royal Society of New Zealand, *Radiation and the New Zealand Community: A Scientific Overview*, The Royal Society of New Zealand Bulletin 34, Wellington, 1998.

New Zealand". The report also provided useful data on radiation exposure in New Zealand. There were few New Zealand references listed for this report, but it is likely that most (if not all) of the data about New Zealand came directly from the National Radiation Laboratory.

Nuclear science in New Zealand

Ernest Marsden, like Rutherford, was a key player in New Zealand's nuclear history. A student of Rutherford, Marsden came to New Zealand in 1915 and in 1926 was appointed head of the DSIR, a position from which he came to champion nuclear science. Marsden was influential in getting New Zealand physicists working on the Manhattan Project and establishing a nuclear sciences team at the DSIR. After leaving the DSIR he continued to advocate nuclear power for New Zealand, though came to caution against the environmental impact of nuclear weapons testing. Marsden has never been the subject of a full biography, though in 1969 he was the subject of a book of personal memoirs about him, written by fellow scientists and colleagues, to commemorate his 80th birthday.[32]

While many early histories of the DSIR or its various divisions mentioned nuclear science it was Ross Galbreath who first focused attention on this area of the DSIR's work. Galbreath's 1998 history of the DSIR included a chapter detailing the birth of nuclear science in New Zealand – from the scientists working on the Manhattan Project during the Second World War to the establishment of the Institute of Nuclear Sciences and their work in fallout monitoring and radiocarbon dating.[33] Galbreath traced New Zealand's success in nuclear sciences back to Ernest Rutherford, through his student Ernest Marsden (later head of the DSIR).

The contribution of this thesis

While books have been written about aspects of New Zealand's nuclear history, the only attempts at looking at this history from a science perspective are Ross Galbreath's articles on the New Zealanders on the Manhattan project and a chapter on the Institute of Nuclear Sciences in his book on the DSIR. There are no books that link these events into a bigger narrative that starts with early uses of radiation technology in New Zealand and carry the story forward to New Zealand's declaring itself nuclear-free. This is, however, not surprising. New Zealand historiography is thin, and it is only since the 1960s that New Zealand history has been given much attention at all. The emergence of New Zealand historiography therefore coincides with concerns about nuclear fallout and nuclear proliferation and their impact on humanity; it is not

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[32] Marsden Booklet Editorial Panel, *Sir Ernest Marsden 80th birthday book*, A. H. & A. W. Reed, Wellington, 1969.
[33] Galbreath 1998, pp140-169.

surprising that anti-nuclear or nuclear-free stories have been given prominence. While general histories of New Zealand are now accompanied by many military and social histories, New Zealand science history has still been neglected, and its nuclear science history as part of that.

This thesis draws on the work of authors such as Clements, Wilkes, Galbreath, Crawford and Templeton, and takes some of the events covered by these authors, and introduces many new events, to provide a coherent narrative of New Zealand's pre-1985 nuclear history. The roles of Ernest Rutherford, Ernest Marsden, and, to a lesser extent, Jim McCahon are examined in this context. This thesis differs from previous histories that cover aspects of New Zealand in the radiation and nuclear age – for example, Templeton's *Standing Upright Here* or Clements' *Back From the Brink* – in that it adopts a history of science perspective. That is, the nature of the science is examined and explained, and issues are considered from the perspectives of the scientists and science organisations involved. These issues are considered against the background of New Zealand's foreign policy stance and the grass-roots nuclear-free movement. As an emerging discipline in New Zealand, a history of science approach can add to published histories by providing a window on New Zealand scientists' involvement in, and responses to, the issues of Pacific nuclear testing, nuclear propulsion and nuclear power development.

I have made special mention in this literature review of a number of "insider histories" in this field. This is not necessarily a problem, so long as the "insider's" involvement in that history is made clear and any biases reported. To be fair, I will now disclose my own very minor involvement with New Zealand's nuclear history. As a teenager in the 1980s I marched against visits by American nuclear warships to Wellington. When I travelled to the United States in the summers of 1986/87 and 1987/88 I was proud of the positive recognition that New Zealand's nuclear-free policy got me. In 1991 I worked for several months as a journalist for the Institute of Geological and Nuclear Sciences (IGNS) in Gracefield, Lower Hutt, a Crown Research Institute that incorporated the former DSIR Institute of Nuclear Sciences. For the next seven years I continued doing contract work for IGNS, writing for annual reports, newsletters and marketing brochures, mostly about geological projects but also about nuclear science projects. It was from this position, and with a growing awareness of the lack of public discrimination between "good" nuclear and "bad" nuclear, that my interest in writing about New Zealand's nuclear history emerged.

Thesis outline

The thesis is arranged chronologically, with each chapter having a specific focus within its time period. Chapter two covers the emergence of the new science of radiation in the late nineteenth century, focusing on the key role played by New Zealander Ernest Rutherford. New Zealand responses to the new technologies are explored in Chapter three, including medical and industrial use of radium and X-rays and the growing awareness of health risks associated with radioactivity. New Zealand was as embracing of these new technologies as any nation, and by the end of the 1930s radiation and X-rays were an important part of diagnostic medicine and treatment. Encouraged by DSIR head Ernest Marsden, scientists were beginning studies of natural radioactivity in New Zealand and starting to use radioactive isotopes as tracers. Key sources for these first two chapters are contemporary issues of the popular press, the *New Zealand Medical Journal* and the *Transactions of the New Zealand Institute*, Department of Health archives, as well as many published biographies, institutional histories, and general histories of science.

From Chapter four onwards the key sources are unpublished official files from Archives New Zealand. During the Second World War, nine young New Zealand scientists and engineers joined with British scientists to work on the Manhattan Project to develop the first nuclear weapons, and on a project in Canada to develop nuclear energy. As shown in Chapter four, Marsden – a former student of Ernest Rutherford – was crucial to the involvement of New Zealanders in these projects. Marsden was keen for New Zealand to be at the forefront of the new field of nuclear sciences, and initiated a South Island search for uranium and set up a nuclear sciences team within the DSIR. When several of the New Zealand scientists who worked on the Canadian nuclear reactor continued on to the United Kingdom, to help build the first nuclear reactor there, Marsden hoped that they would bring their knowledge back to New Zealand to build a Commonwealth nuclear reactor on New Zealand soil.

As shown in Chapter five, in 1955 the New Zealand Government joined with the United Kingdom Atomic Energy Authority to form a company to produce heavy water for the British nuclear programme, and electricity for local use. The proposed plant, at Wairakei, would use geothermal steam to power both ventures. The heavy water plant did not proceed, however, as in 1956 the United Kingdom withdrew from the venture for financial reasons. When British Prime Minister Anthony Eden asked New Zealand Prime Minister Sidney Holland for use of the Kermadec Islands as a testing site for hydrogen bombs, Holland considered the request but refused. But New Zealand support for the British nuclear testing programme came in other ways, with the use of New Zealand navy ships for surveying and as weather ships during the 1957 and 1958 nuclear tests in Malden and Christmas Islands. New Zealand took pride in British nuclear achievements and while concern developed over levels of radioactive fallout reaching New Zealand, British and American nuclear bomb testing was generally seen as an essential part of winning the Cold War arm's race.

Chapter six reveals the story of the DSIR-initiated search for uranium in New Zealand, and the intensive prospecting that followed the 1955 discovery of uranium-bearing rock in the Buller Gorge. Two New Zealand companies, Buller Uranium and Uranium Valley, prospected in the Buller Gorge and Paparoa Ranges for more than a decade, joined intermittently by several international companies. The Mines Department and the DSIR's Geological Survey supported the prospectors, acting in the hope that economic deposits of uranium would be found and a mining industry established in New Zealand. No one protested at the possibility of a uranium mining industry and when prospecting came to a halt at the end of the 1970s it was because repeated investigations had shown that the uranium deposits in the region were not economic to mine. The wartime uranium survey that Owen Wilkes covered in 2002, and that Galbreath had briefly covered in 1998, was elaborated on in a 2006 academic article and an encyclopaedia entry by this author, in which the 1944-45 surveys were established as the first significant event in a 35-year government-supported search for economic deposits of uranium in New Zealand. This author's article published in the *New Zealand Geographer* forms the basis for this chapter.[34]

Chapter seven looks at public and official concerns about safety with regard to the use of nuclear and radiation technologies in New Zealand and shows that early public concerns about radioactive fallout from nuclear bomb tests did not extend to fear of nuclear science and technology. Radiation protection work was driven by the Department of Health, but the public and the media were increasingly aware of and concerned about radioactive fallout and its impact on people's health, with this fuelling opposition towards nuclear bomb testing and helping to strengthen a growing movement opposing the further development and testing of nuclear weapons. At the same time, waste from the Antarctic nuclear reactor being shipped through Lyttelton and radioactive contamination discovered at Victoria University raised some concerns about public exposure to radioactive materials. Cold War concerns about the possibility of New

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[34] Rebecca Priestley, 'The Search for Uranium in "Nuclear Free" New Zealand: Prospecting on the West Coast, 1940s to 1970s', *New Zealand Geographer*, 62, 2 (August 2006) pp121-134; Rebecca Priestley, 'The Search for Uranium in New Zealand', *Te Ara Encyclopaedia of New Zealand* www.teara.govt.nz/EarthSeaAndSky/MineralResources/RadioactiveMinerals/en

Zealand becoming a nuclear target led to the establishment of a Ministry of Civil Defence. This chapter covers the period from 1949, when New Zealand's first radiation protection legislation was introduced, until the early 1960s.

Chapter eight shows New Zealand's enthusiasm for what the United States called "peaceful uses of the atom" and the gifts made to New Zealand under the American Atoms for Peace programme, including equipment for the DSIR Institute of Nuclear Sciences and the University of Auckland and a sub-critical nuclear reactor for the University of Canterbury's engineering school. It also examines non-military uses of nuclear science and technology in New Zealand in the 1950s and early 1960s, including the Institute of Nuclear Sciences work in radiocarbon dating, and the discussions and decisions with regard to the possible use of a nuclear reactor in New Zealand, and the New Zealand delegations to United Nations conferences on the Peaceful Uses of Atomic Energy.

New Zealand's plans for nuclear power for electricity generation are the focus of Chapter nine, from early speculation about nuclear power in the 1950s, to firm plans for nuclear power generation in the 1960s. To prepare for nuclear power, engineers were sent to the United Kingdom for training and sites were investigated in the Kaipara Harbour and near Wellington. When the time came to either start work on building a nuclear power station or finding alternatives, a Fact Finding Group on Nuclear Power and then a Royal Commission on Nuclear Power Generation in New Zealand were set up to report on the issue. By the time the Royal Commission reported back to the Government, in 1978, New Zealand's electricity demand projections were greatly reduced and the discovery of the Maui gas field meant that New Zealand now had sufficient indigenous resources to meet projected demand. While many people made submissions to the Commission against the introduction of nuclear power on safety grounds, the decision not to proceed with building a nuclear power station had already been made. The opinions of the different players, however – scientists, engineers, politicians and foreign affairs officials – are examined, along with media and NGO responses to the issue.

In Chapter ten, the nuclear-free movement and the emergence of New Zealand's nuclear-free policy is followed. By the time France began its nuclear testing programme in the Pacific in the 1960s, the United Kingdom and the United States had finished their Pacific testing programmes and there was no sense of loyalty to stop New Zealanders protesting against French nuclear testing. This time, the Government joined in, and the combined stance of the New Zealand Government and people was firmly against any further nuclear testing in the Pacific. In the 1970s, public opposition to visits from nuclear-powered warships grew as well, with people protesting on the grounds that these warships could be carrying nuclear weapons but also due to concerns about nuclear-powered warships being unsafe and a possible target in a nuclear war. In 1985, the Labour Government refused entry to a United States warship on the grounds that it would neither confirm nor deny if it was carrying nuclear weapons. In 1987, the nuclear-free policy was entrenched in legislation with the passing of the New Zealand Nuclear Free Zone, Disarmament and Arms Control Act. The French bombing of the *Rainbow Warrior* in Auckland Harbour and the suspension of New Zealand from the ANZUS agreement by the United States only served to cement New Zealand's adherence to the new nuclear-free policy: being nuclear-free was something most New Zealanders were proud of and it rapidly became an important part of the collective identity.

Chapter eleven offers a brief conclusion to the thesis.

Chapter 2
The radiation age:
Rutherford, New Zealand, and the new physics

"Other young New Zealanders have distinguished themselves in various walks of life, but not one of them can in any way approach the brilliant achievements of Professor Rutherford."
The Press, Christchurch, 25 July 1905, p4

"It was quite the most incredible event that has ever happened to me in my life. It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you."
Ernest Rutherford, Cambridge, 1937[1]

The science of radiation and the nucleus, as a branch of physics, emerged at the end of the nineteenth century, with the discovery, in close succession, of electrically generated X-rays, spontaneous radiation emanations from uranium, and the radioactive elements radium and polonium. It was a New Zealand scientist who determined the nature of this newly discovered radioactivity, then went on to change forever scientists' understanding of the structure of the atom, and the nature of the nucleus inside it. It is ironic perhaps, that the birthplace of Ernest Rutherford, known as "the father of nuclear physics", is now well known around the world for being "nuclear free".

Rutherford left New Zealand when he was a young man, to continue his education and career in the universities of the United Kingdom and Canada. He maintained close links with New Zealand, visiting several times, helping local scientists to procure radium, and recommending his former student Ernest Marsden to positions in Wellington.

Apart from the gifts of radium, however, New Zealanders' response to the new physics had little or nothing to do with Rutherford, who began his work on radioactivity after X-ray technology was adopted in New Zealand, and who was not well known outside of Nelson and Christchurch. The enthusiastic response to the new science by medics and scientists in New Zealand can be seen as enterprising and open-minded professionals making good use of a helpful, fascinating and potentially lucrative new technology.

[1] Ernest Rutherford, 'The Development of the Theory of Atomic Structure'. In Joseph Needham and Walter Pagel, *Background to Modern Science*, Cambridge University Press, Cambridge, 1938, p68.

Ernest Rutherford in New Zealand

Ernest Rutherford was born on 30 August 1871 to James Rutherford, who worked at various times as a flax-miller, mechanic and wheelwright, and Martha, a former teacher. Education was important to the Rutherfords, and Martha taught all the Rutherford children reading, writing and arithmetic before they started school. The family was not wealthy, however, and post-primary education was costly. With 12 children in the house, scholarships were important for advancing the children's education to secondary level. At the age of 15, Ernest Rutherford won a scholarship to Nelson College, a school modelled on British public schools, which focused on "the advancement of religion and morality, and … the promotion of useful knowledge".[2]

Rutherford was a strong student: in 1889, his final year at Nelson College, he was head boy and dux and sat university scholarship examinations. He won a scholarship and the following year began his studies at the University of New Zealand's Canterbury College in Christchurch where he studied Latin, English, French, mathematics, mechanics and physical science and gained a Bachelor of Arts degree. In 1893 he became one of only 14 postgraduate students in New Zealand, graduating in 1894 with Master of Arts with first class honours in mathematics and physical science. Rutherford was recognised by the university as an exceptional student, brilliant and determined, and over the summer he was given the use of a small room beneath a staircase (now immortalised as "Rutherford's Den") to conduct original research. He returned to Canterbury College in 1894, enrolling in a Bachelor of Science in chemistry and geology.[3]

As well as passing his BSc exams, Rutherford completed two articles on the high-frequency magnetization of iron, a subject of interest to the electricity industry, "where alternating currents and iron-covered transformers were the high technology of the day".[4] The articles were published in the *Transactions and Proceedings of the New Zealand Institute (TPNZI)*, the journal of New Zealand's state-coordinated system of scientific societies, in 1894 and 1895. Rutherford also submitted the articles as an application for an Exhibition of 1851 Research Scholarship. The scholarship commemorated Prince Albert's Great Exhibition of 1851 – a showpiece of British industry and science held in London – with a scheme for providing outstanding postgraduate research students with £150 per year for two years to conduct original research in a field of importance to their national industries. When James Maclaurin, the selected candidate, turned down the opportunity of the one scholarship available to a New Zealander that

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[2] John Campbell, *Rutherford: Scientist Supreme*, Christchurch, AAS Publications, 1999, pp1-16, 40-42. Quote from p45.
[3] Campbell 1999, pp62-67, 84-87, 122, 144-45, 151-52.
[4] Campbell 1999, p158.

year, it was offered to Rutherford. A few weeks later Rutherford was on the steamer *Wakatipu* bound for further studies at the University of Cambridge.[5]

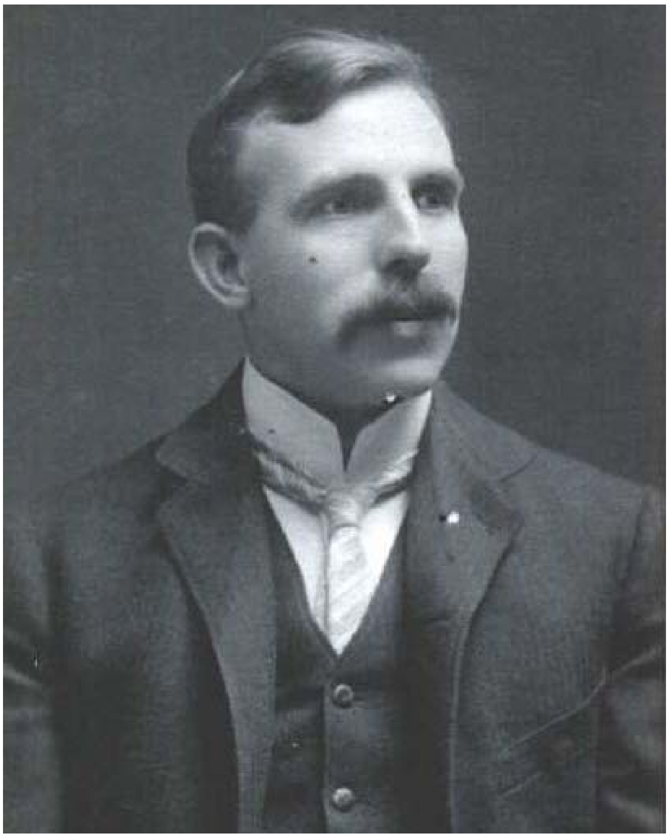

Figure 2.1: Ernest Rutherford in his Canterbury University College days. Source: Public domain image downloaded from wpclipart.com on 22 April 2010.

The 1851 Exhibition Scholarships were important to the advancement of students like Rutherford as they provided access to the world's best scholars and laboratories. Physics, Rutherford's field, was not a national priority, and New Zealand lacked the staff, laboratories and libraries for advanced scientific research. Rutherford left New Zealand at the end of a 10-year economic depression, at a time when the Government saw the country's few professional scientists primarily as a means of assisting the economic development of the country. Encouragement was given to applied sciences – like mining and agriculture – that had a tangible economic return. While the country's initial gold rushes were long over, new gold and coal deposits continued to be discovered and exploited. And with the advent of refrigerated shipping in the 1880s, New Zealand mutton joined wool as a significant export product, increasing the country's dependence on agriculture. [6] (It is interesting to note that today, in 2010, nearly

[5] Campbell 1999, pp149-192; David Wilson, *Rutherford: Simple Genius*, Cambridge, The MIT Press, 1983, p62; E. Rutherford, 'Magnetization of Iron by High-Frequency Discharges', *Transactions and Proceedings of the New Zealand Institute (TPNZI)*, 27 (1894), pp481-513; E. Rutherford, 'Magnetic Viscosity', *TPNZI*, 28 (1895), pp182-204.

[6] W. J. Gardner, E. T. Beardsley and T. E. Carter, *A History of the University of Canterbury, 1873-1973,* Christchurch, University of Canterbury, 1973, p129; 'Science' in A. H. McLintoch (ed), *An Encyclopaedia of New*

two decades after the science reforms of the 1990s, the New Zealand Government has a similar understanding of the value of science as something that must bring an economic return. It is worth reflecting, however, that a scientist like Rutherford can make enormously valuable advances from curiosity-driven rather than economically focused science.)

Figure 2.2: During the summer of 1893/94 Rutherford worked in a small cloakroom beneath the tiered seating of the clock tower lecture theatres. This room is now part of "Rutherford's Den", a museum and educational facility. Source: ID: 1/2-055425-F, Alexander Turnbull Library, Wellington, NZ.

Despite the Government's focus on applied science, by the late nineteenth century, gentlemen scientists who focused on natural history and geology still dominated New Zealand science.[7] Articles in the *TPNZI* were generally grouped under headings of zoology, botany, geology, chemistry and "miscellaneous", where the occasional physics article sat alongside articles on archaeology, ethnology and literature. Physics articles were few and far between and in the five years of Rutherford's enrolment at Canterbury College the only *TPNZI* articles on physics were by Rutherford and his chemistry professor Alexander Bickerton.[8]

In contrast, Europe in 1895 was poised for a revolution in physics, and an overseas position was Rutherford's only opportunity for advancing his knowledge and participating in this revolution. Rutherford arrived at Cambridge University in 1895. He enrolled in a BA by research, and began work at the Cavendish Laboratory, under the Professor of Experimental Physics, Joseph John (J.

Zealand, Wellington, Government Printer, Vol 3, 1966, p180; Philippa Mein Smith, *A Concise History of New Zealand*, Cambridge, Cambridge University Press, 2005, pp 81-82, 84, 93, 97-98.

[7] Francis Reid, ' "The Democratic Politician does not Trouble Himself with Science": Class and Professionalism in the New Zealand Institute, 1867-1903', *Tuhinga*, 16 (2005), pp16-31.

[8] *TPNZI* 23 (1890), 24 (1891), 25 (1892), 26 (1893), 27 (1894).

J.) Thomson. Rutherford began his research in electromagnetism and wireless signalling, and after sending messages from the Cavendish Laboratory to his rooms more than a kilometre away, he briefly held the record for long-distance wireless telegraphy. At about the same time, however, the sensational discovery of X-rays attracted the attention of scientists around the world, Rutherford included.[9]

A new science is born

Wilhelm Röntgen's discovery of X-rays had a significant impact on theoretical physics as well as practical applications of the science. Röntgen, a German physicist, discovered X-rays in November 1895. While experimenting with passing an electric current through a Crookes tube – a glass bulb from which most of the air has been removed – he was astonished to find that a small barium platino-cyanide screen at the other side of the room was glowing. At the time the Crookes tube was encased in heavy black paper, shutting out any light it might emit, so Röntgen concluded that the screen was glowing in response to some invisible energy radiating out from the tube. He became engrossed in his finding and for months spent every day and night at his laboratory, continuing to experiment with the mysterious new rays. As he could not determine their source, Röntgen called them "X-rays", finding that they passed not only through paper, but through wood, rubber, copper and even thin sheets of most metals; however, they did not pass well through human bones or lead. By placing opaque objects between the source of the rays and a photographic plate, Röntgen discovered he was able to take X-ray pictures.[10]

Röntgen published his results in a German journal in late December 1895, with an English translation published in *Nature* the following month.[11] News of his discovery spread quickly to the popular press where it caused an international sensation. Responding to public excitement about the discovery, Röntgen appeared at packed public lectures to demonstrate the workings of his X-ray machine, training it on the skulls, arms, and legs of enthusiastic volunteers. Some people were alarmed by his discovery. There was talk of banning X-rays in opera glasses for fear of insulting the virtue of the female singers by seeing through their clothes – one company even started to market X-ray-proof underwear. Others were quick to take up the relatively simple science involved. The American inventor Thomas Edison developed one of the first

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[9] Campbell 1999, pp207-24; J. J. Thomson, *Recollections and Reflections*, London, G. Bell and Sons, 1936, p137.
[10] Catherine Caulfield, *Multiple Exposures: Chronicles of the Radiation Age*, London, Penguin Books, 1989, pp3-5; 'Röntgen, Wilhelm Konrad (1845-1923)', in Roy Porter and Marilyn Ogilvie (eds), *The Biographical Dictionary of Scientists*, 3rd ed, Vol 3, New York, Oxford University Press, 2000, pp810-11; William Rontgen, H. J. W. Dam, and others, 'The Discovery of X-Rays', in John Carey (ed), *The Faber Book of Science*, London, Faber and Faber, 1995, pp181-87.
[11] Arthur Stanton, 'Wilhelm Conrad Röntgen On a New Kind of Rays: Translation of a Paper Read Before the Wurzburg Physical and Medical Society 1895', *Nature* 53 (1896), pp274-6.

fluoroscopes, which produced instantaneous X-ray pictures by projecting the rays onto a fluorescent screen rather than onto a photographic plate. Doctors quickly saw the potential to use X-rays as a diagnostic tool, and in February 1896 Canadian surgeons used X-rays to assist in removing a bullet from a man's leg. Doctors also began to use X-rays for ostensibly therapeutic purposes – to treat dermatitis, cancer and tuberculosis.[12]

X-rays arrive in New Zealand

The New Zealand media – concerned mainly with colonial news, the price of mutton in London, and the latest shipment of British goods to arrive at Ballantyne's or at Kirkcaldie & Stains – were more subdued, responding only after the discovery of X-rays made news in Britain. *The New Zealand Mail* reported that London doctors were using Röntgen's discovery to take pictures of gallstones and injuries to the bones, achieving "astonishing results".[13] Many New Zealanders would have read about the discovery and its applications in British newspapers that were regularly bundled up and shipped to New Zealand to keep the colonists up to date with news from "Home" and on the continent.

Members of the New Zealand Medical Association, whose local branches subscribed to international medical journals and had regular meetings to discuss local cases and international developments, were particularly interested in the discovery of X-rays.[14] In the July 1896 issue of the *New Zealand Medical Journal*, the London correspondent described the new photography developed by Röntgen, exclaiming that never "has a scientific discovery excited more general interest, been followed up with such rapidity, and attained such extended success".[15] The discovery of X-rays was also discussed at meetings of the New Zealand Institute's incorporated societies. William Travers, in his presidential address to the Wellington Philosophical Society in July 1896, provided a detailed account of the discovery of "Röntgen Rays", which he described as "a most remarkable event in the history of physical and chemical science".[16]

The New Zealand medical profession did more than talk about the new discovery. Many doctors were aware of its ground-breaking applications to medicine and, as Ryan, Sutton and Baigent recount in their history of Australasian radiology, the technology was easy to reproduce: all that was needed was "one spark coil, one battery, one Crookes tube and some facility in handling

[12] Caulfield 1989, pp5-8.
[13] *New Zealand Mail*, 6 February 1896, p36.
[14] *New Zealand Medical Journal (NZMJ)*, 9 (1896).
[15] *NZMJ*, 9 (July 1896), pp169-70.
[16] *TPNZI*, 29 (1896), pp118-25.

photographic plates".[17] (By the end of the nineteenth century mains electricity was only available in a few parts of New Zealand and batteries and generators were essential to powering electrical equipment.) At the 26 August 1896 meeting of the Otago Branch of the New Zealand Medical Association, Mssrs Kempthorne, Prosser and Co, who were in the process of establishing a Dunedin laboratory offering "skiagraphy" (X-ray photography) to the medical profession, demonstrated the new technology to the gathered doctors.[18] The same year, William Hosking, medical superintendent at Masterton Hospital, imported a six-inch coil to be used for the generation of X-rays.[19] Ryan, Sutton and Baigent recount that Hosking "installed his X-ray equipment in his home … using electric power from a generator in an old wooden structure at the back of the house", using his equipment for both diagnosis and therapy.[20] Other entrepreneurs and doctors wasted no time in taking up the new technology, which was particularly useful for identifying broken bones and lung disease. Rather than purchase their own X-ray equipment, hospitals initially contracted radiological services from local doctors or electricians who had purchased and installed their own X-ray equipment. In 1898, however, the Auckland, Wellington and Christchurch Hospital Boards each acquired their first X-ray apparatus, and the Otago Hospital Board followed in 1904.[21]

Harry de Lautour – a Dunedin doctor who between January 1899 and October 1900 took 157 "radiographs" of patients – wrote the first radiological paper published in New Zealand, which appeared in the *New Zealand Medical Journal* in 1900. De Lautour advised X-ray exposure times of "four or five minutes for a hand or foot; eight or ten minutes for an ankle, leg or forearm; twenty to twenty-five minutes for a thigh, shoulder or chest", reassuring the reader by saying: "so far I have not yet had any experience of burning".[22]

While most of the early users of X-rays were doctors, amateurs and hobbyists were also attracted to the new technology. A. D. Bell, a north Otago sheep farmer with a broad scientific interest, used a battery-powered six-inch spark coil in the late 1890s for use in "radiographing dogs' legs, locating foreign bodies, and even the examination of broken wrists".[23]

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[17] James Ryan, Keith Sutton and Malcolm Baigent, *Australasian Radiology: A History*, Sydney, McGraw-Hill Book Company, 1996, p20.
[18] *NZMJ*, 9 (October 1896), p243.
[19] C. C. Anderson, 'The Development of Radiology in New Zealand', *Australasian Radiology* 10 (1966), p296. This article is the main source of information that has been referred to in subsequent histories.
[20] Ryan et al 1996, p295.
[21] Anderson 1966, p297-98; Derek Dow, 'Electricians Left to Run Early X-ray Machines', *New Zealand Doctor,* 30 September 1998, p35.
[22] A. C. Begg, 'The Father of Radiology in New Zealand', *NZMJ*, 83, 543 (1975), pp1-5; Harry A de Lautour, 'On the Localisation of Foreign Bodies by Means of the X-rays', *NZMJ,* 1, 2 (1900), p74.
[23] Anderson 1966, p296.

In the introduction to their book on the history of Australasian radiology, Ryan, Sutton and Baigent say that New Zealand was less affected than Australia by the "tyranny of distance" when it came to the early development of X-rays and organ imaging.[24] It is not clear why this is so – perhaps New Zealanders had more aptitude than Australians in putting together the "one spark coil, one battery, one Crookes tube" necessary to take X-rays? It is unlikely that New Zealand being the birthplace of Rutherford had any impact on the update of X-ray technology, however, as Rutherford's work on radiation post-dated the adoption of X-rays in New Zealand and was not well publicised outside of Christchurch.

Discovery of radioactivity and radium

Rutherford, now working at Cambridge, was fascinated by the discovery of X-rays, and he enclosed in an 1896 letter to his parents two of the new "Röntgen photographs"; one of a frog and one of a hand. Inspired by the new discovery, he put aside his research into electromagnetism and began working on X-rays with his professor J. J. Thomson.[25]

Also inspired by Röntgen's work, Henri Becquerel, professor of physics at the Museum of Natural History in Paris, began to investigate the possibility that phosphorescent materials might generate X-rays. He knew that when exposed to sunlight, certain minerals, such as those found in uranium salts, would, even when moved into the dark, phosphoresce, or glow. He tested many mineral samples by exposing them to sunlight, then wrapping them in black paper and placing them on light-sensitive photographic plates. Any rays that penetrated the black paper to darken the photographic plate, he reasoned, were X-rays, the same as Röntgen's. Only one of the samples, a uranium compound called potassium uranyl sulphate, seemed to be emitting such rays. Then he made a surprising discovery, finding that the salt emitted the rays whether left exposed in the sun or not, leading him to conclude that the mineral was spontaneously emitting the rays. He tested other uranium compounds and found the same results, and discovered that pure uranium emitted more X-rays than any of its compounds.[26]

Still in Paris, physics student Marie Curie was inspired by Becquerel's work in the naturally occurring emissions of uranium, initially called Becquerel rays. As well as studying uranium, Curie began testing other elements and found that thorium, as well as uranium, emitted the rays,

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[24] Ryan, Sutton and Baigent 1996, pxii.
[25] Campbell 1999, pp219, 234-5.
[26] Henri Becquerel, 'No Sun in Paris', in Carey pp188-90; Caulfield, pp22-23; 'Becquerel, Antoine Henri (1852-1908)', in Porter and Ogilvie, pp131-32; Henri Becquerel, 'On Radiations Emitted with Phosphorescence', and 'On the Invisible Radiations Emitted by Phosphorescent Bodies', *Comptes Rendus de l'Académie des Sciences* 122 (1896), reproduced in translation in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp404-6.

which she called “radio-activity”. More significantly though, she found that pitchblende, a black, shiny ore from which uranium was extracted, was even *more* radioactive than pure uranium, indicating that there was another radioactive element in the ore. Excited by her discovery, Marie Curie’s husband Pierre, a physics professor, put aside his research into crystals and joined his wife in her search for the new element.[27]

Working with about a teacup of pitchblende they went through the process of separating the ore into its constituent components. First they ground the pitchblende into a fine powder, which they dissolved in acid. They then repeatedly boiled, froze and precipitated the acid solution. After removing all traces of uranium and other known elements, a process that took many months, they had reduced their teacup of pitchblende to a handful of fine black radioactive powder. Marie Curie named the new element polonium, in honour of her native Poland. But with the final refinement of polonium came an astonishing discovery; the residual powder was still radioactive, meaning that there must be another unknown radioactive element in the pitchblende. This new element was present in such minute quantities that it took several more months to isolate it. Marie and Pierre Curie announced the discovery of the new element, which they named radium, at the end of 1898. To isolate pure radium and determine its atomic weight and number, a lot more pitchblende – and a lot of time – was needed. Working with a cast-iron basin and an iron mixing bar, Marie Curie worked in a big draughty shed in a courtyard of the Sorbonne’s School of Physics, going through the painstaking process of extracting radium from the tonnes of pitchblende residue she had shipped in from the tailings of the Joachimsthal uranium mine in Bohemia. By March 1902, after three years of work, the Curies had isolated radium – which was found to make up only 0.1 gram per ton of pitchblende – and supplied figures for its melting and boiling points, atomic weight, and other chemical properties. Pierre Curie went on to measure radium’s remarkable energy output – each gram of the highly-radioactive radium could inexplicably heat a gram of water from freezing to boiling point in less than an hour.[28]

In 1901, Röntgen was awarded the first ever Nobel Prize in physics for his discovery of X-rays. Marie and Pierre Curie shared the 1903 Nobel Prize in physics with Henri Becquerel –

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[27] Susan Quinn, *Marie Curie: A life,* New York, Simon and Schuster, 1995, pp145-48, 151.
[28] Eve Curie, ‘The Colour of Radium’, in Carey pp191-201; John Gribbin, *Science: A History 1543-2001,* London, Allen Lane, 2002, p498; Quinn 150-52, 154-55, 171-72, 174; Pierre Curie and Marie Curie, ‘On a New Radioactive Substance Contained in Pitchblende’, *Comptes Rendus de l’Académie des Sciences*, 127 (1898), pp175-8 and Pierre Curie, Marie Curie and G. Bemont, ‘On a New Substance Strongly Radioactive, Contained in Pitchblende’, *Comptes Rendus de l’Académie des Sciences,* 127 (1898), pp1215-7, reproduced in translation in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp432-436.

Becquerel winning for his discovery of "spontaneous radioactivity" and the Curies for "their joint researches on the radiation phenomena".[29]

Rutherford embraces the new physics

The new challenge for physical scientists like Rutherford was to determine the nature of the "X-rays" and "Becquerel rays", or what the Curies had called "radio-activity". Rutherford had begun his investigations into the new rays by working with Thomson to examine the effect of X-rays on gases through which an electric current was passed.[30] In 1897 Rutherford was capped as one of Cambridge's first BA research students. The university extended his scholarship for a third year and he continued his studies into X-ray-induced conduction in gases.[31]

Thomson, who had continued to investigate the nature of cathode rays, announced in February 1897 his conclusion that the cathode ray was not made of light waves but was a fast-moving stream of miniscule particles or "corpuscles" (later called electrons). By subsequently measuring their speed and charge he deduced that these particles each had a mass nearly one two-thousandth that of the smallest known particle, the hydrogen atom. Along with Röntgen's discovery of X-rays, and Becquerel and the Curies' discovery of radioactivity emanating from different elements, Thomson's discovery of the electron revealed the existence of a sub-atomic world. With this radical departure from classical physics – which said the atom is indivisible – the sub-atomic age had begun. Following his discovery of the electron, and with experimental evidence that stripping an atom of electrons left a positively charged atom with an almost unchanged mass, Thomson developed a "plum pudding" model of the atom with negatively-charged electrons dispersed like raisins in a solid, spherical, positively-charged atom.[32]

Rutherford was an "immediate convert"[33] to the new theory (some scientists continued to believe that the atom was indivisible) and began his investigation of the sub-atomic world by studying the radiations emitted by uranium and thorium. He concluded in 1899 that uranium emitted "at least two distinct types of radiation – one that is very readily absorbed [it could be stopped by a piece of paper or a few centimetres of air], which will be termed for convenience the α [alpha]

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[29] From Nobel Prize organisation website at http://nobelprize.org/physics/laureates/1901/ and http://nobelprize.org/physics/laureates/1903/, downloaded 5 May 2005.
[30] Campbell 1999, p235.
[31] Campbell 1999, pp238-40.
[32] J. J. Thomson, 'Cathode Rays', *Philosophical Magazine*, 44 (1897), pp293-311, reproduced in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp416-426; American Institute of Physics internet entry on J. J. Thomson at www.aip.org/history/electron/jjhome.htm downloaded 23 June 2005; Campbell 1999, p242; Gribbin 2002, pp490-504; Richard Rhodes, *The Making of the Atomic Bomb*, New York, Touchstone, 1986, p40.
[33] Campbell 1999, p243.

radiation, and the other of a more penetrative character, which will be termed the β [beta] radiation".[34] In 1900 French physicist Paul Villard discovered a third type of radiation, a form of high-energy penetrating X-rays, that he named gamma (γ) radiation.[35]

With his scholarship money running out, Rutherford applied for and was appointed Professor of Physics at McGill University in Montreal, Canada, where X-rays were already a big research topic. When he arrived in 1898, Rutherford introduced the study of radioactivity to the laboratory and after a year's research had identified the emanation from thorium as a new gaseous element. Christchurch newspaper *The Press* kept readers up to date with Rutherford's overseas achievements and his 1900 visit to New Zealand, describing his career as "brilliant" and acclaiming his achievements as raising the value of New Zealand degrees.[36]

Rutherford returned to New Zealand in 1900 to marry Mary Newton. As was the custom with the arrival of distinguished passengers, the *Lyttelton Times* reported Rutherford's arrival:

> Professor Ernest Rutherford, formerly at Canterbury College, and at present Professor of Physics at M'Gill [sic] College, Montreal, is now in Christchurch on a visit. Professor Rutherford, who has had a very distinguished career, succeeded Professor Callendar at M'Gill College, and has been devoting his attention principally to the study of radiations from such bodies as uranium and thorium. Some of his original researches there attracted the attention of the scientific world, and are quoted by the highest authorities.[37]

While in New Zealand, Rutherford submitted papers to the University of New Zealand for the degree of DSc.[38] By the time of Rutherford's visit to New Zealand, the new physics had captured the public imagination and was beginning to enter the popular culture. In the Christchurch papers during Rutherford's visit was the following advertisement for peppermints:

> The unassuming Rontgen Ray
> Appears to burn the flesh away
> And leave the white and ghastly bones,
> The cause for shudders, sighs, and groans;
> So like a man who is ill and cold,
> Who thinks he's dead until he's told
> The way to health in manner sure
> By taking Woods' Great Peppermint Cure.[39]

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[34] Gribben 2002, p502; Ernest Rutherford, 'Uranium Radiation and the Electrical Conduction Produced By It', first published in *Philosophical Magazine,* January 1899 and reproduced in Ernest Rutherford, *The Collected Papers of Lord Rutherford of Nelson,* Vol 1, London, George Allen and Unwin Ltd, 1962, pp169-215. Quote from p175.
[35] Paul Villard, 'On the Reflection and Refraction of Cathode Rays and Deviable Rays of Radium', *Comptes Rendus de l'Académie des Sciences,* 130 (1900), pp1010-1012, reproduced in translation in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp446-8.
[36] Campbell 1999, pp253-55; *The Press,* 9 August 1898, p4.
[37] Campbell 1999, p258.
[38] Campbell 1999, p261.
[39] *The Press*, 20 June 1900, p6.

Back in Montreal, Rutherford continued his research into the nature of the emanations from thorium and radium. The same year, he began collaborating with McGill chemist Frederick Soddy. By the end of their 18-month collaboration, Rutherford and Soddy had discovered that in the process of emitting radiation, an element is spontaneously transformed, either into another element, or into an isotope (a physically different form of the first element). This remarkable discovery, the transmutation of one element into another that they described as "modern alchemy", helped to explain the seemingly inexhaustible supply of energy from radioactive elements like radium.[40] They discovered that all the radioactive elements had a distinct "half-life" – the time it takes for half of the atoms of the original sample of an element to decay into a new element or an isotope. The half-lives of the elements they tested varied wildly – uranium's half-life was calculated at 4.5 billion years, radium's half-life was 1,620 years, and a decay product of thorium had a half-life of only 22 minutes. Other decay products were found to have half-lives of only fractions of a second.[41]

Rutherford and Soddy were establishing the science that would eventually lead to the development of nuclear bombs and energy. In a 1903 paper on "Radioactive Change" they concluded that "the energy latent in the atom must be enormous".[42] Rutherford and Soddy speculated about the release of energy from the atom and the possibility of atomic weapons, with Rutherford jokingly speculating that "some fool in a laboratory might blow up the universe unawares".[43] In 1905 Albert Einstein published his special theory of relativity, including his equation $E=mc^2$, suggesting that mass could be transformed into energy and energy could be transformed into mass, and putting a figure to the enormous amount of energy inherent even in one tiny atom.[44] In public lectures, and a popular book, Soddy spoke of matter as a storehouse of energy, boasting that a pint of uranium could drive an ocean liner from London to Sydney and back.[45]

Rutherford combined scientific meetings with family reunions on a 1905 visit to New Zealand with his new family. *The Press* called him "[one] of the most distinguished scientists of his age"

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[40] Campbell 1999, p261; Badash 1995, p13.
[41] Campbell 1999, p272; Gribbin 2002, p503; Rhodes 1986, p42-43.
[42] E. Rutherford and F. Soddy, 'Radioactive Change'. First published in *Philosophical Magazine*, May 1903. Reproduced in Ernest Rutherford, *The Collected Papers of Lord Rutherford of Nelson*, London, George Allen & Unwin, 1962, Vol 1, pp596-608. Quote from p608.
[43] A. S. Eve, *Rutherford: Being the Life and Letters of the Rt Hon Lord Rutherford, O. M.*, Cambridge, Cambridge University Press, 1939, p102.
[44] David Bodanis, *$E=mc^2$: A Biography of the World's Most Famous Equation*, London, Macmillan, 2000, pp73-74; Gribben, pp438-39.
[45] Spencer R. Weart, *Nuclear Fear: A History of Images*, Harvard University Press, Cambridge, Mass., 1988, p6.

in one of several stories about his life and visit to New Zealand.[46] At a scientific talk to a crowded meeting of the Philosophical Institute of Canterbury on “Radium and its Transformations”, Rutherford entertained the staff, students and dignitaries with an informative lecture and several experiments involving radium.[47] Before his visit he had sent J. S. S. Cooper, a teacher who had followed Rutherford through Canterbury College, a sample of radium, which at the time was extremely rare and, for most scientists, prohibitively expensive. Campbell recounts that the radium “was later shown around the country at appropriate events, for example in Auckland in conjunction with a lecture on electricity.”[48]

Rutherford continued to investigate the nature of radiation, and by 1907 had demonstrated that beta radiation was a stream of negatively charged electrons and that alpha radiation consisted of positively charged helium atoms ejected during radioactive decay.[49] In 1907 he resigned his post at McGill, and took up the position of chair of physics at the University of Manchester in Britain. In 1908 Rutherford was awarded the Nobel Prize, not in his academic field of physics, but in chemistry. [50] The announcement cited Rutherford “for his investigations into the disintegration of the elements, and the chemistry of radioactive substances”.[51] These were the early years of the Nobel Prizes (which were first awarded in 1901) and the awards were not as high profile as they are today. The New Zealand media response was subdued, with only small stories appearing under modest headlines like “New Zealander honoured” on page 5 of the *Auckland Star*.[52]

Rutherford’s prize was presented at a ceremony in Stockholm on 10 December 1908. In gaining the Nobel Prize in Chemistry, he joined others who had made contributions to the new physics (though they had won Physics prizes): Röntgen for the discovery of X-rays; Becquerel and the Curies for their work on radioactivity; German physicist Philipp Eduard Anton Lenard for his work on cathode rays; and Rutherford’s Cavendish Professor J. J. Thomson for his investigations

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[46] *The Press*, 15 July 1905, p12.
[47] *The Press*, 29 July 1905, pp10-11; Campbell, p296, *TPNZI*, 38 (1906), p595.
[48] Campbell 1999, p284; Dr Bertrand Goldschmidt, *Uranium’s Scientific History 1789-1939,* originally presented at the 14th International Symposium held by the Uranium Institute in London, September 1989. Downloaded from www.world-nuclear.org/ushist.htm on 27 June 2005.
[49] Badash 1995, p14; Rhodes 1986, p43.
[50] The physics prize went to Gabriel Lippmann – who had been an early mentor of Marie Curie – for his method of colour photography. (Nobel Prize organisation web page at http://nobelprize.org/physics/laureates/1908/ downloaded 6 May 2005; Quinn, p149.)
[51] Campbell 1999, p309; Nobel Prize organisation web page at http://nobelprize.org/chemistry/laureates/1908/, downloaded 6 May 2005.
[52] *Auckland Star*, 25 November 1908, p5.

on the conduction of electricity by gases.[53] In his presentation speech, the president of the Royal Academy of Sciences noted that Rutherford's discoveries "led to the highly surprising conclusion that a chemical element, in conflict with every theory hitherto advanced, is capable of being transformed into other elements". At the formal banquet following the prize-giving, Rutherford joked that the fastest transformation he had ever encountered was his own instant one from physicist to chemist.[54]

Rutherford gave away some of his Nobel Prize money (of £7680, compared to his annual salary of £1000) but used some of the rest to buy radioactive materials for his research at Manchester University. With the help of his assistant, Hans Geiger, Rutherford perfected an electrical method of counting alpha particles. Geiger went on to improve the detector with Müller. Initially referred to as a Geiger-Müller tube, it is more commonly known today as a Geiger counter.[55]

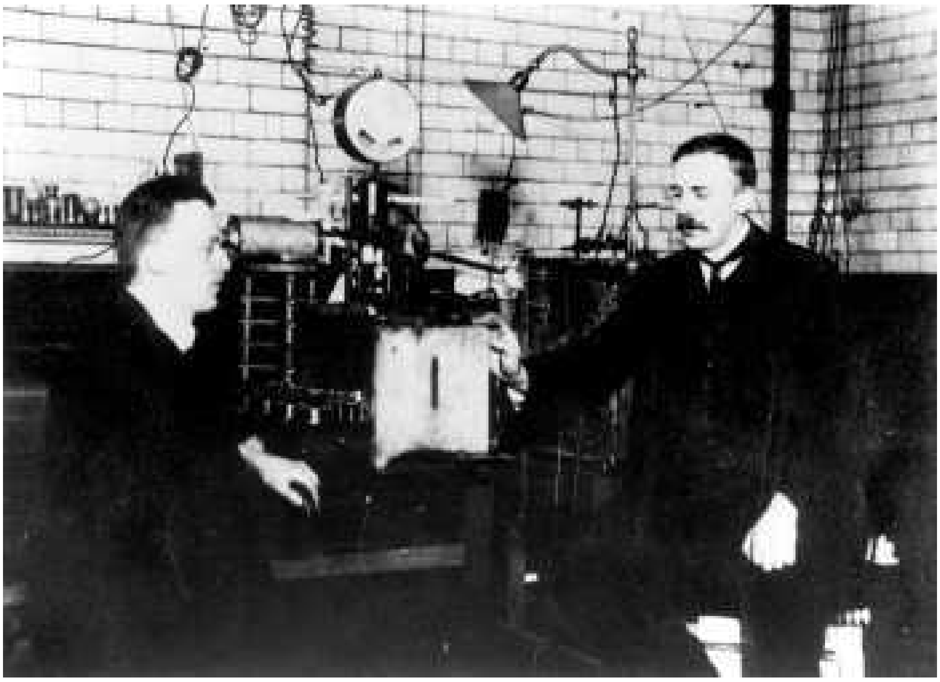

Figure 2.3: Hans Geiger and Ernest Rutherford in the laboratory at the University of Manchester.
Source: Sir Ernest Marsden Collection, F-65890-1/2, Alexander Turnbull Library, Wellington, NZ.

[53] Campbell, p305; Nobel Prize organisation web pages at http://nobelprize.org/physics/laureates/1901/ and http://nobelprize.org/physics/laureates/1903/, http://nobelprize.org/physics/laureates/1905/, http://nobelprize.org/physics/laureates/1906/ downloaded 6 May 2005.
[54] Rebecca Priestley, 'Lord of the Atoms', *New Zealand Listener*, 15 November 2008, pp28-32; Presentation Speech by Professor K.B. Hasselberg, President of the Royal Academy of Sciences, on December 10, 1908, http://nobelprize.org/nobel_prizes/chemistry/laureates/1908/press.html, downloaded on 3 June 2010.
[55] Campbell, p320; MIT Inventor of the Week entry on Johannes Geiger at http://web.mit.edu/invent/iow/geiger.html, downloaded 22 August 2005.

The new physics in New Zealand

The application of the "new physics" in New Zealand was initially restricted to medical doctors rather than scientific researchers, though it was not for lack of interest. From May 1896 onwards, X-rays, radium and radioactivity were occasional topics for popular lectures, always with experiments and demonstrations, at the regional philosophical societies and science institutes that made up the New Zealand Institute. The first such lecture took place just five months after Röntgen's discovery, when Professor Shand, of Otago University, gave a lecture on "Röntgen photographic rays" to the May 1896 meeting of the Otago Institute, "illustrated by numerous experiments".[56] Some scientists made use of overseas connections to obtain tiny samples of radium, and at a meeting of the Otago Institute in June 1904 Dr Marshall exhibited specimens of what he called "pitchblende radium".[57] Later that year, at a meeting of the Wellington Philosophical Society, Mr Earp Thomas exhibited a tube of "bromide of radium" which he claimed to have obtained from Madame Curie.[58]

It took longer for New Zealand scientists to conduct their own research into radioactivity and X-rays. Apart from a short paper on X-rays in 1896, it was not until 1906 that the *TPNZI* carried an article by a New Zealand scientist researching a topic in the new physics. In a 1906 article, *Notes on the Radioactivity of Certain Soils*, John Howell, director of the Christchurch Technical College, tested the radioactivity of various soils and mineral spring deposits from Auckland and Te Aroha.[59] Clinton Coleridge Farr and David Florance of Canterbury University College added to Howell's investigation of local radioactivity levels with an examination of the radioactivity of water from Christchurch's artesian wells, published in the *TPNZI* in 1909. To standardise the electroscope they used to measure radioactivity, they used a standard solution of radium provided by Rutherford (Florance had been a student of Rutherford's in Manchester).[60] The same year, Farr and Florance also examined the radium content of igneous rocks from New Zealand's subantarctic islands, with their findings communicated by Rutherford to the *Philosophical Magazine* in London.[61] In 1910, using the same radium solution prepared by Rutherford, Dominion Analyst James Maclaurin – who in 1895 had declined the 1851

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[56] *TPNZI* 29 (1896), p626.
[57] *TPNZI* 37 (1904), p614.
[58] *TPNZI* 37 (1904), p603.
[59] W. P. Evans, 'Refraction and Reflexion of X-rays', *TPNZI* 29 (1896), pp573-4; James W. Brodie. 'Howell, John Henry 1869-1944'. *Dictionary of New Zealand Biography*. Updated 16 December 2003. Downloaded from www.dnzb.govt.nz on 21 June 2005; J. H. Howell, 'On the Radio-activity of Certain Soils', *TPNZI* 39 (1906), pp223-6.
[60] C. C. Farr and D. C. H. Florance, 'On the Radio-activity of the Artesian Water System of Christchurch, New Zealand, and the Evidence of its Effect on Fish-life', *TPNZI* 42 (1909), pp185-190.
[61] 'Nuclear Science in New Zealand', from A. H. McLintoch (ed), Vol 2, pp700-703.

Exhibition Scholarship that Rutherford had then accepted – worked with a colleague to study the radioactivity of thermal waters at Rotorua, Taupo and Te Aroha. Waters from Rotorua's Hamurana and Fairy Springs were found to be the most radioactive, though at levels much lower than water and gases from hot springs at Yellowstone Park in the United States.[62]

Of greater international significance, however, was research by Thomas Laby at Victoria University College in Wellington. Like Rutherford, Laby was a past recipient of an 1851 Exhibition Scholarship. In 1905 he had travelled from his home in Australia to Cambridge, where he spent four years at the Cavendish Laboratory under Professor J. J. Thomson. In 1909 Laby came to New Zealand, to the newly created chair of physics at Victoria University College. There he continued the research into gamma rays – using a radium source provided by Rutherford with financial assistance from the Royal Society – that he had begun at the Cavendish Laboratory. [63] Working with his research student Percy Burbidge, Laby published a paper on gamma rays in the *TPNZI* of 1911.[64] Laby also published results of his New Zealand research internationally, including in the British journals *Nature* and *Proceedings of the Royal Society of London*.[65]

Laby was the first dedicated physics professor appointed in New Zealand. The inaugural physics professor at Canterbury University College was Australian-born Clinton Coleridge Farr, who was appointed in 1911 following his study with David Florance of the radioactivity of Christchurch's water. At Auckland University College the first physics professor was a Welshman, Gwilym Owen, who was appointed in 1913. Otago University, a separate institution, did not establish a chair in physics until 1914, when they appointed Robert Jack from Scotland. Before the appointment of physics professors, the subject was taught by either more junior physics staff or by chemistry or natural history professors.[66]

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[62] J. S. Maclaurin, 'Report on Radio-activity of the Thermal Waters of Rotorua, Taupo and Te Aroha'. In the *Forty-fourth Annual Report of the Dominion Laboratory*, Wellington, Government Printer, 1911; Campbell 1999, p187-188.
[63] Ed Muirhead, *A Man Ahead of his Times: T. H. Laby's Contribution to Australian Science,* Melbourne, The University of Melbourne, 1996, p5; Campbell 1999, p375.
[64] John Cawte Beaglehole, *Victoria University College: An Essay Towards a History*, Wellington, New Zealand University Press, 1949, pp105-6; T. H. Laby and P. Burbidge, 'The Nature of Gamma Rays', *TPNZI* 44 (1911), pp30-31.
[65] T. H. Laby and P. Burbidge, 'The Nature of γ-rays'. *Nature*, 87 (1911), p144; T. H. Laby and P. Burbidge. 'The Observation by Means of a String Electrometer of Fluctuations in the Ionization Produced by γ Rays'. *Proceedings of the Royal Society of London,* A86 (1912), pp333-348. Both listed in Muirhead, p82.
[66] John Campbell, 'Farr, Clinton Coleridge 1866–1943', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz downloaded on 21 June 2005; Jim Sullivan, 'Jack, Robert 1877–1957', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz downloaded on 17 July 2008; Rachel Barrowman, *Victoria University 1899-1999: A History*, Victoria University Press, Wellington, 1999, p23; Keith Sinclair, *A History of the University of Auckland 1883-*

While some researchers were lucky enough to acquire an overseas source of radium, other New Zealanders focused their attention on finding a local source of the newly discovered element. Some prospectors were convinced they had found uranium ore from which radium could be extracted, but the Mines Department was sceptical. In 1928 they advised the Imperial Institute in London – which was seeking information on possible sources of radioactive minerals – that “no radium-ore has yet been found in New Zealand, though one or two prospectors without scientific training have made futile attempts to discover radium-bearing localities in districts where they are very unlikely to exist”.[67]

Ernest Marsden and the gold foil experiment

While New Zealand-based physicists lagged behind, Rutherford was leading a team working at the forefront of the new physics. In 1909, one of Rutherford’s undergraduate students at Manchester, a 20-year old Lancashire man called Ernest Marsden, began to assist Hans Geiger with experiments in which a beam of alpha particles was scattered after passing through a thin metal foil. In response to Geiger’s advice that Marsden was now ready for a research project of his own, Rutherford asked Marsden to see if he could get evidence of alpha particles directly reflected from a metal surface. In a now famous experiment, Marsden observed that instead of passing through, a tiny fraction of alpha particles were deflected straight back from a thin gold foil. Rutherford later described this result as being “almost as incredible as if you had fired a fifteen-inch shell at a piece of tissue paper and it came back and hit you”.[68] Two years later, after pondering the results of what is now known as the Marsden-Geiger experiment, as well as additional scattering experiments, Rutherford came up with a new theory for the structure of the atom. In an article published in May 1911, Rutherford proposed an atom with a centralised concentration of mass and positive charge – which he called the nucleus – surrounded by empty space and a sea of orbiting negatively charged electrons.[69] Rutherford’s revolutionary “nucleus” model of the atom, which contrasted markedly with Thomson’s earlier “plum pudding” model, initially received very little attention from fellow scientists. Perhaps one of the reasons

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1983, Auckland University Press, Auckland, 1983, pp80-81; W. P. Morrell, *The University of Otago: A Centennial History*, University of Otago Press, Dunedin, 1969, p117.

[67] Elaine Bolitho, *Reefton School of Mines, 1886-1970: Stories of Jim Bolitho*, Reefton, Friends of Waiuta in association with Reefton School of Mines and the Bolitho family, 1999, p110. Bolitho cites Archives New Zealand file MD1, 646-7, 5/11, File 2A, Archives New Zealand. This paragraph also references notes kindly provided by Elaine Bolitho, taken from research into this file. Archives New Zealand could not locate a file with this reference covering this time period.

[68] Rutherford in Needham and Pagel 1938, p68; Hans Geiger and Ernest Marsden, ‘On a Diffuse Reflection of the α-Particles’, *Proceedings of the Royal Society*, 82 (1909), pp495-499, reproduced in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp696-700.

[69] E. Rutherford, ‘The Scattering of Alpha and Beta Particles by Matter and the Structure of the Atom’, *Philosophical Magazine* Series 6, 21 **(**1911), pp669-88.

Rutherford's model was not initially embraced is that this experimentally derived model of the atom posed uncomfortable contradictions with the laws of classical physics.[70]

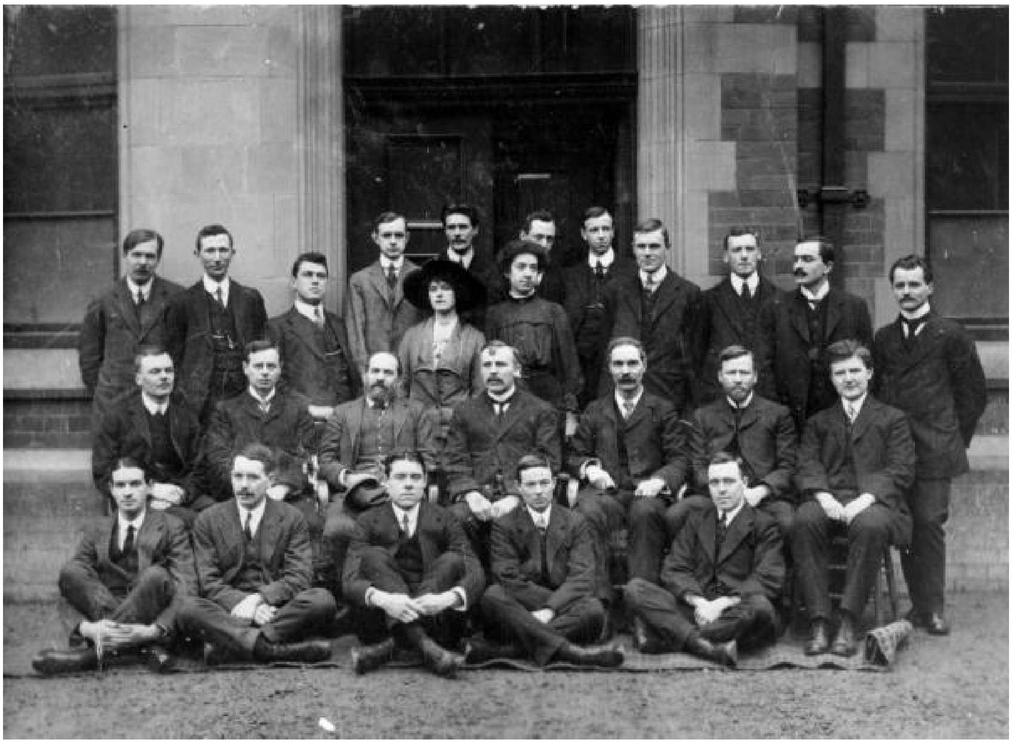

Figure 2.4: Ernest Marsden and Ernest Rutherford met in 1909, when Marsden was a student in Manchester. In this photograph of Manchester University scientific staff and research students, Marsden is in the front row on the viewer's far right and Rutherford is in the centre of the second row. Source: Photographer Ward of Manchester, Lady Marsden Collection, PAColl-0091-1-006, Alexander Turnbull Library, Wellington, NZ.

Ernest Marsden graduated later in 1909 and went to a lecturing position in London, but in 1912 he returned to Manchester where he succeeded Geiger as Rutherford's assistant and gained a DSc. In 1915, on Rutherford's recommendation, Marsden came to New Zealand to replace Thomas Laby (who had taken a position at the University of Melbourne) as professor of physics at Victoria University College in Wellington. Very soon after arriving, however, he volunteered for war service and found himself fighting in trenches opposite Hans Geiger. Back at Victoria University College after the war, rather than focusing exclusively on radioactivity, Marsden broadened his research interests to include new fields such as seismology and coal efficiency, and organised the building of a physics wing of the university's Hunter Building.[71]

Marsden also continued his research into the nature of radioactivity. Laby had taken his supply of radium with him to Melbourne, so Rutherford successfully petitioned the Royal Society to get

[70] Ernest Marsden, 'Rutherford at Manchester', in J. B. Birks (ed) *Rutherford at Manchester*, London, Heywood and Company, 1962, pp7-11; E. N. Da C. Andrade, *Rutherford and the Nature of the Atom*, Peter Smith, Gloucester, Mass., 1978, pp116-122; Rhodes 1986, p51.

[71] *TPNZI* 54 (1923), p817; TPNZI 55 (1924), p768; *Sir Ernest Marsden 80th Birthday Book*, 1969, p42-43; Ross Galbreath, 'Marsden, Ernest 1889 – 1970', *Dictionary of New Zealand Biography*, downloaded from www.dnzb.govt.nz on 20 June 2005; Muirhead 1996, p9.

a supply of radium sent to Wellington for Marsden to use.[72] During his short professorship at Victoria University College Marsden used this precious supply of radium to conduct experiments into cosmic radiation, an extremely penetrating form of radiation coming from the depths of space, discovered by Austrian scientist Victor Hess in 1912.[73]

The Rutherford-Bohr model of the atom

As the new physics became increasingly well accepted, physicists and chemists worldwide continued to seek a better understanding of the atom, its particles, and their properties. One of the problems of Rutherford's nucleus model of the atom was that there was no explanation of why the electrons, with their negative charge, did not collapse into the positively charged nucleus. In 1913, the Danish physicist Niels Bohr, who had begun working with Rutherford in 1912, extended Rutherford's model of the atom by fixing the energy levels in which electrons could orbit the nucleus. Bohr explained that atoms emitted fixed amounts (quanta) of energy, or radiation, when electrons jumped from one stable orbit to another. The "Rutherford-Bohr" model – which is essentially an overlay of quantum requirements on an otherwise classical conception of an atom as consisting of a nucleus and orbiting electrons – became the new accepted model of the atom, and is broadly the picture of the atom we use today.[74]

Conclusion

The late nineteenth and early twentieth century saw the development of an entirely new branch of physics, the physics of radiation, which led to the physics of the atom and the nucleus. While New Zealand did not have the scientists or laboratories to conduct original research in this new discipline, the technology was seen as useful and worthwhile and was readily adopted for medical applications. X-rays were in use in New Zealand just months after their European discovery, and medics and researchers made use of scarce and valuable radium made available thanks to the efforts of New Zealander Ernest Rutherford, who in his work in the northern hemisphere was at the forefront of the new science.

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[72] Campbell, p375; Wilson, p393.

[73] *TPNZI* 55 (1924), p768; Nobel Prize organisation web page on Nobel Prize in Physics 1936 at: http://nobelprize.org/physics/laureates/1936/press.html downloaded 26 September 2005; Viktor F. Hess, "Penetrating Radiation in Seven Free Balloon Flights", *Physikalische Zeitschrift*, 13 (1912), pp1084-91, reproduced in translation in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp672-5.

[74] Gribben, pp512-4; Niels Bohr, 'On the Constitution of Atoms and Molecules', *Philosophical Magazine*, 26 (1913), pp1-19, reproduced in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp751-765.

Rutherford’s initial influence in New Zealand with regard to radiation science was in providing radium for scientific use and attracting people to his lectures on radiation and radium on his visits to New Zealand. His most lasting influence, however, was in recommending his student Ernest Marsden to the role of professor of physics at Victoria University College in Wellington: Marsden would go on to play an influential role in New Zealand’s nuclear history, as will be shown over the following chapters.

Another factor worthy of consideration is that physics was not a well-established academic subject in New Zealand before the twentieth century. It is not therefore surprising that the physics professors appointed in the second decade of the century were embracing of the “new physics”. Unlike in Europe and North America, there was no old guard of physicists holding on to Newtonian ideals and resisting the new science.

Chapter 3
The public are mad on radium!
Applications of the new science

"… the public are mad on radium …"
Government balneologist Arthur Wohlmann, 1914[1]

"The energy produced by the breaking down of the atom is a very poor kind of thing. Anyone who expects a source of power from the transformation of these atoms is talking moonshine."
Ernest Rutherford, 1933.[2]

For New Zealand medics, scientists and the general public, the "new physics" had an immediate allure. Like New Zealanders today, these early twentieth century professionals were early adopters, striving to keep up to date with the latest applications of radiation science, especially for the treatment of diseases and the promotion of health. Patients, in turn, sought the assurance of having the latest treatments on offer in New Zealand. As the use of X-ray and radium technologies became more widespread around New Zealand and the world, however, so did awareness of the hazards of working with radiation.

The new technologies of X-rays and radium were linked in that they both produced penetrating (and what we now know as ionising) forms of radiation that could be used in diagnostic or therapeutic medicine. While the public were unlikely to be aware of the physical differences between, for example, X-ray therapy and radium therapy, they were in fact two very different processes: an X-ray machine produced an electrically-generated form of electromagnetic radiation emitted by electrons that could be used in diagnosis or therapy; radium, or its daughter product, radon gas, was used mostly as a close-range therapy for the alpha particles it emitted. Radium had applications outside medicine too: when mixed with beryllium, scientists could use it as a source of neutrons for physics experiments.

Early use of diagnostic X-rays

The application of X-ray and radium technology to medicine in New Zealand happened mostly independently from other countries, with Australasian cooperation not formalised until the

[1] Wohlmann to GM of Dept of Tourist and Health Resorts, 25 May 1914, TO1, 24/34, *ANZ.*
[2] *New York Herald Tribune*, 12 September 1933. News clipping reproduced in Charles Weiner, 'Physics in the Great Depression', *Physics Today* 23, 10 (1970), p33.

Australian and New Zealand Association of Radiologists was formed in 1935. The pace of development was similar in both countries, though uptake of the new technology was somewhat faster in New Zealand. As well as having a population of technologically savvy early-adopters it is possible that the small size of the country meant that a few keen individuals could have a widespread impact on the adoption of a new technology.[3]

By the second decade of the twentieth century diagnostic X-rays were in widespread use. In 1916, for example, Auckland Hospital used their X-ray apparatus for 1,394 diagnostic examinations.[4] X-rays were also used for dental diagnosis from the 1910s and were in routine use by the 1930s.[5] Specialised medical attention like X-rays, however, came at a cost to the patient. An X-ray radiograph cost between half a guinea and three guineas in 1917 (up to $100 in 2010 New Zealand dollars) limiting its application to wealthier patients.[6]

The First World War was a period of great technological advancement, particularly in medicine, and many of New Zealand's medical officers were exposed to these new technologies; for example, in the form of mobile X-ray units used to detect lodged bullets and pieces of shrapnel. The war also saw the development of new X-ray apparatus and the standardisation of X-ray techniques, most of which reached New Zealand by 1920.[7] The technology was sophisticated, and New Zealand, with its small population, did not yet have the trained professionals to use it. By December 1924, 35 New Zealand hospitals had X-ray apparatus, and 17 of them employed lay radiographers.[8] In the remaining hospitals, the X-ray equipment was used by anyone "who could be impressed into service"; medical superintendents, house surgeons, hospital engineers, electricians or nurses were all called upon to take responsibility for radiography.[9] One nurse was known to take her knitting into the X-ray room – "it worked out something like half a row of sock for an ankle and up to two rows for a lumbar spine".[10]

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[3] James Ryan, Keith Sutton and Malcolm Baigent, *Australasian Radiology: A History.* Sydney, McGray-Hill Book Company, 1996, p497.
[4] Ryan et al 1996, p336.
[5] Diane J. Campbell, 'A Brief History of Dental Radiography', *New Zealand Dental Journal* 91 (1995), pp127-133.
[6] F. O. Bennett, *Hospital on the Avon: The History of the Christchurch Hospital 1862-1962*, North Canterbury Hospital Board, Christchurch, 1962, p193; John Angus, *A History of the Otago Hospital Board and its Predecessors*, The Otago Hospital Board, Dunedin, 1984, p138. (A guinea was 21 shillings, a little over one pound. In 2010 dollars, an X-ray cost between $50-$300.)
[7] C. C. Anderson, 'The Development of Radiology in New Zealand', *Australasian Radiology* 10 (1966), p300.
[8] Memo from Director-General of Health to Pensions Dept, 9 January 1924, H1, 53/19 (28298), ANZ; Anderson 1966, p299.
[9] Anderson 1966, p299.
[10] J. F. Borrie, 'A History of Training for the Diploma of the Society of Radiographers (London)', *Shadows* 16, 1 (1973), p16.

As the technology became more advanced and established, medical applications for X-rays expanded beyond diagnosing bone fractures and joint conditions. Chest X-rays became an important tool for confirming the diagnosis and extent of pulmonary tuberculosis, which only a few decades earlier had been the number one killer of New Zealanders. By injecting or feeding a patient solutions that were impervious to X-rays, such as compounds containing barium or iodine, soft tissues such as the digestive and urinary tracts could be examined by X-ray.[11]

X-ray technology was applied wherever it was seen to be potentially beneficial, even to antenatal care. By 1926, 44 New Zealand hospitals had X-ray equipment, and the Director-General of Health was proud to announce that arrangements had been made for pregnant women to have X-rays for diagnosis of conditions such as multiple pregnancy, hydrocephalus or malformation of the foetal skeleton. The practice of offering antenatal care to all pregnant women was new, launched only two years earlier as part of the Department of Health's Campaign for Safe Maternity. With the new X-ray screens and fast films now in use, the Department of Health assured there was "no danger either to mother or child".[12] By the mid-1930s the antenatal X-ray was on the list of standard X-ray procedures offered by New Zealand hospitals, available for an outpatient charge of 5 shillings a film.[13]

X-rays were popular and the public was happy to pay for them: as well as being offered in hospitals, X-ray machines were used in health spas (to diagnose joint conditions) and by chiropractors. In shoe shops, sales staff with no training in radiography operated "pedascopes" or "shoe-fitting fluoroscopes". Most pedascopes had no limits on radiation exposure time, and children could play unsupervised on the machines, irradiating their feet and watching their foot bones on the screen.[14]

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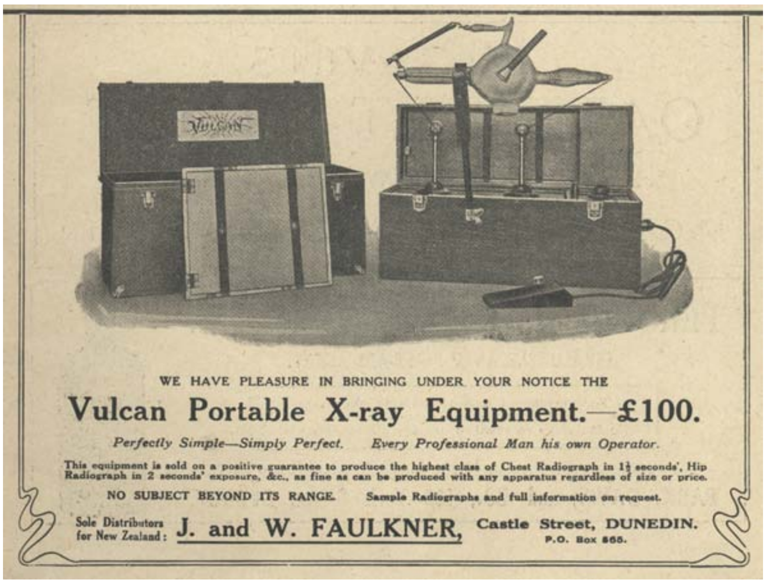
[11] *New Zealand Appendices to the Journals of the House of Representatives (AJHR)* 1927, Vol 3, H-31, pp19-22; *Otago Witness*, 11 April 1922, TO1, 24/34, *ANZ;* C. C. Anderson, 'The X-ray Examination of the Kidney Pelvis', *New Zealand Medical Journal* (NZMJ*)* 28, 145 (1929), pp149-156.
[12] Director-General of Health to Commissioner of Pensions, 9 December 1926, H1, 53/19 (28298), *ANZ*; *AJHR* 1926, Vol 2, H-31, p29; *AJHR* 1927, Vol 3, H-31, p35; Philippa Mein Smith, *Maternity in Dispute: New Zealand 1920-1939,* Department of Internal Affairs, Wellington, 1986, pp23-26.
[13] Director-General of Health to Auckland Hospital Board, 16 September 1936, H1, 53/19 (28298), *ANZ.*
[14] Anderson 1966, p303; Ian Rockel, *Taking the Waters: Early Spas in New Zealand,* Government Print, Wellington, 1986, p40; Ryan et al 1996, p454; Oak Ridge Associated Universities internet article on 'Shoe-fitting fluoroscope' (ca. 1930-1940) downloaded from www.oran.org/ptp/collection/shoefittingfluor/shoe.htm on 2 June 2004.



Figures 3.1 and 3.2: From a handful of X-ray machines at the turn of the century, New Zealand had an estimated 450 X-ray installations by 1944. These advertisements ran in the *New Zealand Journal of Health and Hospitals* in 1920. Source: H1, 53/19 (28298), Archives New Zealand, Wellington, NZ.

X-ray and radium therapy

X-rays were used diagnostically as soon as it was discovered that human bones were opaque to X-rays, but their therapeutic use followed experiments to determine their effect on skin diseases.

X-rays were perceived to have a beneficial effect on skin conditions like acne, ringworm and skin cancer, though it was soon noticed that radiation also caused skin burns and hair loss.[15]

As with adoption of diagnostic X-rays, experiments with radiation therapy in New Zealand followed close behind the first international publication of the new techniques. Radiotherapy trials in New Zealand began as early as 1901, but more advanced therapy was taking place in London, and some New Zealanders travelled there for treatment.[16] In 1902, *The Press* described how a Christchurch patient, Craig Robertson, who had suffered for 26 years from "rodent ulcer" (now known as basal cell carcinoma), was treated in London with the new "X-Ray Light Cure".

Before leaving for London, Robertson had been through 15 operations to treat his condition, which affected his face, and the "ulcer, which started in his cheek, just to one side of the mouth, had extended close to his eye … and he was in great fear that it would go to the brain".[17] On arriving in England, Robertson received treatment at London Hospital. *The Press* described his treatment as follows:

> The light ... is administered through a round globe ... The patient sits down before the battery, with the globe placed on a wooden stand at about the level of his head, and from twelve to eighteen inches in front of him. Two small coils are attached to points at the two ends of the globe, from the battery. A leaden mask is placed over the patient's face, with a small hole cut in it just over the place where the ulcer is, and the apparatus is placed so that the light from the X-Rays will fall exactly upon that spot. The mask is used to prevent the rest of the face being shrivelled away. A tap is given to the battery in the manner of touching a spring, and the process begins. When it has lasted for ten minutes a second touch with the finger cuts off the light. An exposure of the ulcerated place to this light during ten minutes each day, for six days a week, forms the whole of the simple process.[18]

Following his treatment, which involved 10-minute X-ray sessions, six days a week, for several months, Robertson declared, "I felt noticeably better after only eight days, and in from five to six months I was quite well."[19]

New Zealand medical practitioners were quick to master the new technology and it wasn't long before individual practitioners in New Zealand were offering paying patients radiotherapy services. William Hosking, superintendent of Masterton Hospital, used radium and X-ray equipment to offer a private radiotherapy service and is credited with using radium to cure a carcinoma of the lip soon after the turn of the century. Other early practitioners of radiotherapy

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[15] Ryan et al 1996, pp215-6.
[16] The *Press*, 20 September 1902, p7.
[17] The *Press*, 19 September 1902, p5-6.
[18] The *Press*, 19 September 1902, p5-6.
[19] The *Press*, 19 September 1902, p5-6.

included P. Clennell Fenwick in Christchurch, Percy Cameron in Dunedin and William Stowe in Palmerston North.[20]

As demonstrated by the enterprising William Hosking, radium, like X-rays, emitted radiation that could be used for therapeutic purposes. An advantage of radium over X-rays was that it could be used to treat cancers that were difficult to reach externally and was therefore used for inter-cavity treatments, for example, for cancer of the uterus, or for direct insertion into tumours. By emitting alpha particles, which travel only a few millimetres, the radium was able to destroy the cancerous tissue into which it was inserted, without damaging the healthy tissue surrounding it. Radium, however, was much more expensive than X-rays and hard to obtain, and it took longer to become established for medical use.[21]

Marie and Pierre Curie had first extracted radium in 1902. By 1907, in recognition of its medical benefits, radium was being extracted in one Austrian and two French factories. By 1913, however, they had together made available only 20 grams of radium. The United States was the next to enter the market, and between 1913 and 1926 put about 200 grams of radium on the market, about half of which was used in medicine (the rest was used in luminous paints). When Belgium and Canada entered the radium market in the 1920s this precious substance became more available and affordable to hospitals in New Zealand. And as the availability of radium increased, its price dropped, from US$160,000 per gram in 1913 to US$120,000 in 1926; and then down to US$70,000 per gram once the Belgian company Union Miniere de Haut Katanga (which sold radium produced from uranium mined from the Belgian Congo) first became a major producer, significantly increasing supply and eventually gaining a near-monopoly on production.[22]

Although radium was becoming increasingly available, New Zealand hospitals were poorly funded and radium was initially prohibitively expensive. Under the Hospitals and Charitable Institutions Act 1909, hospitals were funded by levies on local bodies, central government subsidies and monies from donations, bequests and patient fees. Public appeals were a common way of raising money for capital expenditure and this was how radium was purchased in the four main centres.[23]

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[20] Anderson 1966, p301.
[21] Ryan et al 1996, p216; Anderson 1966, p301.
[22] Anderson 1966, p301-2; Dr Bertrand Goldschmidt, *Uranium's Scientific History 1789-1939*, originally presented at the 14th International Symposium held by the Uranium Institute in London, September 1989. Downloaded from www.world-nuclear.org/ushist.htm on 27 June 2005.
[23] Angus 1984, pp78, 132.

In 1914, Percy Cameron, who was in charge of Dunedin Hospital's X-ray department, recommended the establishment of a "Radium Institute" at the hospital. Cameron had bought a small supply of radium in 1911 and had been using it successfully at the hospital and in private practice.[24] The same year, Herbert McClelland Inglis, honorary radiologist to the Christchurch Hospital, made an appeal for public funds to buy a supply of radium for the hospital. Medical opinion, however, was divided on the success of radium as a therapy and in Wellington, the hospital's medical superintendent cited the "enormous cost of radium … [it was selling for £20,000 a gram at the time], the differences of opinion amongst eminent medical authorities as to its therapeutic value, the dangers attending its use, and the absolute necessity of having a trained expert for its administration" as reasons to hold over a proposal to secure a supply of radium for Wellington Hospital.[25]

By 1917, however, medical and public opinion had moved in favour of radium. A 1917 public campaign in Dunedin raised enough money for an additional 180 mg of radium, and patients came from all over New Zealand for treatment. In 1921 another public appeal raised more than £2000, which – along with a Government subsidy of 24 shillings to the pound[26] – Dunedin Hospital used to purchase more radium applicators.[27]

Wellington was next. In November 1923, following the success of the Dunedin campaign, a committee led by the Mayor of Wellington launched a public campaign to raise £10,000 towards establishment of a radium department at Wellington Hospital. The money from the successful public campaign, along with a government subsidy at the lower rate of 10 shillings in the pound, was used to purchase 750 mg of radium for £12,250, along with deep X-ray therapy apparatus at a cost of £3740. In London, Ernest Rutherford selected a tube of radium bromide from Radium Belge's radium supplies. The radium arrived at Wellington Hospital, along with an authentication certificate signed by Marie Curie.[28] In 1925, Noel Hill, then a part-time physics student at Victoria University College, installed, under Marsden's supervision, 650 mg of the hospital's radium supply in a radon plant in the hospital's basement. Radon gas emanating from the radium (it was also called "radium emanation") was collected and sealed in tiny glass tubes

[24] Anderson 1966, p301; Angus 1984 p156; Sir Charles Hercus and Sir Gordon Bell, *The Otago Medical School Under the First Three Deans*, E & S Livingstone Ltd, Edinburgh and London, 1964, p343; *Otago Daily Times*, 6 February 1914, p3.
[25] *The Press*, 4 May 1914, p6; *The Press*, 9 May 1914, pp10, 11.
[26] There were 20 shillings to a pound, so a subsidy of 24 shillings to the pound meant their money was more than doubled.
[27] Anderson 1966, p301; *Otago Witness*, 11 April 1922 in TO1, 24/34, *ANZ.*
[28] Curie's radium institute in Paris provided a service measuring radium samples against a standard. (Susan Quinn, *Marie Curie: A life,* Heinemann, London, 1995, p406.)

before being enclosed in suitable applicators, including platinum seeds and needles, for use in cancer treatment throughout the country.[29]

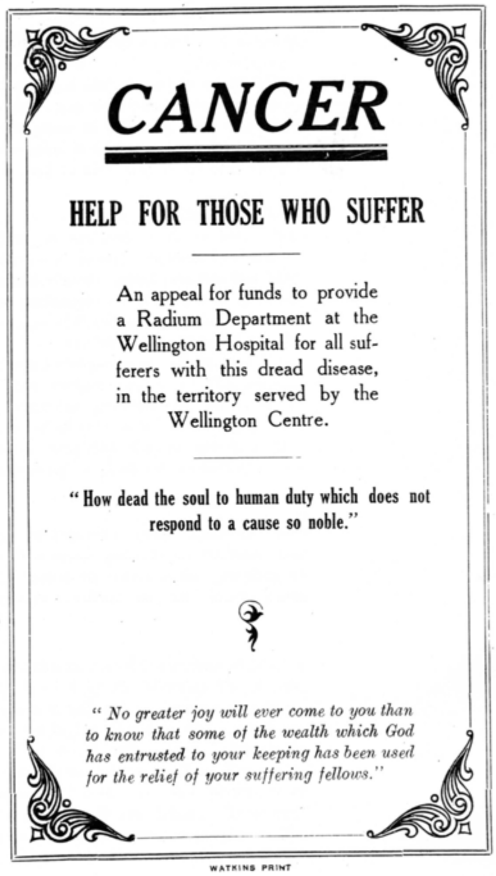

Figure 3.3: Wellington's radium appeal successfully appealed to citizens' sense of duty in raising £10,000 for purchase of radium and radiotherapy equipment for Wellington Hospital. Source: MS-Papers-1293-119/03, Misc Records, Hutt City Council, Alexander Turnbull Library, Wellington, NZ.

Christchurch Hospital's radium and deep therapy department was made possible by a then-anonymous donation of £4000 from Sir Arthur Sims, a Christchurch businessman and philanthropist who had earlier been taught by Rutherford at Christchurch Boys' High School.[30] Combined with an earlier donation of £500, and the government subsidy of 10 shillings in the pound, this money was used to purchase half a gram of radium and a deep therapy X-ray machine. Clennell Fenwick was appointed to head the department and he travelled to the United Kingdom to train in radium therapy and bring back the required plant. A public appeal followed,

[29] ABRR 7563, W4990, box 4, *ANZ*; Radium appeal brochure in MS-papers-1293-119/03, Misc records, Hutt City Council, *ATL*; The *Dominion*, 12 November 1923, p9; Anderson 1966, p302; P. D. Cameron, 'Demonstration of Radium Emanation Plant, Wellington', *NZMJ*, 28, 146 (1929), pp240-241; D. Macdonald Wilson, *A Hundred Years of Healing: Wellington Hospital 1847-1947*, A. H. & A. W. Reed, Wellington, 1948, p92.
[30] Alan Mitchell, *84 Not Out: The Story of Sir Arthur Sims*, Hennel Locke in association with George G. Harrap & Co., London, 1962, pp161-163.

bringing additional funds to the newly established service.[31] By December 1924 the X-ray therapy plant and radium was installed and the department established, with Fenwick working “day and night” treating patients.[32] As medical practitioners increasingly recognised the value of radium therapy, demand increased. Just two years after the department was established Fenwick was finding it very difficult to keep up with the demand for radium therapy; he described the hospital’s radium supply as being in “incessant use”.[33]

Auckland Hospital was slower on the uptake, but after the chairman of the hospital board declared that “Auckland had taken a back seat too long and should not play second fiddle to any city in the Dominion” it too launched a radium appeal. With the £10,000 raised it bought radium and a deep therapy unit for treatment of cancer patients at Auckland Hospital.[34]

Radium, the subject of public appeals in the four main centres, had needed little introduction; as the Government balneologist Arthur Wohlmann, who ran the Department of Tourist and Health Resorts’ Rotorua Bathhouse, wrote in 1914, “the public are mad on radium”.[35] In 1905 Rutherford had spoken on “Radium and its Transformations” to a crowd at Canterbury University College.[36] In 1919, Auckland public lectures on “The Discovery and Properties of Radium” and “The Lessons of Radium” by Professor Gwilym Owen, Auckland’s physics professor, were packed, with the hall’s 400 capacity not big enough to accommodate the enthusiastic crowds.[37]

As well as being known for their medical use, X-rays and radium had become part of popular culture, with some manufacturers using the terms to give their products an air of modernity and superior strength. From as early as 1911 Radium Polishes Ltd offered a range of polishes (none of which contained radium).[38] As well as Radium Floor Polish with which “everything will be brighter”, New Zealand housewives could clean their stoves with X-ray Stove Polish with “The Shine That Lasts Longest” and, somewhat alarmingly, bake bread using Radium Brand Flour.[39]

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[31] H1, 85/46 (19137), *ANZ*; Bennett 1962, p201-3; P. C. Fenwick, *North Canterbury Hospital and Charitable Aid Board*, Andrews Baty and Co., Christchurch, 1926, p26.
[32] *Christchurch Sun*, 4 December 1924.
[33] Letter from Fenwick to Department of Health, 6 May 1926, H1 15/1/6 (8486), *ANZ.*
[34] Borrie 1973, p21; Bennett 1962, p200.
[35] Letter from Wohlmann to General Manager, Dept of Tourist and Health Resorts, 25 May 1914, TO1, 24/34, *ANZ.*
[36] *The Press*, 29 July 1905, pp10-11; John Campbell, *Rutherford: Scientist Supreme*, Christchurch, AAS Publications, 1999, p296-7.
[37] *TPNZI*, 52 (1920), p489.
[38] CO-W, W3445, box 146 (alt no 1911/16), *ANZ*
[39] *Auckland Star*, 25 November 1908, p10; *The Dominion*, 29 October 1925, p14; Campbell 1999, p296.

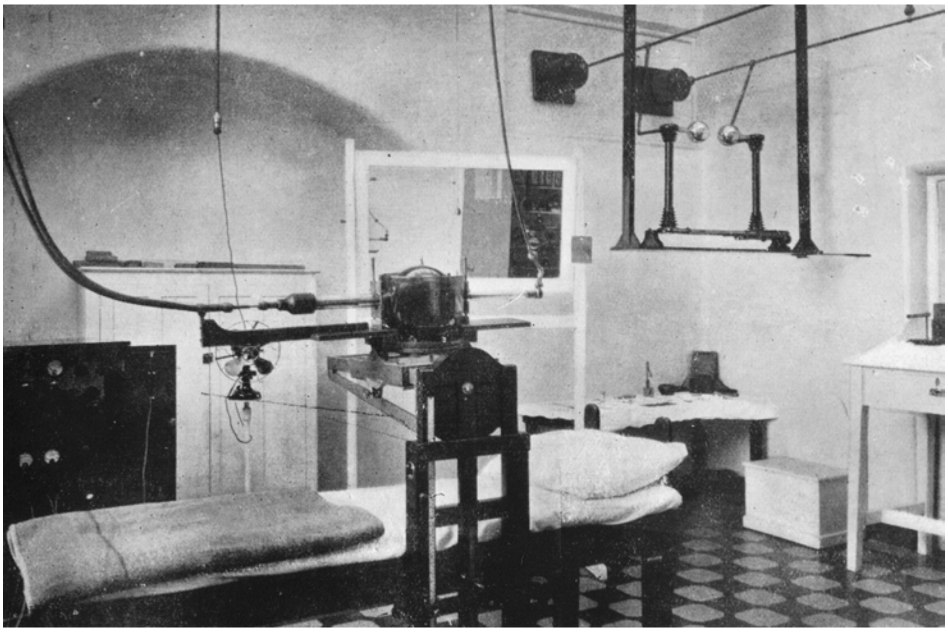

Figure 3.4: Christchurch Hospital X-ray Department, c1920s, as shown in P. C. Fenwick's *History of the North Canterbury Hospital Board*. Source: B-K 675-32, Alexander Turnbull Library, Wellington, NZ.

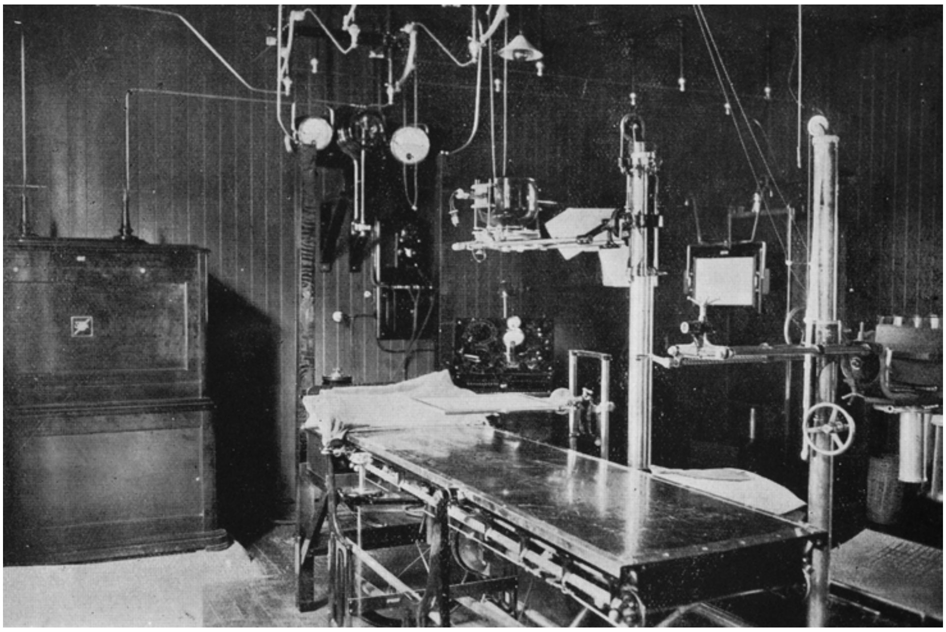

Figure 3.5: Christchurch Hospital Deep Therapy Department as shown in P. C. Fenwick's *History of the North Canterbury Hospital Board*. Source: B-K 675-28, Alexander Turnbull Library, Wellington, NZ.

Figure 3.6: Advertisers used the connection with “radium” and “X-rays” to confer superior cleaning power on their polishing products. Source: Newspaper advertisements from *Auckland Star*, 25 November 1908, p10, *The Dominion*, 1 November 1923, p2 and *The Dominion*, 29 October 1925, p14.

Once full radiotherapy services were established in the four main centres, the hospital boards worked to add to their supplies of radium and keep their equipment up to date. At first William Massey’s Reform Government matched public donations to the tune of 10 shillings in the pound.

Lobbying from the hospital boards led Gordon Coates' Government to match donations pound for pound to a total of £5000 of government money for each of Auckland, Wellington, Christchurch and Dunedin hospitals.[40] Patients outside these centres needing treatment could either have X-ray therapy from local equipment or if "deep therapy" was required, they could travel to the main centre, or have an appropriate stock of radon sent out for their treatment. The maximum fee for a complete course of deep therapy was set at £25.[41]

By 1929, the combined radium stocks of Auckland, Wellington, Christchurch and Dunedin hospitals (in the form of pure radium, radium needles and radium plaques) was such that New Zealand had a greater supply per head of population than the United Kingdom. Wellington Hospital, with 650 mg of radium in the emanation plant plus 100 mg of radium available for use in needles and applicators, had the greatest supply. Smaller amounts of radium were held by Wanganui Hospital, Victoria University College, and by independent medical practitioners around the country.[42] Following consultation with radiologists using radium, the Department of Health decided that each main centre should have a one-gram supply.[43] By this time radium was selling for £12,000 per gram, which the *Dominion* described as "more costly than the rarest jewels".[44]

Smaller regional hospitals continued to request funds for their own radium supplies but by 1931 New Zealand was in the throes of the Great Depression. The Department of Health's budget had been slashed and money was not available for what was still considered unproven treatment. The Department of Health's stance was that:

> … knowledge in regard to radium and its uses is in a state of flux and the position needs clarifying as regards dosage, technique, and the form in which the Radium should be applied before further large sums of money are spent in purchasing additional supplies of this therapeutic agent.[45]

By this time, however, the British Empire Cancer Campaign Society (the forerunner of today's Cancer Society) was active in New Zealand and began subsidising smaller centres to purchase their own stocks of radium.[46]

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[40] Memo for Cabinet, 22 June 1926, H1, 15/1/6 (8486), *ANZ.*
[41] File note on deep therapy treatment in New Zealand, c.1929 in H1, 15/1/6 (8486), *ANZ.*
[42] Memo on radium element, 4 March 1929 and File minute on radium supply for hospital boards, 20 August 1929, H1, 15/1/6 (8486), *ANZ.*
[43] Memo on radium requirements for New Zealand, 25 May 1929, H1, 15/1/6 (8486), *ANZ.*
[44] *The Dominion,* 29 January 1930, p10; Memo on Subsidy on voluntary contributions for radium, 29 April 1929, H1, 15/1/6 (8486), *ANZ.*
[45] From Circular Letter No 21 Hosp 21/1931, H1, 131/1/6, *ANZ.*
[46] *The Timaru Herald*, 22 July 1931.

Other uses of radium

The mechanisms by which radiation worked as a cancer treatment – and therefore the potential dangers of its use – were not well understood by the public, or even by some medical professionals. If radiation was such a successful treatment for cancer surely it could be used for other conditions? Enthusiasm for radium led unscrupulous quacks and well-meaning medics to take advantage of the new therapy, prescribing first X-rays and then radium for all manner of ailments. Respected Dunedin Hospital radiologist Colin Anderson described radium being used in the 1920s to treat women with non-malignant conditions such as fibroids, or even irregular or excessive menstruation; the standard treatment was to insert a 50 mg tube of radium bromide into the uterus for 24 hours. Anderson noted, "haemorrhaging in young girls is even more difficult to control than in older women" and suggested that "fairly large doses may be given without fear of destroying ovarian function".[47] New Zealand, however, with its smaller population, escaped some of the most bizarre applications of radium. Internationally, radiation was also used to "treat" acne, ringworm, arthritis and depression and for cosmetic purposes such as banishing unwanted facial hair. Radium was also introduced to products as unlikely as toothpaste, contraceptive gels, face creams and even chocolate bars.[48]

New Zealanders who read magazines and newspapers from abroad would have been aware that radon, the radioactive gas that emanated naturally from radium, was being promoted in Europe and the United States as a cure-all and general tonic, often in the form of radon water. In New Zealand, the Rotorua Bathhouse – a large and elaborate complex in the style of a European spa – had the dubious distinction of including radon water among its list of "treatments", which otherwise included soaks in mineral springs, mud baths and a range of massage, hydro and electrical therapies. Following a visit to Europe, Arthur Wohlmann, the Government Balneologist, advised the manager of the Department of Tourist and Health Resorts that treatment by radioactive waters had come to stay and its "possibilities were very great". He recommended the purchase, for £250, of a "radium activator" to create radioactive water to sell at the Rotorua Bathhouse. Cabinet approved the purchase and the apparatus arrived in late 1914.[49]

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[47] C. C. Anderson, 'Results of X-ray and Radium Therapy at the Dunedin Hospital', *NZMJ*, 28, 146 (1929), pp200-211.

[48] Catherine Caulfield, *Multiple Exposures: Chronicles of the Radiation Age*, Penguin Books, London, 1989, p28; Quinn 1995, p410.

[49] Wohlmann to General Manager, Dept of Tourist and Health Resorts, 25 May 1914, TO1, 24/34, *ANZ; AJHR* 1914, Vol 3, H-2, p9; *AJHR* 1915, Vol 3, H-2, p10; Rockel 1986, pp28-36.

The radium activator consisted of a porcelain jug with a side tap for draining off water. Inside the jug, a small porcelain container contained a minute quantity of radium bromide (probably mixed with some other mineral salts) whose continuous emanation of radon gas irradiated any water that filled the jug. The radioactive water was to be drawn off and replenished daily. Radium, whose chief naturally occurring isotope radium-226 has a half-life of 1,620 years, could irradiate the water almost indefinitely. Radium's daughter gas, radon-222, however, had a half-life of less than four days, and to be "effective" users were told that the radioactive water had to be drunk within 24 hours of being drawn. Wohlmann tested and verified the radioactivity of the activated water and recommended each patient take four-to-six small glasses a day.[50] Wohlmann's recommendations demonstrated, on the one hand, a sophisticated understanding of the different radioactive elements and their relationship to each other, but, on the other hand, overconfidence in a type of "therapy" that had no scientific basis and involved ingestion of radioactive substances, which had already proved to be potentially harmful.

In a story about the bathhouse's new treatment, the *Rotorua Times* declared radioactive water to be especially valuable in treating gout and diabetes, soothing the nerves and "tightening loose teeth".[51] The radon water "therapy" was initially popular; Wohlmann said the treatment was successful and a number of patients were sent to Rotorua with the express purpose of taking the radon water. Sales of Rotorua's radon water peaked in 1916, when more than 8,500 glasses were sold. After that, however, there was a steady decline in sales, with returns dropping by almost 50 per cent each year.[52] It is likely there was an element of enthusiasm for a new fad that contributed to the initial popularity of radon water therapy. By 1922, however, by which time John Duncan had succeeded Wohlmann as Government Balneologist, sales of radon water had declined to less than 300 glasses a year, and the general manager of Tourist and Health Resorts asked Duncan to "take steps to have the sale of radium water discontinued". The declining sales, and the manager's wish to have sales discontinued, were possibly because of increasing evidence that radium could be harmful. Radon water sales continued for two years after the request to discontinue but by 1925, when the general manager asked the tourist manager now in charge of the Rotorua Bathhouse about the location of the radium emanation apparatus, he was told that the jar, inside of which was "a porcelain cylinder containing what appears to be a kind of earth" was chipped and broken and sitting in a storeroom. Let's hope the tourist manager didn't investigate the "earth" too closely, because there are potentially fatal consequences of

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[50] Wohlmann to General Manager, Dept of Tourist and Health Resorts, 25 May 1914, TO1, 24/34, *ANZ; AJHR* 1914, Vol 3, H-2, p9.
[51] *Rotorua Times*, 30 October 1914 in TO1, 24/34, *ANZ*.
[52] TO1, 24/34, ANZ; *AJHR* 1915, Vol 3, H-2, p10.

touching even minute quantities of radium, consequences which by this time were beginning to be appreciated.[53]

Hazards of radioactivity realised

Enthusiasm for X-rays and radium lasted long after radiation had been shown to cause superficial burns and more serious damage. Thomas Edison and his assistants suffered problems with their eyes following X-ray exposure as early as 1896, and skin damage following X-ray exposure was reported later that year.[54] In 1901 Pierre Curie and Henri Becquerel published a paper in which they described the burns they had received – both intentionally and inadvertently – from exposure to radioactive substances.[55] It was public knowledge that there were dangers associated with radioactivity. In 1905, Rutherford, lecturing to a crowded hall at Canterbury University College, complained he was not able to illustrate his lecture on “Radium and its Transformations” with striking experiments “because it was hardly safe to carry in one’s cabin a sufficient amount of radium to make such experiments”.[56] Some New Zealand scientists and medics, however, were rumoured to have radium even closer to their person – there are reports of both Masterton doctor William Hosking and Wellington physicist Charles Watson-Munro carrying radium around in their pockets.[57]

The science of radiology was new, and practitioners in New Zealand as well as overseas experimented with arrangements of equipment and procedures. As with any new technology, there were accidents and mishaps. While it was noticed very early that X-rays could cause skin burns, the more long-term effects of the radiation were not initially known. In addition, the machines were rarely earthed, and operators were at risk from electrical shock as well as radiation.[58]

New Zealand doctors and technicians did not escape harm. In 1905 Mr Wright, the electrical instructor at the Thames School of Mines, overexposed his hand in an X-ray machine. John Campbell, Rutherford’s biographer, recounts that the “wound would not heal, creating great medical interest as the first case of x-radiation injury in Australasia”. The pain was so great that Wright chose to have his hand amputated rather than travel to the United Kingdom for

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[53] TO1, 24/34, ANZ; *AJHR* 1922, Vol 2, H-2, p4; *AJHR* 1923, Vol 2, H-2, p5; *AJHR* 1925, Vol 3, H-2, p5.
[54] G. E. Roth, ‘Radiation Protection: Historical Aspects and Radiographer Responsibilities’, *Shadows* 16, 4 (1973), pp6-14.
[55] Quinn 1995, p180
[56] *The Press*, 29 July 1905, p10.
[57] *Sunday Star*, 10 April 1988, pA-13; Ryan et al 1996, p295.
[58] A. C. McEwan, *Radiation Protection and Dosimetry in New Zealand: A History of the National Radiation Laboratory*, NZ Department of Health, Wellington, 1983, pp13, 29; Ryan et al 1996, p297.

treatment.[59] Medical practitioners from around the country received radiation damage to their hands, from either handling radium, or from exposure to X-rays. As well as being exposed to scattered radiation, resulting from poor shielding of X-rays tubes, operators regularly exposed themselves to radiation through a process known as “setting the tubes”. The operator placed their hand between the radiation tube and the fluorescent screen, and adjusted the equipment until a sharp image of the bones of the hand appeared on the screen. When using a screen rather than film, the exposure had to be long enough for the doctor to study the picture, and they would often stand in the path of the radiation to get a better view of the screen. Frequent and prolonged use of these practices often led to radio-dermatitis and, eventually, to radiation-induced cancer. Many New Zealand medics suffering X-ray burns complained of ongoing pain and some were forced to retire.[60] A dentist who had seen many colleagues with radiation burns to their hands described the condition as “excruciatingly painful … absolutely demanding morphia for the control of pain”.[61] Other medics, including Dr Clark, an Auckland Hospital radiographer, Dr Keith Macky, an Auckland orthopaedic surgeon who did a lot of X-ray work, and Dr Donald J. Goodwin of Whangarei, whose desk was next to the X-ray chest stand, were unknowingly receiving radiation that would eventually lead to their deaths from cancer. Christchurch’s Clennell Fenwick suffered radiation damage to his fingers from handling radium, and Percy Cameron, who worked first in Dunedin and then in Wellington, suffered blindness, as well as hand and bone injuries caused by radium handling.[62]

Patients, too, were often victims of what radiologist Colin Anderson later referred to as “ignorance” or “irresponsibility”. In his history of the development of radiology in New Zealand he recounted an episode in a North Island hospital where a patient was receiving treatment to the anterior chest wall. The hospital matron who was administering the treatment was called away and forgot about the patient, who suffered an X-ray burn the thickness of his chest wall. Several years later a man died in Timaru Hospital from a huge carcinoma of the anterior abdominal wall, which had developed at the site of extensive X-ray burns received some years earlier while he was receiving radiotherapy.[63] Dental X-rays had their own hazards. An

[59] Campbell 1999, p291.
[60] Anderson 1966, p303; Campbell 1995, p177; Caulfield 1989, pp10-11; Bennett 1962, p194.
[61] W. A. Knox, ‘Protective Measures in Dental Roentgenology’, *New Zealand Dental Journal*, March 1920, p137.
[62] Anderson 1966, p303-4; Ryan et al 1996, p303-304.
[63] C. C. Anderson, ‘Radon Ointment in Superficial Radiation Injuries’, *New Zealand Medical Journal* (NZMJ), 58, 323 (1959), pp69-71; Anderson 1966, p303. (Radon ointment was probably not used in New Zealand until the 1940s when its use in America was reported, and continued in use until at least the 1960s.)

account in the *New Zealand Dental Journal* told of a patient who suffered complete hair loss for six months, as well as persistent dermatitis of the scalp, following a series of dental X-rays.[64]

One treatment for radiation burns was, ironically, radon ointment. The ointment used was a preparation of radon in Vaseline. Following the idea that radiation accelerated healing, the ointment was used to treat small skin areas suffering necrosis after radiotherapy.[65]

Radiation-induced cancer

While it was established early on that radiation could cause superficial burns and skin irritations, by 1920 a terrible irony had emerged concerning the medical use of radiation. While radiation was found to be wonderfully effective in *treating* cancer, scientists and physicians concluded it was also instrumental in *causing* cancer, as well as sterility, bone disease and other afflictions.[66]

The cancer-risk of working with even small amounts of radioactive material came to light in the late 1920s with the widely published fate of the radium dial painters in the United States. The United States Radium Corporation factory in New Jersey employed up to 250 dial painters. The workers, mostly young women, sat side by side at long workbenches using radium paint to illuminate numerals on the dials of soldiers' wristwatches, aeroplane instruments, and other military equipment. To get a fine point on the brush for more control over their work, the women would wipe the radium-contaminated brush between their lips. While the dangers of gamma radiation from radium were known by this time, radium paint, containing one part radium to some 30,000 parts zinc sulphide, was not believed to be dangerous.[67]

The radium paint business flourished after the First World War, with radium used to illuminate millions of wristwatches along with dolls' eyes, gun-sights and fish-bait. Then, between 1921 and 1924, three of the United States Radium Corporation's dial painters died, seemingly from natural causes. Many of the other dial painters began having serious problems with their teeth and jaws. The dial painters were variously diagnosed with necrosis of the jaw, phosphorus poisoning, anaemia and stomach ulcers.[68]

[64] Knox 1920, p136.
[65] Hugh Jamieson, 'Early Hospital Physics in NZ: Some Memory Fragments (1945-95)', in Hugh Jamieson (ed), *The Development of Medical Physics and Biomedical Engineering in New Zealand Hospitals 1945-95,* 1995, p9.
[66] J. Samuel Walker, *Permissible dose: A History of Radiation Protection in the Twentieth Century,* University of California Press, Berkeley, 2000, p3.
[67] Caulfield 1989, pp29-40; Barrie Lambert, 'Radiation: Early Warnings; Late Effects', in Paul Harremoes (ed), *The Precautionary Principle in the 20th Century: Late Lessons from Early Warnings,* Earthscan Publications, London, Sterling VA, 2000, pp32-33; Walker 2000, p4-5.
[68] Caulfield 1989, pp29-40; Walker 2000, pp4-5.

A 1925 investigation found the incidence of anaemia and infected mouths among former employees of the United States Radium Corporation to be beyond coincidence. More thorough investigations followed. All the dial painters examined had abnormal blood counts. On being examined in a dark room, the women were found to be luminous – their faces, hair, hands, arms, even their corsets and underwear glowed in the dark, contaminated by minute particles of radium. The same year, a paper in the *Journal of the American Medical Association* described radium's "deadly … rays" and reported that once radium entered the body it spontaneously and continually irradiated the "blood forming centres" and over time could cause severe anaemia and other disorders. By 1928 at least 15 dial painters had died from confirmed radium poisoning. Five former employees of the United States Radium Corporation received wide publicity and public sympathy when they filed a lawsuit against the company.[69]

The injuries and deaths of the radium dial painters taught scientists and doctors that internal exposure to radium could be fatal, and had to be controlled. Continued medical investigations of the dial painters provided information about the behaviour of ionizing radiation in the body, showing that rather than being passed straight through the body as previously thought, these isotopes accumulated in various organs – radium tended to accumulate in the bones – from where it irradiated the surrounding cells.[70] At about the same time as these links were being made, the American biologist Hermann J. Muller established that X-rays could induce detrimental genetic mutations and chromosomal changes in fruit flies.[71] This 1927 discovery provided a vital clue as to how exposure to radiation could lead to cancer.

Evidence for the links between radiation exposure and cancer continued to build and was published internationally, including in New Zealand. In 1929 the American Medical Association condemned the use of radiation to remove unwanted body hair, and in 1932 it withdrew radium from its list of remedies approved for internal administration. By 1934 more than 200 American radiologists were reported to have died from cancers attributed to radiation exposure. And in July 1934, Marie Curie, the celebrated discoverer of radium, died from pernicious anaemia after suffering years of ill health resulting from her exposure to radium; her fingers were already scarred by a painful radiodermatitis and her eyes clouded by radiation-induced cataracts.[72]

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[69] Caulfield 1989, pp28-40; Quinn 1995, p411; Walker 2000, pp4-5.
[70] Caulfield 1989, pp28-40; Walker 2000, pp4-6.
[71] Nobel Prize organisation Internet entries on Muller at: http://nobelprize.org/medicine/laureates/1946/muller-bio.html, downloaded 4 October 2005.
[72] Caulfield 1989, pp28-40; G. E. Roth, 'Radiation Hazards: A Survey'. Department of Health, 1952, p3; Quinn 1995, pp410, 416, 431-2; Walker 2000, pp4-7.

In New Zealand, there was growing public awareness of the hazards of radiation exposure. The *Evening Post* of 21 January 1933 reported from London on the perceived need for control of radium, which Lord Lee of Fareham described as "the most lethal and dangerous of poisons". In 1932, the American millionaire industrialist and golf champion Eben Byers had died after drinking three bottles of radioactive water a day for several years. His anaemia, brain abscess and necrosis of the jawbone were attributed to radium poisoning. The case was widely publicised and radon water, along with other radium-based "health" products, declined in popularity.[73] The *Evening Post* reported on Byers's fate, describing the radon water as causing "intense suffering" and "a slow death".[74] By this time the sale of radon water at the Rotorua Bathhouse had been discontinued, but Byers's death did not stop an enterprising company trying to sell radon water in New Zealand in the 1950s.[75]

Radium continued to be used to treat benign medical conditions, however, despite its potential for skin damage and radiation burns. As late as the 1940s, X-rays were used to treat eczema, warts, acne and even birthmarks (naevi); the practice was advertised as £1 for the first treatment and 5 shillings for subsequent treatments.[76]

Charles Hines, the radiographer in charge of Christchurch Hospital's radium department, described the practice of radiotherapy treatment of naevi:

> A [radium] plaque is applied, with strapping, in close contact with the naevus for 12 minutes. The treatment is absolutely painless, which is a great advantage for it is best commenced at a very early age – six to eight weeks. Most naevi show a definite paling and diminution in size in two or three weeks after treatment, which is repeated at monthly intervals. Six or eight treatments are usually necessary to effect complete disappearance, though naturally, much depends on the size of the lesion, which can vary from the size of a lentil to – in some cases – an area of skin covering perhaps the whole of an arm and shoulder.[77]

Despite the mounting evidence of the dangers of radioactivity, many people still considered it to be curative. In 1936 the Department of Scientific and Industrial Research (DSIR) conducted tests on a "specially prepared flannel said to possess radioactive properties" promoted for the treatment of various complaints. Thankfully for any users of the flannel, it was found to contain

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[73] Caulfield 1989, p28; Lambert 2000, p33; Paul W. Frame, 'Radioactive Curative Devices and Spas', originally published in the Oak Ridger newspaper, 5 November 1989, downloaded from www.orau.org/ptp/articlesstories/quackstory.htm on 1 June 2004; Walker 2000, p4.
[74] *Evening Post*, 15 April 1932.
[75] Radon Sparklets Bulbs promotional material in H1, 108/11 (26717) *ANZ.*
[76] North Canterbury Hospital Board scale of charges, November 1931, H1, 15/1/6 (8486), *ANZ;* Jo Kellaway and Mike Maryan, *A Century of Care: Palmerston North Hospital 1893-1993,* Focus Books, Double Bay, 1993, p46.
[77] Charles F. Hines, 'The Use and Care of Radium in Hospital Practice', *New Zealand Nursing Journal*, 34, 12 (1941), p403.

little detectable radioactivity.[78] Holidaymakers and invalids continued to flock to the "Radium Bath" at the Rotorua Bathhouse, which was widely believed to have therapeutic radioactive qualities, even though it contained "less radium than ordinary tap-water".[79]

Safety measures introduced

The Department of Health took the initial lead in alerting practitioners to the hazards of working with X-rays and radium, though it was some time before concerns about patients caught up with concerns about medical staff. Departmental staff kept up to date with radiation safety measures being recommended in the United Kingdom, Australia and the United States and, while there were no official safety standards in New Zealand, hospitals were alerted to relevant literature, with recommendations that they adopt the overseas standards. In a 1921 circular, the Department of Health drew the attention of hospital medical superintendents to the September 1921 issue of the *New Zealand Journal of Health and Hospitals*. Alongside articles on the risk of anthrax infection from Japanese shaving brushes and the disinfectant properties of tobacco smoke, was a report on the preliminary findings of the British X-Ray and Radium Protection Committee.[80] The report was concerned with the safety of people working in X-ray and radium departments. The dangers of overexposure to radiation and X-rays were reported as including "visible injuries to the superficial tissues" and "derangements of internal organs and changes in the blood". Recommendations included advice on the use of lead screens, shields and gloves to help protect the operator from radiation exposure from X-rays, and guidelines for the safe handling of radium, which it advised, "should always be manipulated with forceps or similar instruments and … carried from place to place in long-handled boxes lined on all sides with 1 cm of lead". The committee also recommended that periodic blood tests be taken from radiation workers, in order to recognise any changes at an early stage. [81]

The report made recommendations that employees in X-ray and radium departments should:
- work not more than seven hours a day
- have Sundays and two half-days off duty each week, "to be spent as much as possible out of doors"
- have an annual holiday of one month or two separate fortnights.[82]

These recommendations were not always heeded. John Campbell, senior radiographer for the

[78] *AJHR* 1937-38, Vol 3, H-34, p88.
[79] Wohlmann to General Manager, Dept of Tourist and Health Resorts, 25 May 1914, TO1, 24/34, *ANZ*.
[80] 1921 circular letter (various dates, ~September) from Dept of Health to medical superintendents, in H1, 53/19 (28298), *ANZ*; *New Zealand Journal of Health and Hospitals (NZJHH)* 4, 9 (1921), pp249-251.
[81] *NZJHH* 4, 9 (1921), pp249-51.
[82] *NZJHH* 4, 9 (1921), pp249.

Auckland Hospital Board, recalled in 1952 that in the 1920s he "was on duty every night, week end, high days and holidays, without pay or time off in lieu".[83] The same issue of the *New Zealand Journal of Health and Hospitals* alerted readers that exposure to radium was believed to be more dangerous than exposure to X-rays, with prolonged exposure leading to possible death from pernicious anaemia. (Though how seriously the article was taken is not clear – it was followed by a story on the "dangers of excessive tea drinking".[84])

Despite New Zealand's early adoption of X-ray technology, in 1922 David Wylie, Director of the Department of Health's Hospitals Division, considered that the "general standard of X-ray work is poor in the majority of hospitals". Wylie called for hospital boards to keep X-ray equipment up to date, and to follow the British habit of employing and training "radiographers" to operate the X-ray apparatus.[85] The following year, the number of injuries and accidents to both radiographers and patients prompted the Director-General of Health, Thomas Valintine, to tighten the conditions under which radiographers operated by issuing an edict that a radiologist should always be present during the administration of X-rays and X-ray therapy. Valintine also consulted radiologists in Auckland, Wellington and Dunedin, and approached the four university colleges, the technical schools, the Education Department, the Society of Radiographers and the School for Radiographers at King's College in London.[86] His subsequent draft bill for the registration of radiographers sought to establish them as medical auxiliaries with the right of unrestricted practice. Anderson reports, however, that amongst the more highly-trained radiologists the draft bill suffered "universal condemnation" as a result of the radiographers being given the right of unrestricted practice.[87]

Operator safety was, however, already beginning to be taken more seriously. In 1922 Dunedin radiologist Percy Cameron was described as wearing gloves and a lead-leather apron and retiring to a lead-lined room to operate the X-ray table.[88] In 1924, when Christchurch Hospital installed a new X-ray therapy plant, the operator was "situated in a room as far distant from the tube as possible, the walls and ceilings of which are lined with heavy sheet lead".[89] Radium used for cancer treatment was stored in a block of lead to protect the attendants from injury.[90]

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[83] John L. Campbell, 'Thirty-six Years in Radiography', *Health and Service*, 8, 1 (1953), p49.
[84] *NZJHH* 4, 9 (1921), p260-61.
[85] *AJHR* 1921-22, Vol 3, H-31, p19.
[86] Ryan et al 1996, p304.
[87] Anderson 1966, 298-9; Borrie 1973, pp15-27.
[88] *Otago Witness*, 11 April 1922, TO1, 24/34, *ANZ*.
[89] The *Press*, 5 December 1924, p14.
[90] *Christchurch Star*, 20 March 1925, in H1 85/46, *ANZ*.

At the second meeting of the International Congress of Radiology in 1928, a consortium of international groups established the International X-ray and Radium Protection Committee. The committee, which was made up of scientists and doctors, made recommendations to reduce hazards in the operation and handling of radiation technology such as specifying the thickness of lead used to shield X-ray tubes and the walls of rooms storing radium. Their recommendations had no statutory authority, however, and were directed wholly at people who worked with X-rays, such as physicians and radiographers, with no reference to the patients receiving treatment.[91]

The lack of precision (compared to today) in the early use of X-rays resulted in varying doses being received by patients, in part due to a lack of consensus as to the appropriate dose as well as imprecise practices and equipment. Decades later, Auckland radiographer John Campbell recalled the procedure for taking an ankle X-ray in the 1920s, which illustrates the potential for electrical (as well as radiation) danger posed by much of the early X-ray equipment:

> The expose time for an ankle was about 15 seconds. As no timing device was incorporated in this model we used the old photographic method – one, two, three, etc., etc., eventually arriving at 15. Another couple of seconds were added for luck. This proved alright if the tube had not emitted several sparks and frightened the patient and he or she had not moved … .[92]

The idea of a safe radiation dose, or "tolerance dose" was considered by the 1928 International Congress of Radiology. Radiation was initially measured by epilation dose (an amount of radiation that would make a subject's hair fall out) or multiples or fractions of an erythema dose (an amount of radiation that would cause the skin to become red and inflamed) but these were inexact and very subjective measures. The International Congress of Radiology chose the roentgen (R) as the unit of X-ray measurement and defined it as the amount of radiation needed to produce a given number of charged ions in a given amount of air. In 1934 the International X-ray and Radium Protection Committee recommended an exposure limit of 0.2 R a day, or 1 R a week. As an extra safety precaution the United States adopted an exposure limit of 0.1 R a day. While exposure to radiation was now recognised as potentially harmful, levels below the tolerance dose were believed to be safe and unlikely to cause permanent damage.[93]

The New Zealand Department of Health continued to keep medical superintendents of all public hospitals advised of international safety advice. In a 1933 letter, the Department drew attention to a revised report of the British X-Ray and Radium Protection Committee published over three

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[91] Caulfield 1989, p17; Lambert 2000, p33; Roth 1973; Walker 2000, p7.
[92] Campbell 1953, p49.
[93] Caulfield 1989, pp17-18, 21; McEwan 1983, p18; Walker 2000, pp7-8.

issues of the *Journal of the Hospital Boards' Association*, and to "further suggestions for the safe custody of radium and precautions to be taken when using radium and radon" contained in two Australian publications.[94] The British recommendations made detailed guidelines with regard to radium therapy, designed to protect workers from the effects of beta rays on the hands, and the effects of gamma rays on "the internal organs, vascular and reproductive systems". Once again, the committee recommended that radiation workers have three-monthly blood tests to detect any changes at an early stage.[95] No New Zealand regulations were drawn up, however, and initiative on the part of the medical superintendents and hospitals was required to research and act on the overseas findings and recommendations.[96]

Before the Second World War, radium and radon were transported around New Zealand by post in ordinary cardboard containers. The photographic company Kodak contacted the Department of Health in 1937, alerting them to the possibility that radioactive material could damage photographic film transported in close proximity. New Zealand had no guidelines regarding the transport of radioactive materials and Kodak's concerns about their film quickly translated into concerns about the possibility of postal workers being unwittingly exposed to radiation. The Department of Health decided to seek the advice of the National Radiation Committee of Great Britain and the New Zealand branch of the British Empire Cancer Campaign Society.[97]

The expert on this matter was physicist Jack Strong, of the British Empire Cancer Campaign Society's Travis Radiophysical Laboratory. Strong looked at the amount of radon Wellington Hospital was sending out from its radon plant and calculated that if one postal worker were responsible for carrying all the radon posted, and if he carried each delivery package for an average of two hours at a distance of 10 cm from his skin, he would receive a radiation dose of 160 R during the year. The tolerance dose at this time was 100 R per year, which Strong called "an exceedingly conservative estimate". The radon was sent to a variety of sources, however, and no one postman had been exposed to the year's supply.[98]

To further clarify the issue, the Department of Health sought information from the British High Commissioner who referred them to the regulations laid down in the International

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[94] The Third Annual Report of the National Radium Trust and Radium Commission and the Report of the Fourth Australian Cancer Conference in Canberra.
[95] *Journal of the Hospital Boards Association of New Zealand,* September 1933, p24-6.
[96] Circular letter from Director-General of Health to medical superintendents of all public hospitals, 14 August 1933, H1, 53/19 (28298), *ANZ.*
[97] Letter from Dunedin Hospital to Director-General of Health, 23 September 1937 and Memo on Protection of radium in transit through post, 11 October 1937, H1, 53/19 (28298), *ANZ.*
[98] Letter from J. A. Strong to Director-General of Health, 1 November 1937, H1, 53/19 (28298), *ANZ.*

Recommendations for X-ray and Radium Protection (of which the New Zealand authorities should have been aware) and the Recommendations of the British X-ray and Radium Protection Committee. The New Zealand authorities were advised that in the United Kingdom, the Post Office authorities permitted up to 50 mg of radium to be sent by post provided the radium was "completely surrounded by one inch of lead".[99] Clearly, the New Zealand safety standards were lacking.

The Department of Health circulated revised International Recommendations for X-ray and Radium Protection in 1942. In an accompanying letter, Michael Watt, who had succeeded Valintine as Director-General of Health in 1930, noted that he believed the recommendations were "already being observed" but asked that staff members be alerted to the recommendations.[100] The international recommendations advised that discretion should be exercised in transmitting radium salts by post, with quantities of up to 50 mg radium able to be posted provided they were in lead-lined boxes. The general recommendations aimed to reduce overexposure to X-rays and radium by providing staff with adequate protection – such as lead screening – and suitable working conditions. With the tolerance dose still at 1R per week, it was recommended that staff carry photographic film badges to measure cumulative radiation exposure.[101]

Despite the new focus on safety, there were still mishaps and carelessness. Radium, expensive and potentially dangerous, was not always treated with the care it deserved. On at least two occasions radium needles used in New Zealand hospitals were accidentally thrown in the rubbish and incinerated, though in both recorded accounts, from 1924 and 1939, the valuable substance was safely recovered.[102] Well into the 1940s, however, New Zealand's medical radiation safety measures were lacking. As Dr Colin Alexander, a house surgeon at Auckland Hospital, recalled to Ryan, Sutton and Baigent:

> … my dominant memory of the early days is the cavalier attitude to X-ray safety, notwithstanding the plain evidence of the potential dangers … In Auckland, the main X-ray room had about four tables, all working simultaneously, separated only by curtains, resulting in a bath of whole body radiation for all concerned. We all had regular blood counts and had extra holidays to compensate for the hazard, but the documented lack of any detectable ill-effect eventually led to our losing the latter perk.[103]

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[99] Memo from British High Commission to Prime Minister, 9 December 1937, H1, 53/19 (28298), *ANZ.*
[100] Circular letter to hospital boards, 21 January 1942, H1, 53/19 (28298), *ANZ;* Derek A Dow, 'Watt, Michael Herbert 1887-1967', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded on 10 October 2005.
[101] International recommendations accompanying circular letter to hospital boards, 21 January 1942, H1, 53/19 (28298), *ANZ.*
[102] Roth 1963, p12; Angus 1984, p155.
[103] Ryan et al 1996, p339.

Travis Radiophysical Laboratory

The New Zealand branch of the British Empire Cancer Campaign Society (now the Cancer Society of New Zealand) was established in Wellington in 1929 to encourage the establishment of cancer treatment clinics and research into the causes of cancer.[104] While tuberculosis was the nineteenth century's biggest killer, better living conditions and hygiene standards, coupled with an increased life expectancy, had led heart disease and cancer to eclipse tuberculosis in causing fatalities. By 1928, New Zealand's cancer death rate was 9.87 per 10,000 people per annum, nearly double the rate from tuberculosis and second only to heart disease in causing mortality.[105]

The Society received subsidies from the Department of Health, and money from public donations. In 1933 the Travis Trust, which was established from the estate of the late William Henry Travis of Christchurch, offered the Society £500 a year for three years to pay the salary of a physicist. Jack Strong – a Victoria University physics graduate and a radium attendant at the hospital since 1932 – was appointed to run the Laboratory. After training in Australia, Strong set up a laboratory and workshop in the basement of Wellington Hospital where he took charge of the radium plant previously staffed part-time by science students, and began to provide cancer treatment centres with help in dealing with the physical aspects of radiation therapy.[106] As well as operating the radon plant, which captured the radon gas emanating from a supply of radium and packaged it for supply to treatment centres around New Zealand, he set up New Zealand's first standards for measuring radiation dosage and travelled to the four main centres to provide advice to radiotherapists and calibrate X-ray apparatus used in radiotherapy.[107] It was now recognised that the success of radiotherapy depended on the accurate measurement and administration of the treatment dose. Successful treatment was a function of experienced technicians, and well-calibrated equipment.[108]

Strong found working conditions at Wellington difficult: the basement room used for standardisation work was found to have high levels of radioactive contamination.[109] In 1937, when Canterbury University College offered to accommodate a specialised X-ray and radium laboratory, and the trustees of the Travis Trust agreed to help pay for it, the Society moved the

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[104] Gordon Parry, *Clipping the Claws: The Story of the First 60 Years of the Otago and Southland Division of the Cancer Society of New Zealand*, Otago and Southland Division of the Cancer Society of New Zealand, Dunedin, 1989, pp5-6.
[105] *AJHR* 1929, Vol 3, H-31, pp6, 8.
[106] G. E. Roth, 'The Physical Services to Radiology in New Zealand', *NZMJ*, 45, 248 (1946), pp384-8; *AJHR* 1934-35, Vol 3, H-31, p5; McEwan 1983, p35.
[107] G. E. Roth, *The Strong Memorial Lecture 1963*; Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, HI, 108/11 (26758) *ANZ;* Anderson 1966, p305.
[108] Roth 1946, p384; Anderson 1966, p305.
[109] From Strong's six-monthly reports on his work, quoted in G. E. Roth, *The Strong Memorial Lecture 1963*.

centre of its radiological service to Christchurch.[110] The Travis Radiophysical Laboratory was transferred to the science department of Canterbury University College where Strong was joined in 1938 by George Roth (who succeeded Strong when he died in 1941). The laboratory's first task was to set up standardisation equipment and to calibrate all of New Zealand's therapeutic X-ray plants and clinical dosimeters (used to measure radiation dose) to this standard. Most developed countries, including the United Kingdom, United States and Germany, inspected X-ray installations only as required and on a cash-for-service basis. In contrast, New Zealand, like Sweden and Australia, established a nationwide physical calibration scheme, whose service was free of charge. The New Zealand service was unusual in that it was set up and organised by a private body, the British Empire Cancer Campaign Society, under close cooperation with the Health Department.[111] For the next 10 years, the Travis Radiophysical Laboratory provided a free service whereby its two physicists visited up to 26 X-ray therapy plants and 18 clinical dosimeters twice a year to calibrate equipment against the laboratory's portable standards and to advise on measures to protect patients and staff from radiation and electrical risks.[112]

Figure 3.6: The Electrical Wiring (X-Ray) Regulations aimed to protect operators and patients from the electrical hazards associated with X-ray equipment. This dental X-ray machine, installed in the 1930s, had an uninsulated overhead high tension wire, which could have caused electric shocks if touched while in use. Source: National Radiation Laboratory, Christchurch, NZ.

[110] Roth 1946, p384; McEwan 1983, p40.
[111] Anderson 1966, p305; McEwan 1983, pp40-42; Roth 1946, p385-6.
[112] Roth 1946, p386-7; *AJHR* 1944, Vol 2, H-31, p3.

In the 1940s, radiologists began taking a leading role in promoting the safe use of radiological equipment. Despite the safety measures introduced by individual hospitals during the preceding two decades, by the 1940s some New Zealand radiologists were expressing concern about the safety of their staff and patients. With no national standards or monitoring procedures in place it fell to individual radiologists to ask the Laboratory to measure the cumulative dose received by individual staff members, and to advise on improvements to existing protective measures.[113] It had also become clear that without a complete record of all publicly and privately owned X-ray plants it was impossible to ensure adequate protection for all X-ray workers at the country's many hundred widely scattered installations.[114] The Laboratory was impressed by the radiologists' requests, and the "severe damages" which they observed had been sustained by some workers. Discussions at a 1943 conference of radiologists called by the Health Department led to drafts being prepared for recommendations and regulations to cover electrical and radiation protection.[115] The next year, in the interest of safety and accuracy, New Zealand radiologists called for all users of X-ray equipment to be registered and for calibration visits to be extended to all diagnostic X-ray plants, as well as to therapy plants.[116]

The Electrical Wiring (X-ray) Regulations were introduced in 1944, by which time there were at least 450 X-ray plants believed to be operating in New Zealand. These regulations provided technical provisions for the electrical safety of X-ray plants and for the first time, required the registration of all X-ray plants.[117] It was not until 1949, however, that radiation protection was also subject to regulation.

Radiation sciences firmly established in medicine

By the beginning of the Second World War, the New Zealand medical system was dependent on radiation technology. Many of the staff now working in radiology departments had studied overseas, and radiology and radiography were becoming more established sciences.[118]

The free hospital care, including X-ray examinations and treatment, established under the first Labour Government's Social Security Act 1938, led to an increase in demand for diagnostic X-rays and a consequent increased workload for radiographers and radiologists, especially when

[113] Roth 1946, p387.
[114] Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, HI 108/11 (26758), *ANZ.*
[115] Roth 1946, p387-8.
[116] Roth 1946, p388.
[117] The Electrical Wiring (X-ray) Regulations 1944, *New Zealand Statutory Regulations 1944,* pp429-436; Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, HI, 108/11 (26758), *ANZ;* McEwan 1983, p48.
[118] Anderson 1966, p298.

out-patient benefits were introduced in 1941 and many people took the opportunity to have a free medical check-up.[119]

The advent of the Second World War led to a further increase in the demand for X-rays in New Zealand. In September 1939, as a step towards eliminating people suffering from active tuberculosis from the armed services, X-ray plants were installed in the military training camps at Burnham, Trentham and Papakura and all military recruits were given a chest X-ray. This screening was later conducted at hospitals around the country.[120]

By the 1940s the death rate from tuberculosis was at an all-time low but it was still a significant health problem, especially for Maori, whose tuberculosis death rate was up to 10 times higher than that for non-Maori. In 1941 the Department of Health began X-raying every Maori secondary school pupil to try to stop the spread of undiagnosed tuberculosis. The establishment of the Department of Health's new Division of Tuberculosis further increased the demand for X-rays. Their research into the incidence of tuberculosis involved the initiation of mass miniature X-ray programmes for early identification of the disease. Chest X-rays were required for all new apprentices, for entrants to teachers' training colleges, and for trainee nurses and dental nurses. (Applicants found to have tuberculosis were not considered acceptable candidates.) This all put a strain on the country's X-ray facilities, and the hospitals were unable to keep up with demand.[121]

The Second World War also impacted on the radon that Wellington Hospital had supplied to hospitals around the country since its radon plant was established in 1925. In 1940 George Roth was commissioned to dismantle the plant, extract its 650 mg supply of radium, and arrange for it to be safely stored until the war was over.[122]

Understanding and using the atom

While scientists and medics throughout the world were taking advantage of the discoveries of X-rays, radium and radioactivity, physicists and chemists continued to seek a better understanding of the atom, its particles, and their properties. Against general scientific opinion, the novelist H. G. Wells predicted in 1914 that the energy in the atom would become available for use. In *The*

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[119] Anderson 1966, p300-1; Social Security Act 1938, *Reprint of the Statues of New Zealand 1908-1957, volume 14,* Government Printer, Wellington, 1961, pp475-577; *AJHR* 1941-42, H-31, p5.
[120] Bennett, p196; T. Duncan and M. Stout, *Medical Services in New Zealand and the Pacific*, Wellington, Department of Internal Affairs, 1958, pp324-6.
[121] *AJHR*, 1941, Vol 2, H-31, p21; *AJHR* 1944, Vol 2, H-31, p5; Memo from Christchurch Medical Officer of Health to Director-General of Health, 28 October 1943, in H1, 181/199 (24106), *ANZ;* Derek A. Dow, *Safeguarding the Public Health: A History of the New Zealand Department of Health,* Victoria University Press, Wellington, 1995, p133-4.
[122] Anderson 1966, p305.

World Set Free Wells envisaged a European conflict involving “atomic bombs” and after which “atomic energy” would be used for the benefit of humankind.[123] The book was widely discussed, but Rutherford – despite his earlier joke that “some fool in a laboratory might blow up the universe unawares”[124] – dismissed Wells’s claims, saying to the *New Zealand Herald* in 1914 “it did not appear within the region of possibility that a substance could be manufactured having the properties of Wells’s bombs”.[125]

Rutherford left Manchester in 1919 and returned to the Cavendish Laboratory at Cambridge, this time as director of the laboratory, following the resignation of J. J. Thomson.[126] Here he concluded from a series of experiments in which he had bombarded nitrogen atoms with alpha particles from a radium source, that the nitrogen atoms were being transformed into oxygen atoms, with a hydrogen nucleus – later called a proton – ejected. Rutherford had “split the atom” and the science of nuclear physics – the manipulation of the atomic nucleus – was launched.[127]

In New Zealand, though, physics was still a poor relation to the biological and earth sciences. In 1919, zoology, botany and geology continued to dominate the *Transactions and Proceedings of the New Zealand Institute*. Of more than 3,000 papers published over the 50 volumes of the journal, only 152 were under the heading of physics, and these included papers on astronomy and meteorology.[128] (These figures did not, however, fully reflect the output of the New Zealand Institute’s members, because, with a topic like physics, without regional boundaries, members were perhaps more likely to publish their work overseas, particularly in scientific journals in the United Kingdom.)

One of the people who would have the greatest influence on New Zealand radiation and nuclear science was Rutherford’s ex-student, Ernest Marsden. In 1922 Marsden left his position as Victoria University’s professor of physics to become assistant director of education. His most influential position, however, was as first permanent secretary of New Zealand’s brand new Department of Scientific and Industrial Research (DSIR). In this role, taken up in 1926, Marsden became a champion of nuclear science and technology in New Zealand. As well as dealing with the management and administration of the DSIR, whose initial focus was on scientific issues of

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[123] H. G. Wells, *The World Set Free: A Story of Mankind*, London, Macmillan and Co, 1914.
[124] This is an unsourced quote but is widely attributed to Rutherford.
[125] *New Zealand Herald*, 31 August 1914, p8.
[126] Mark Oliphant, *Rutherford: Recollections of the Cambridge Days*, Amsterdam, New York, Elsevier Pub. Co., 1972, p15.
[127] Oliphant 1972, p15; David Wilson, *Rutherford: Simple Genius*, Cambridge, Massachusetts, The MIT Press, 1983, p394; John Gribbin, *Science: A History 1543-2001*, London, Allen Lane, 2002, p506.
[128] L. Cockayne, ‘Presidential Address’, *TPNZI* 51 (1919), pp485-95.

relevance to agriculture, Marsden continued to be involved in his own research. In the late 1930s, working with a young DSIR scientist called Charles Watson-Munro, Marsden conducted a survey of radioactivity in New Zealand soils, in an attempt to establish a connection between radioactivity and the regional incidence of goitre.[129] The effect of radioactivity on people was not fully understood and links between radioactivity and a variety of health effects were being sought. In 1937 the Director-General of the Mental Hospitals Department wrote to Marsden querying any regional link between radioactivity and "feeble-mindedness".[130]

Other New Zealand scientists had continued to examine the radioactivity of New Zealand soil and water through the 1920s. Particular attention was paid to both geothermal water and Christchurch's artesian water supply, which was found to have a radon content 10-to-20 times higher than other New Zealand samples tested. Other researchers made use of X-rays for experiments such as chemical and crystal analysis or as a remote means of detecting mouldy apple cores in apples destined for export markets.[131]

Back in the United Kingdom, following Rutherford's transmutation of nitrogen into oxygen, he and his team at the Cavendish Laboratory conducted further experiments in "artificial disintegration" of elements. They soon discovered, however, that the experiment only worked for a few light elements. Rutherford determined that artificial disintegration of heavier elements would require a source of radiation with more energy, and in greater supply, than a stream of radioactive particles from a radium source. Under Rutherford's instruction, Cavendish laboratory physicist John Cockcroft and research student Ernest Walton spent years designing and building electrical devices to accelerate streams of electrons and protons. By 1930 there were five international research laboratories in a race to develop electrical equipment to accelerate particles to high speeds. In 1932, when Robert Van de Graaff in the United States developed a 1.5 million volt accelerator, an impatient Rutherford hurried his team along. Using their modest 300,000 volt equipment – a handmade array of transformers, rectifiers, glass tubes and vacuum pumps – Cockcroft and Walton bombarded a target of lithium with high voltage

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[129] *AJHR* 1939, Vol 3, H-34, p129; Ross Galbreath, *DSIR: Making Science Work for New Zealand*, Victoria University Press, Wellington, 1998, pp21-33; E. Marsden and C. Watson-Munro, 'Radioactivity of New Zealand Soils and Rocks', *New Zealand Journal of Science and Technology* (NZJST) 26, 3B (1944), pp99-114; SIR 1, W1414, 20/4/1, *ANZ.*

[130] T. G. Grey to Ernest Marsden, 19 April 1937, SIR1, W1414, 20/4/1, *ANZ.*

[131] 'Nuclear Science in New Zealand' in A. H. McLintock (ed). *An Encyclopaedia of New Zealand*, Vol 2, Government Printer, Wellington, 1966, p701; M. N. Rogers, 'An Examination of the Radon and Iodine-Content of Certain Christchurch Artesian and Other Waters, with Respect to the Incidence of Goitre', *TPNZI* 57 (1927), pp893-9; F. J. T. Grigg and M. N. Rogers. 'Radioactivity and Chemical Composition of Some New Zealand Thermal Waters', *NZJST* 11, 4 (1929), pp216-8; R. R. D. Milligan and N. M. Rogers, 'Radium Emanation and Goitre', *TPNZI* 59 (1928), pp389-94; *TPNZI* 60 (1930), p31; *TPNZI* 50 (1918), p345; L. W. Tiller and E. R. Cooper, 'X-ray Detection of Mouldy-core in the Delicious Apple', *NZJST*, 21, 3A (1939), pp168-9; *AJHR* 1933, Vol 3, H-34, p41.

protons and detected alpha particles on a scintillation screen, evidence that some of the lithium atoms had absorbed a proton and split in half: $^{7}Li_{3} + {}^{1}H_{1} > 2^{4}He_{2}$. While Rutherford had, in 1917, used a natural source of radioactivity to knock a proton out of a nitrogen atom's nucleus, Cockcroft and Walton had literally split a lithium atom in half. ("The atom split but world still safe," read the *Sunday Express*. "Let it be split, so long as it does not explode" said the *Daily Mirror*.) Cockcroft and Walton's splitting of the lithium atom was artificial disintegration by artificial means and they soon concluded experiments into the energy releases and mass changes to confirm Albert Einstein's equation that $E=mc^2$ (energy equals mass times the square of the speed of light). Cockcroft and Walton would go on to win the 1951 Nobel Prize in Physics for these achievements.[132]

Experimental evidence for the neutron was provided in 1932 by James Chadwick, a former student of Rutherford's at Manchester. The existence of a nuclear particle with a similar mass to the proton but no electrical charge had been proposed more than a decade earlier.[133] Chadwick's discovery of the neutron more fully explained isotopes – how a single element could come in several forms with the same chemical properties but different atomic weights and degrees of radioactivity.[134] In 1935 he won the Nobel Prize in Physics for this discovery.

Although he was scientifically isolated in New Zealand, Marsden kept up to date with international developments in the world of nuclear physics and was quick to adapt new technologies for New Zealand. Following Victor Hess's 1912 discovery of cosmic radiation, Marsden had taken an interest in the phenomenon. In 1919 the Wellington Philosophical Society had granted Marsden £125 for the purchase of apparatus with which he conducted experiments in Apia (Samoa), and on Mount Egmont in Taranaki to "ascertain whether or not there is an extra-terrestrial radiation of a radio-active nature".[135] In 1936 Hess's discovery of cosmic radiation won him the Nobel Prize for Physics, and Marsden established a cosmic-ray meter at

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[132] Lawrence Badash, Scientists *and the Development of Nuclear Weapons: From Fission to the Limited Test Ban Treaty 1939-1963*, Humanities Press, New Jersey, 1995, p15; Brian Cathcart, *The Fly in the Cathedral: How a Small Group of Cambridge Scientists Won the Race to Split the Atom*, Viking, London, 2004.
[133] Nobel Prize organisation web page on Nobel Prize in Physics 1935 at: http://nobelprize.org/physics/laureates/1935/chadwick-bio.html downloaded 10 October 2005; Cathcart 2004, p31-32, 34.
[134] Gribbin 2002, p507. Uranium, for example, is now known to have three isotopes – uranium-238, which is most abundant, uranium-235 and uranium-234. The number after the element name is the atomic mass and is a measure of how many particles – a mixture of protons and neutrons – there are in the nucleus. All uranium atoms have 92 protons, so the different isotopes of uranium are determined by how many neutrons there are in the nucleus.
[135] *TPNZI* 54 (1923), p817; *TPNZI* 55 (1924), p768.

the DSIR's Magnetic Observatory in Christchurch, which sent its results to the Carnegie Institute in Washington for compilation with other results from around the world.[136]

Figure 3.7: As head of the DSIR from 1926 to 1947, Ernest Marsden championed the development of nuclear sciences in New Zealand. Source: Sir Charles Fleming Collection, 1/4-018564-F, Alexander Turnbull Library, Wellington, NZ.

Marsden also made early use of the commercial products of cyclotrons. In 1931 – as part of the race to develop equipment for the electrical acceleration of sub-atomic particles – Ernest Lawrence, of the University of California, invented the cyclotron. The cyclotron was designed to generate high-energy ions for studying nuclear reactions, but its ability to produce radioactive isotopes was soon recognised as an important function. For most of the 1930s Lawrence and his colleagues were the only source of these isotopes, which soon began being used as radioactive tracers. As well as being used in chemistry and medicine, these artificially radioactive isotopes –

[136] Nobel Prize organisation web page on Nobel Prize in Physics 1936 at: http://nobelprize.org/physics/laureates/1936/press.html downloaded 26 September 2005; *AJHR* 1937-38, Vol 3, H-34, p147; SIR1, 74/2/6, *ANZ*.

of elements like iodine, phosphorus, sodium, and iron – were used to study the distribution of these elements in animal organs and tissues.[137]

Marsden saw local applications for the new technology, pioneering the non-medical use of radioactive isotopes in New Zealand in innovative agricultural experiments. By the late 1930s the ovine disease known as "bush sickness", which caused slow wasting and death of affected animals, had been traced to a deficiency in cobalt rather than iron, to which it had previously been attributed. In 1938 Marsden designed an experiment to establish the role played by cobalt in animal metabolism, which involved administering radioactive cobalt (radiocobalt) to a sheep and then conducting a post-mortem examination of the cobalt contents of different organs of the body.[138] Marsden, following the hands-on experimental tradition of his teacher Ernest Rutherford, first considered producing radiocobalt in New Zealand – he planned to irradiate cobalt with neutrons from a radium-beryllium source – but acknowledged that it could be produced "much better and with more activity by a cyclotron".[139] In January 1939, in response to a written request, Marsden received a small quantity of radioactive cobalt and radioactive manganese prepared in Ernest Lawrence's cyclotron at the University of California in Berkeley.[140] Charles Watson-Munro of the DSIR's Dominion Laboratory, working with other DSIR and Department of Agriculture scientists, conducted a series of experiments in which selected sheep were injected or fed with a solution containing radioactive cobalt and then killed. Their organs were then examined, to determine the distribution of cobalt, using an ionisation chamber built by Watson-Munro.[141] Initial results suggested that the small amount of cobalt that was retained in the body (most was expelled in urine and faeces) was concentrated in the liver but later analysis revealed an error in technique and the results of the experiment were "rendered useless".[142] The manganese, meanwhile, was injected into an apple tree and its distribution in the felled tree measured. Following the failure of the bush sickness experiments a further series of experiments was recommended, using larger quantities of radiocobalt. But when the Second World War intervened, pure research was put aside to focus on research of direct benefit to the war effort.[143]

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[137] W. B. Mann, *The Cyclotron,* 4th edition, London, Methuen and Co, 1953, pp1-24, 78-89; SIR1, 20/4/2, *ANZ.*
[138] Marsden to Dr J. J. Livinggood at Berkeley, 11 November 1938, SIR 1 20/4/2, *ANZ.*
[139] Marsden to J. Fleming at Carnegie Institute, 24 August 1938, SIR 1, 20/4/2, *ANZ.*
[140] In return for Ernest Lawrence's generosity, Marsden sent him a biography of Rutherford which he – Ernest Marsden – had written. (Letter from Marsden to Lawrence, 9 February 1939 in SIR 1 20/4/2, *ANZ*.)
[141] *AJHR* 1936, Vol 3, H-34, pp9; *AJHR* 1939, Vol 3, H-34, p129; *Evening Post*, 31 January 1939; G. T. Seaborg to Marsden, 9 January 1939 and Report on work with radiocobalt, January 1940, both in SIR1, 20/4/2, *ANZ.*
[142] Memo from Animal Research Division of Department of Agriculture, 14 May 1940, SIR1, 20/4/2, *ANZ.*
[143] *AJHR* 1940, Vol 3, H-34, p70; Report on work with radioactive cobalt, January 1940, in SIR1, 20/4/2, *ANZ.*

In 1933 Ernest Rutherford had reiterated his belief that the power of the atom could not be harnessed, saying that the “energy produced by the breaking down of the atom is a very poor kind of thing. Anyone who expects a source of power from the transformation of these atoms is talking moonshine.”[144] But by the dawn of the Second World War, the understanding of the atom was growing in complexity and true to H. G. Wells’s predictions, so was the possibility of a future when atomic transmutation would provide the means of providing nuclear power and destructive weapons.

Conclusion

New Zealanders were quick to take advantage of X-ray and radium technology. X-rays were useful and relatively easy to use and medical practitioners were soon offering X-ray medical services to a paying public. While radium was harder to obtain and more complex to use, it was also considered to be of potentially enormous medical use. Some enterprising New Zealand doctors were using radium as early as 1901, soon after its discovery and well before radium therapy was widely accepted. Patients eagerly sought radium therapy once it became available, and an enthusiastic and generous public helped to fund radium therapy plants in the four main centres: by 1929 New Zealand had more medical radium per head of population than the United Kingdom. There were wider pseudo-medical applications of X-rays and radium too, with X-ray machines a popular “toy” in shoe shops and radon water sought for dubious treatment from a public that Government Balneologist Arthur Wohlmann’s described as “mad on radium”.[145]

With regard to safety, New Zealand learned from mistakes and discoveries made internationally, but also from its own mistakes and discoveries: many of the early doctors working with X-rays and radium suffered work-related illness, injuries or death. The Department of Health followed safety measures being recommended in other countries and made recommendations to New Zealand’s medical profession on safe procedures for working with X-rays and radium. By the 1940s, however, this top-down instruction had reversed and the radiologists were pushing for national standards and regulations: the Electrical Wiring (X-Ray) Regulations were introduced in 1944.

While physics was still a fringe science in New Zealand, non-medical scientists, who kept up to date with international science journals, took advantage of the new science to examine the radioactivity of New Zealand soil and waters, and measure cosmic radiation. In Europe, Ernest

[144] *New York Herald Tribune*, 12 September 1933. News clipping reproduced in Charles Weiner, ‘Physics in the Great Depression’, *Physics Today* 23, 10 (1970), p33.
[145] Wohlmann to General Manager, Dept of Tourist and Health Resorts, 25 May 1914, TO1, 24/34, *ANZ.*

Rutherford delved deeper into the atom, launching the field of nuclear physics and earning himself the title of the “father of nuclear physics”. Rutherford, however, was not to see the application of this science. Lord Rutherford of Nelson, as he had elected to be known when he was elevated to the peerage in 1931, died in October 1937, just two years before the start of the Second World War set in train developments that would soon lead to the manufacture and use of nuclear weapons and energy.[146] It was Rutherford’s student, Ernest Marsden, as head of New Zealand’s DSIR, who would now have the greatest influence on New Zealand and its work in the new field of nuclear science.

[146] Campbell 1999, pp423-28, 473.

Chapter 4
Some fool in a laboratory: The atom bomb and the dawn of the nuclear age

"How proud New Zealand must be that the foundations of the amazing discovery concerning latent atomic energy were laid by her own great scientist Rutherford."
Viscount Bledisloe in telegram to New Zealand, 9 August 1945[1]

*"When the first atomic bomb exploded,
the world as we have come to know it came, I believe, to an end."*
Karl Popper, Christchurch, August 1945[2]

The Second World War saw the application of nuclear science to a new and deadly form of weapons and a way of generating electricity. This work hinged on the early twentieth century discoveries of New Zealander Ernest Rutherford. Because of this Rutherford connection, and the efforts of the DSIR's Ernest Marsden, New Zealand's support for the development of the first nuclear weapons and nuclear energy was not just theoretical: a team of young New Zealand scientists worked on the Manhattan Project, the American-led project to develop the first nuclear weapons, and on the Canadian-based British-led project to develop nuclear energy. While the New Zealanders' role in the massive Manhattan Project was minor, the New Zealand team in Canada played a significant role in the development of the first nuclear reactors in Canada and subsequently in the United Kingdom.

New Zealand was supporting the British efforts in nuclear science as she did in all aspects of the war, but also had self-interested motives. After the Second World War Marsden took the lead in establishing a nuclear sciences team within the DSIR and gained support to use the skills gained in the northern hemisphere to built a nuclear reactor in New Zealand.

There was no public outcry when the New Zealand scientists' involvement was revealed after the war – New Zealand was as proud of the work of her scientists as of her soldiers who had fought in the war. And although he had died in 1937, the development of the bomb saw Ernest Rutherford elevated within New Zealand's sense of its own identity and place in history.

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[1] Viscount Bledisloe to Minister of External Affairs, 9 August 1945, EA1, W2619, 121/1/1, part 1, *ANZ.*
[2] Kate Dewes and Robert Green, *Aotearoa/New Zealand at the World Court*, The Raven Press, Christchurch, 1999, p9; Glyn Strange, 'Popper's A-bomb dilemma', *Evening Post*, 14 August 1995, p5.

Physics and the Second World War

New Zealand joined Britain in declaring war on Germany in September 1939, with New Zealand's strong links with Britain demonstrated in Prime Minister Michael Joseph Savage's loyal declaration that "where she goes, we go, where she stands, we stand".[3] Over the next six years, as the war escalated and expanded, more than 200,000 New Zealanders would serve in the war in Europe and the Pacific.[4] Following the outbreak of the Second World War Ernest Marsden, secretary of the DSIR, was given the title of Scientific Advisor to the Defence Department and, later, Director of Scientific Developments, in which role he was charged with mobilising New Zealand's scientific manpower.[5] Conscription to the armed forces was introduced in 1940 and, after 1942, remaining workers, including scientists and science students, could also be directed by Manpower Committees into what were considered essential industries.[6]

The DSIR put its efforts into supporting the war effort, particularly through advances in agriculture and food science, and by finding local sources of scarce goods. Geologists were directed to find strategic minerals like mica and asbestos, and chemists experimented with new fuel sources and created insect and shark repellents for soldiers stationed in the Pacific. The DSIR's biggest efforts, however, were in physics – Marsden's field of expertise – with the establishment of two new physical sciences laboratories that grew to become two of the DSIR's largest divisions. Scientists at the Wellington-based Radio Development Laboratory were involved in a secret programme to develop radar, which was initially the Allies' top scientific priority. The Physical Testing Laboratory, which in 1943 was renamed the Dominion Physical Laboratory, was established to cater to the Armed Services' demands for physical testing and calibration of instruments.[7]

Radium too, played its part in the war effort. In January 1944, a "luminising laboratory" was set up in a Dominion Physical Laboratory base in Lower Hutt. Four young women were employed to apply radium-activated luminous paint to illuminise dials and markings on radio

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[3] W. David McIntyre, 'From Dual Dependency to Nuclear Free'. In Geoffrey W. Rice (ed), *The Oxford History of New Zealand, 2nd edition,* Oxford University Press, Auckland, 1992, p524.
[4] Philippa Mein Smith, *A Concise History of New Zealand,* Cambridge University Press, Cambridge, 2005, pp160-161.
[5] Ross Galbreath, *DSIR: Making Science Work for New Zealand*, Victoria University Press, Wellington, 1998, pp115-6, 120.
[6] Jock Phillips, 'New Zealand Celebrates Victory'. In John Crawford (ed), *Kia Kaha: New Zealand in the Second World War*, Oxford University Press, Melbourne, pp306-307; Nancy Taylor, *The New Zealand People at War: The Home Front,* Volume 2, Government Printer, Wellington, 1986, pp663-675.
[7] Galbreath 1998, pp109-114.

communication equipment for the New Zealand Armed Forces to use in jungle and tropical areas. They were only one group of workers using radioactive paint during the war. In 1943, T. R. Ritchie, the Director-General of Health, had written to Marsden about the use of radioactive paints at a factory in Auckland and in an Air Force factory, expressing his concern that "workers do not realise the tremendous danger of the inhalation and ingestion of the powder used".[8] Ritchie and George Roth, head of the Travis Radiophysical Laboratory, agreed that regulations should be made to cover every person handling unsealed radioactive substances, with a six-monthly radon-exhalation test and GM counter test.[9] Marsden, however, thought that such regulations would be premature, stating that the cost would be "excessive for the small amount of work to be done which is only on an experimental scale".[10] It was against this background, and in the absence of any New Zealand regulations, that the DSIR laboratory was established. The laboratory was set up, however, with reference to the British Factories (Luminising) (Health and Safety Precautions) Order 1942 and was required to comply with British standards as modified by Roth.[11] Copies of the United States Bureau of Standards Handbook on Safe Handling of Radioactive Luminous Compound were also circulated by the Department of Health.

Despite the well-publicised plight of the American radium-dial painters in the 1920s, safety was not given the priority it deserved and conditions in the Lower Hutt laboratory were not up to international standards. The young women employed to apply radium-activated luminous paint to the dials and knobs of wireless-ammeters worked three to four hours daily on this task. They worked in a makeshift laboratory set up in three small Army huts.[12] The young women sat on upholstered seats above floors covered in tarred paper. They worked at Vitrolite-covered benches covered in a hood with an exhaust draught to remove radon gas and stray particles and applied paint with brushes. They wore gowns, aprons, caps and gloves, washing the gloves at the end of the day. The radioactive paint was kept stored in a steel safe with 2-inch walls in a concrete-based windowless hut.[13]

A Dr J. M. Davidson inspected the luminising laboratories in May 1944 and found conditions wanting. Davidson condemned the makeshift laboratory as "ill-adapted for this purpose

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[8] T. R. Ritchie to Marsden, 29 September 1943, H1, 108/7/1, 45543, 1944-61, *ANZ.*
[9] File note by T. R. Ritchie, 12 October 1943, HI, 108/7/1, 45543, 1944-61, *ANZ.*
[10] Marsden to Ritchie, 4 November 1943, H1, 108/7/1, 45543, 1944-61, *ANZ.*
[11] File note in H1, 45543, 108/7/1, 1944-61, *ANZ*
[12] Director-General of Health to Captain Chisholm, 23 May 1944, H1, 45543, 108/7/1, 1944-61, *ANZ.*
[13] Tingey, J. M. C. 'Luminizing Army Radio Equipment', *NZJST* 27B, September 1945, pp138-146.

[making] it unnecessarily difficult to maintain a high standard of hygiene and safety".[14] Davidson found radioactive contamination on various tins and bottles in cupboards, in crevices around painting hoods and even in a bottle of sweets which had been surreptitiously introduced into the painting room. The gloves the women washed at the end of the day and hung up to dry were found to be "heavily contaminated with luminous paint".[15]

The Dominion Physical Laboratory was receptive to the Davidson report and the laboratory was closed for three weeks while they wet-cleaned the painting room, installed new work stations, laid linoleum on the floor, replaced upholstered chairs with easily-cleaned steel tube chairs, installed new ventilation systems and replaced paint brushes with resin-impregnated wooden meat skewers that were disposed of after each working period.[16] From September 1944, 1-litre breath samples were collected from each staff member of the luminising laboratory and sent monthly to the radiophysical laboratory in Christchurch. Here Roth and his colleagues had developed equipment for measuring the radon content of operators' breath, with the aim being the early detection of ingested or inhaled radium. (Sporadic tests were also undertaken of four luminisers working for the RNZAF.)[17] In December 1944, results of the radon exhalation tests revealed that four of the five staff had results between 10 and 80 per cent of the tolerance dose (the acceptable limit) and one had a result of 130 per cent of tolerance dose, which reduced to less than 10 per cent of tolerance after a rest and an unspecified treatment.[18] Roth stated that the radon exhalation tests "proved that the protective measures recommended for luminising work in New Zealand were wholly successful in that all the workers examined at the end of their employment remained well within the tolerance limit for ingested and inhaled radium".[19]

Over a period of 18 months, from January 1944 to June 1945, the Dominion Physical Laboratory workers used more than 400 g of radium-activated luminous powder to paint some 14,000 milliammeter dials. Over the same period the laboratory also used radium paint to develop prototype luminous rifle sights, jungle trail markers and tuning controls, which were passed on to the Ministry of Supply. In a 1945 paper in the *New Zealand Journal of Science and Technology*, J. M. C. Tingey, who led the Dominion Physical Laboratory team of dial painters,

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[14] Director-General of Health to Captain Chisholm, 23 May 1944, H1, 45543, 108/7/1, 1944-61, *ANZ.*
[15] Davidson to Director-General of Health, 30 May 1944, and Director-General of Health to Captain Chisholm, 23 May 1944, H1, 45543, 108/7/1, 1944-61, *ANZ.*
[16] DPL to Assistant Secretary DSIR, 23 May 1944, H1, 45543, 108/7/1, 1944-61, *ANZ;* Tingey 1945, pp138-146.
[17] G. E. Roth, 'Radon Micro Determination by the Curtiss-Davis a-particle Counting Method', *NZJST* 27B, 2 (1945), pp147-153.
[18] Cooper to Director-General of Health, 15 December 1944, H1, 45543, 108/7/1, 1944-61, *ANZ.*
[19] Roth 1945, p152.

reported that over the course of the work, "[r]outine testing of dial painters showed that the close contact with this highly radioactive material had not affected any to a measurable degree".[20]

Figure 4.1: After the review of the laboratory's safety measures, staff worked in a ventilated painting cabinet, with hard surfaces that were easy to clean. This photo is probably of J. M. C. Tingey, who led the Dominion Physical Laboratory team that used radioactive paint to illuminate dials and ammeters for military use. Source: J. M. C. Tingey, "Luminizing Army Radio Equipment", *New Zealand Journal of Science and Technology* 27B (1945), p140.

Safety measures at the luminising laboratory were initially substandard, but it was not public opinion, media pressure or staff concerns that led to changes, rather it was the actions of health scientists keeping up to date with best practice internationally, and DSIR officials being willing to heed this advice and take on the recommendations.

Unleashing the energy of the nucleus

While radium and X-rays had been among the great discoveries in physics at the end of the nineteenth century, early twentieth century developments in the new physics were now

[20] Tingey 1945, p138.

culminating in a wartime project to unleash the energy inside the atomic nucleus, thanks in part to the work of New Zealand's Ernest Rutherford.

As covered in chapter three, the first explorations into the nucleus had been made by Rutherford in 1909 when he had devised the experiment that led to his discovery of the nucleus. Then, in 1917, he had "split the atom": nitrogen atoms he bombarded with alpha particles emitted a hydrogen nucleus, or proton, and were transformed into oxygen atoms.[21] Physicists soon understood that this transmutation of one element into another was chiefly a nuclear process. But, by the late 1920s, years of exhaustive research trying to determine the structure and composition of the nucleus by bombarding it with alpha particles from radium had yielded limited new information. A more powerful stream of particles was believed to be possible using electricity. Experiments by Rutherford's team at the Cavendish Laboratory at Cambridge – John Cockcroft and Ernest Walton – had split a lithium atom in half.[22]

Walton and Cockcroft had conducted their experiments on lithium, the third element in the periodic table, which contains only three protons and either three or four neutrons in its nucleus. A greater source of electrical energy would be needed to investigate the nucleus of heavier elements. The Italian scientist Enrico Fermi soon led the way, after realising that slowing the neutrons, through collisions with water or another hydrogen-containing substance, improved the outcomes of the experiments. Fermi was bombarding heavy elements like uranium – the heaviest naturally-occurring element – with these slow neutrons and somehow creating new elements heavier than those he had started with (some of the atoms he was working with were absorbing the neutrons). German chemist Otto Hahn and physicist Lise Meitner were inspired by Fermi's work and set out to repeat his experiments. After Meitner fled Nazi Germany for Sweden, Hahn continued the work with a colleague, Fritz Strassmann, conveying the results to Meitner by post. In Sweden, with the help of her physicist nephew Otto Frisch, Meitner realised that by bombarding uranium with slow neutrons, Hahn had fractured atoms of uranium into lighter elements, such as barium, with more neutrons, and energy, being released in the process. Meitner calculated the incredible release of energy from the disintegration of uranium, which she called "fission", as being in the order of 200 million electron volts from a single atom. In principle, given a great enough mass, a *critical* mass, of a heavy material such as uranium, the neutrons emitted by the fission of one atom would initiate fission in neighbouring atoms, setting

[21] John Gribbin, *Science: A History 1543-2001,* Allen Lane, London, 2002, p504-6.

off a chain reaction and initiating an incredible release of energy. When these results were published in 1939, a global search for a way to harness this energy began and, with war imminent, the focus was on using the energy for a bomb.[23]

Scientists in the United Kingdom, the United States and the Soviet Union soon began working on fission but by the start of the Second World War, in September 1939, Germany was the only country to have a military office focused on nuclear energy. When, in 1940, it was established that uranium-235, an isotope comprising only 0.7 per cent of natural uranium, was responsible for fission, scientists began to focus on separating uranium-235 from natural uranium, which comprises mostly uranium-238, and on determining the critical mass that would be needed to sustain a chain reaction.[24]

Britain set up the MAUD Committee, focused on directing secret research towards producing a uranium bomb, in 1940. Four of the five original committee members were Cavendish alumni, who had studied under or worked with Ernest Rutherford: James Chadwick, John Cockcroft, Philip Moon and the Australian physicist Mark Oliphant. The MAUD Committee's reports, presented in June and July 1941, recommended that it was feasible to make an effective uranium bomb with as little as 25 lb (about 11 kg) of uranium-235, and that it would be possible to create electricity from nuclear energy, using uranium as the fuel source and heavy water as a moderator to slow the neutrons.[25] Their report stated that a 25 lb uranium bomb would not only have the equivalent destructive power of 1800 tons of TNT, it would "release large quantities of radioactive substances, which would make places near to where the bomb exploded dangerous to human life for a long period". When the British government accepted the MAUD Committee's recommendations to proceed with both a nuclear power project and a nuclear bomb project, a new directorate with the nonsensical code name "Tube Alloys" was established within the British DSIR.[26] Following the MAUD Committee's advice to secure control of uranium supplies, Britain initiated a Commonwealth search for uranium, but felt secure in the knowledge

[22] Brian Cathcart, *The Fly in the Cathedral: How a Small Group of Cambridge Scientists Won the Race to Split the Atom*, Viking, London, 2004, pp225-261; Lawrence Badash, *Scientists and the Development of Nuclear Weapons: From Fission to the Limited Test Ban Treaty 1939-1963*, Humanity Books, New York, 1995, pp15-16.
[23] Badash 1995, pp16-17, 23-26; Richard Rhodes, *The Making of the Atomic Bomb*, Touchstone, New York, 1986, pp257-75.
[24] Badash 1995, pp28, 30.
[25] Heavy water is water containing a higher than normal proportion of the hydrogen isotope deuterium, or heavy hydrogen. While normal hydrogen has a single proton in its nucleus, deuterium has one proton and one neutron, making it approximately twice as heavy as hydrogen.
[26] Margaret Gowing, *Britain and Atomic Energy1939-1945*, Macmillan and Co Ltd, London, 1964, pp45, 105-9, 394-436; Anna Binnie, 'Oliphant, the Father of Atomic Energy', *Journal and Proceedings of the Royal Society of New South Wales* 139 (2006), p12.

that of the world's two known largest uranium supplies, in Canada and the Belgian Congo, one was on Commonwealth land.[27]

The United Kingdom's nuclear programme was initially more advanced than the American programme, where scientists were also working on nuclear projects. There was a free exchange of information and ideas between scientists from the two countries, though this was mostly from the United Kingdom to the United States.[28] Following the American entry into the Second World War in 1941, however, a coordinated and well-financed United States effort to develop nuclear bombs was launched, the Manhattan Project. One of the first key sites was at Oak Ridge, Tennessee, where a plant was built to separate uranium-235 from uranium-238 using both electromagnetic and gaseous diffusion techniques. At Hanford, Washington, nuclear reactors were built to produce a newly discovered artificial element, plutonium, as an alternative fuel source for a fission weapon. Plutonium was produced by bombarding uranium (the heaviest naturally occurring element) with neutrons in an atomic pile and had atomic number 94, compared to uranium's atomic number 92.[29] At Los Alamos, in New Mexico, scientists were tasked with putting the raw materials together to design and produce a nuclear bomb. Together, the Manhattan Project became the world's biggest ever scientific endeavour; it eventually had a budget of more than US$2 billion.[30]

As the American project advanced ahead of the British project, and the United States refused to share information, Britain sought to join forces with the United States. After the signing of the Quebec Agreement of August 1943, under which the British and American scientists would collaborate on their nuclear energy projects, the Tube Alloys Project was subsumed into the American nuclear programme and groups of British scientists began working on specific aspects of the Manhattan Project.[31] Oliphant went to Berkeley in November 1943, to work with his friend Ernest Lawrence, the inventor of the cyclotron, on the separation of uranium-235 by electromagnetic means.[32] Two other Australian scientists, Harrie Massey and Eric Burhop, also

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[27] Gowing 1964, pp105, 297.
[28] Gowing 1964, p132.
[29] An 'atomic pile' is a simple nuclear reactor. Early nuclear projects refereed to 'atomic energy' and the 'atomic bomb', but the more correct 'nuclear' is now used. The word 'pile' originated because the early nuclear reactors were essentially huge piles of natural uranium interspersed with a moderator such as graphite. See, for example, Laura Fermi, 'In The Black Squash Court'. In John Carey (ed), *The Faber Book of Science*, Faber, London, 1995, pp324-334.
[30] Badash 1995, p33-34.
[31] Bertrand Goldschmidt, 'A Historical Survey of Nonproliferation Policies', *International Security* 2, 1 (1977), pp69-87, downloaded from www.jstor.org/stable/2538660 on 24 February 2010; Gowing 1964, pp193-4, 233-41.
[32] Binnie 2006, p16; Watson-Munro to Marsden, 26 February 1945, SIR1, W1414, 74/10, *ANZ.*

Cavendish graduates, joined the British group at Berkeley, where Massey led a group of theoretical physicists.[33]

In April 1944, John Cockcroft flew to Montreal to lead a joint American-British-Canadian project to produce an experimental pile, or reactor, using uranium rods in a heavy water moderator to produce an intended output of 10,000 kW. A rural site near the village of Chalk River, on the south bank of the Ottawa River, was eventually chosen for the laboratory.[34]

New Zealand scientists on the Manhattan and Montreal Projects

It seems surprising that of all the Commonwealth countries, New Zealand would have played a significant role in the British nuclear programme, but it makes sense when it is recognised as being due to the efforts of one man, Ernest Marsden, and the result of New Zealand's Rutherford connection to nuclear science. In his role as head of the DSIR, Marsden made several wartime trips to the United Kingdom, mostly to advance the secret programme to develop radar in New Zealand. Here he learnt of the nuclear programme through his many contacts in the British physics community.[35]

In December 1943 Marsden was travelling through the United States on his way to the United Kingdom where, in Washington DC, he chanced upon James Chadwick, by now scientific director of the British nuclear research project, as well as Australian physicist Mark Oliphant and Danish physicist Niels Bohr, who had been smuggled out of Denmark and was travelling under an assumed name. Following the August 1943 signing of the Quebec Agreement, Chadwick and Oliphant were in Washington with the top secret task of arranging details of scientific cooperation between the United Kingdom and United States' nuclear research programmes. Oliphant later recalled they were in their hotel lobby waiting for the elevator when they felt taps on their shoulders and turned to find Marsden in full military uniform. They were taken aback to hear Marsden say, "I can guess why two nuclear physicists are here!" During the elevator journey Marsden put in a good word for New Zealand's participation in the bomb project. He followed this up in London with Sir John Anderson, Chancellor of the Exchequer and the British Minister in charge of atomic energy matters. Many of the Commonwealth scientists working on the British nuclear research programme were, like Marsden, past students

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[33] Binnie 2006, p16; Gowing 1964, pp256-8; R. W. Home, 'Burhop, Eric Henry Stoneley (1911–1980), *Australian Dictionary of Biography*, http://adbonline.anu.edu.au/biogs/A130339b.htm, downloaded 6 December 2008.
[34] Gowing 1964, p271-8.
[35] Galbreath 1998, pp109-139.

or colleagues of Rutherford, and Marsden was able to trade successfully on his reputation of being involved in the birth of nuclear physics, which, as Harrie Massey later said, had earned Marsden "a place among the immortals".[36]

Following the necessary protocol, the British Government asked New Zealand Prime Minister Peter Fraser for five New Zealand men to join the British nuclear research team.[37] Robin Williams, a young physicist with the DSIR's Radio Development Laboratory, recalled reporting to Wellington in July 1944 to find Marsden "cock-a-hoop about the fact that he had managed to get a number of New Zealanders in on the atom bomb project."[38] Williams was joined by Bill Young, from the DSIR's Defence Development Section and George Page and Charles Watson-Munro, also from the Radio Development Laboratory. Their terms of employment seconded them to the United Kingdom DSIR for "a period of one year or for the duration of the war, whichever is the longer". Marsden was very keen for New Zealand to launch an atomic research programme when the war finished and following the secondment the men were required to return to New Zealand for at least one year.[39]

Most of the British scientists working on the electromagnetic separation of uranium had now transferred to the University of California at Berkeley. When Williams and Page joined this team in July 1944, they took the number of British men on this part of the project to 35, though Gowing points out that "the influence of the British was far higher than their numbers would suggest".[40] As well as Williams and Page, there were two other New Zealand-born scientists on the team who had arrived from the United Kingdom with the British group.[41] One of them was Maurice Wilkins who later, disturbed by the outcome of their project, abandoned physics for biophysics and went on to share the 1962 Nobel Prize for Physiology or Medicine for his work on the structure of the DNA molecule.[42]

The electromagnetic separation process the British scientists at Berkeley were working on involved first accelerating ionised uranium using an electric field, then passing the beam of

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[36] Gowing 1964, pp107, 247-249; Marsden Editorial Committee, *Sir Ernest Marsden 80th Birthday Book*, A. H. & A. W. Reed, Wellington, 1969, pp47, 101-103.
[37] World War II narrative no. 9, Atomic Energy, AAOQ, W3424 (box 16), *ANZ*.
[38] Robin Williams, Reflections on My Involvement in the Manhattan Project, seminar at Victoria University, 10 August 2001.
[39] Terms of employment memos, 19 July 1944, SIR1, W1414, 74/10, *ANZ*; World War II narrative no. 9, Atomic Energy, AAOQ, W3424 (box 16), *ANZ*; 'New Zealand Participation in Atomic Bomb Development', released to the press 13 August 1945, EA1, W2619, 121/1/1, *ANZ.*
[40] Gowing 1964, pp256-8.
[41] Page to Marsden, 19 September 1944, SIR1, W1414, 74/10, *ANZ*; Gowing 1964, p258.

accelerated ions through a magnetic field which deflected the uranium-235 ions slightly more than it deflected the uranium-238 ions (because of their lower mass), and allowed for separate collection of the two isotopes. The different masses of the uranium-235 and uranium-238 isotopes would lead them to different receivers for collection. The challenge was to design and build the most efficient plant possible, and theoretical and experimental physicists were needed to help solve problems arising from the design challenge and the operation of the plant. Williams mostly worked under Massey, with a group of theoretical physicists who contributed to the project by improving the team's understanding of the fundamental processes involved in the uranium separation. Page, along with the engineers on the project, made significant contributions to improving and simplifying the design of the electromagnetic separation plant.[43] Both Williams and Page, though based at the University of California in Berkeley, made several trips to the base at Oak Ridge, Tennessee, which Williams described as being like a "workers' camp and a prison camp combined with lots of fences … lots of mud and prefabricated houses".[44]

Links between the nuclear project and Rutherford continued. In Canada, a team of mostly English and Canadian scientists, led by another Rutherford old-boy, John Cockcroft, had begun a project to develop a heavy-water nuclear reactor. In assembling his team, Cockcroft was seeking "engineers with a decent physics background and physicists with a flair for engineering". Watson-Munro and Young travelled to Montreal from New Zealand and another New Zealander, Ken George, reported directly to Montreal from his post as the DSIR's scientific liaison officer in Washington, where, in recognition of the growing importance of the relationship with the United States, New Zealand had opened a legation only two years before. As part of the Canadian team, which comprised 40 Canadians, 40 British, and a small group of men from France and other nations, the New Zealanders began work on building a low-energy atomic pile, using natural uranium fuel and heavy water as a moderator.[45] The leaders of the British nuclear programme were very pleased with the New Zealand scientists, and Oliphant told New Zealand's scientific liaison officer in London that New Zealand was being compared favourably with Australia for offering "five good men without questioning the soundness of the

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[42] Veronika Meduna and Rebecca Priestley, *Atoms, Dinosaurs & DNA: 68 Great New Zealand Scientists*, Random House, Auckland, 208, pp78-79.
[43] Gowing 1964, p259; Marsden Editorial Committee, 1969, p103.
[44] Williams 2001.
[45] Gowing 1964, pp275-280; SIR1, W1414, 74/10, *ANZ*; McIntyre 1992, p521.

purpose and the good faith of the British government".[46] It wasn't really a matter of New Zealand's unquestioning support, however. Marsden strongly believed that it would be to New Zealand's ultimate advantage to have men gaining scientific experience on the world's most ambitious scientific project.

After connecting the New Zealand physicists with the nuclear project, what was Marsden's role? He could have left the New Zealand scientists to their work and focused on his many other duties as head of the DSIR, but a reading of his letters of this time suggests he was preoccupied with the work in North America. As a scientist turned administrator, Marsden was tremendously excited about these new applications of nuclear physics and felt stymied and frustrated in his administrative and managerial role so far from the action. He wrote regularly to the American-based scientists, asking, sometimes inappropriately, for details of their research.[47] In January 1945, after the New Zealand team had been in North America only a few months, Cockcroft wrote to Marsden requesting three more scientists from New Zealand. Marsden, in turn, wrote to the Minister of Scientific and Industrial Research seeking permission to send three more men to North America.[48] He also recommended that "in view of the overwhelming importance of the work to the future of New Zealand ... it is in my opinion most necessary that we should have a team of men on this work and one way to do this would be for Cabinet to give authority for such a section or team and appoint the men to it to return for duty in New Zealand as soon as hostilities cease". Marsden was either prescient in his thinking – or well informed – when he added "I presume the full story of the operations of the T. A. project will 'break' within say six months, and if we are able to announce that the Government has taken appropriate action in the matter, i.e. such as the above, it will be a source of justifiable satisfaction to the country."[49] It was a little less than eight months later that the operations of the "Tube Alloys" project "broke", and the atom bomb was dropped on Hiroshima.

Marsden gained permission to send the additional New Zealand scientists, and in March 1945, Arnold Allan and Gordon Fergusson, both assistant physicists with the Radio Development Laboratory, left New Zealand to join Watson-Munro's team in Montreal.[50] In response to Cockcroft's request for a third man, Marsden first recommended Ian Walker "an excellent New

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[46] SLO to Marsden, 4 January 1945, SIR1, W1414, 74/10, quoted in World War II narrative No. 9, AAOQ, W3424 (box 16), *ANZ*.
[47] See correspondence in SIR1, W1414, 74/10, *ANZ*.
[48] Marsden to Minister of SIR, 11 January 1945, SIR1, W1414, 74/10, *ANZ*.
[49] Marsden to Minister of SIR, 30 January 1945, SIR1, W1414, 74/10, *ANZ*.
[50] Various correspondence from March 1945, SIR1, W1414, 74/10, *ANZ*; 'New Zealand Participation in Atomic Bomb Development', released to the press 13 August 1945, EA1, W2619, 121/1/1, *ANZ*.

Zealand electronics man in UK", but, as an alternative, asked "can you find room for me at a senior scientific officer grade – in any direction of work, for any period of time".[51] At receiving no response to this offer, Marsden repeated it to Watson-Munro writing "I would be quite glad to get back to pure research for the rest of my life".[52] Cockcroft, perhaps alarmed by Marsden's inappropriate offer, informed Marsden in May 1945 that a third man was not required – for now.[53]

As he was unable to be involved in the North American research programme, Marsden directed his enthusiasm to plans for a nuclear research team in New Zealand after the war and a search for uranium in the South Island. In a letter to Ken George in April 1945 Marsden wrote "we shall have a self-contained team on TA in New Zealand in due course" and "we are having quite a lot of fun chasing radioactive minerals (don't repeat this!). They are fairly widespread in small concentrations and the problem is in care and methods of concentration."[54] In July 1945 he gained Cabinet approval to place all the men working on the nuclear project in America, together with some remaining in New Zealand, in a special team, and on the permanent staff of the DSIR.[55]

Wartime uranium survey

Marsden's characteristic positivity, which his colleagues later described as "infectious enthusiasm" and "irrepressible optimism", had overstated the results of the uranium survey.[56] When the United Kingdom had initiated a Commonwealth search for uranium in 1942, they had excluded New Zealand, whose geology was not considered promising.[57] Marsden, however, thought he knew better and in December 1943, while on his fruitful trip through the United States, had taken matters into his own hands, writing to the director of New Zealand's Geological Survey to ask him to initiate a search for radioactive minerals in the South Island.[58] At about the same time, Marsden initiated publication of a radioactivity survey he and Watson-Munro had made in the 1930s.[59]

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[51] Marsden to Cockcroft, 26 March 1945, SIR1, W1414, 74/10, *ANZ.*
[52] Marsden to Watson-Munro, 12 April 1945, SIR1, W1414, 74/10, *ANZ.*
[53] Cockcroft to Marsden, 15 May 1945, SIR1, W1414, 74/10, *ANZ.*
[54] Marsden to George, 5 April 1945, SIR1, W1414, 74/10, *ANZ.*
[55] Marsden to Watson-Munro, 4 July 1945, SIR1, W1414, 74/10, *ANZ.*
[56] Marsden Booklet Editorial Panel 1969, pp33, 57, 81.
[57] Gowing 1964, p297.
[58] Retold in Marsden to Hon. D. G. Sullivan, 6 July 1944, SIR1, W1414, 74/10, *ANZ.*
[59] *AJHR* 1939, Vol 3, H-34, p129; Galbreath 1998, pp21-33; E. Marsden and C. Watson-Munro, 'Radioactivity of New Zealand Soils and Rocks', *NZJST* 26, 3B (1944), pp99-114; SIR W1414, 20/4/1, *ANZ.*

Back in New Zealand, Marsden consolidated the plans for a uranium survey. In July 1944, Marsden wrote to D. G. Sullivan, the Minister in charge of Scientific and Industrial Research, to say that although the likelihood of finding commercial quantities of uranium in New Zealand was small, "in view of the coming importance of the subject and likely demand, I recommend that authority be given for a thorough survey ...". The New Zealand War Cabinet approved funding for the uranium survey in July 1944 and a team of DSIR physicists assembled at the Dominion Physical Laboratory in Wellington to start work on the uranium project.[60] After reading relevant books and journals the team decided the best way to detect uranium was to use a Geiger counter, a radiation-measuring device developed by Rutherford's assistant Hans Geiger, so they set about trying to make them, and reducing them to a reasonably portable size.[61] In October 1944, a mining engineer and a physicist, carrying a Geiger counter to measure radioactivity, began secretly exploring beach sands along the West Coast of the South Island, from Karamea to the Moeraki River. Surveys of Stewart Island beach and river sands, and of beach sands and dredge tailings at Gillespies Beach, followed.[62] In late 1944, Marsden made requests to Ian Coop, the DSIR's scientific liaison officer in London, for instruments and materials for the uranium search. Coop was able to procure some items – lead, tungsten wire and sieves – and send them to Marsden in New Zealand, but, because of the war, many of the requested items were in short supply. In his reply, Coop advised that the British Directorate of Tube Alloys were surprised to find out about the New Zealand uranium survey and were concerned to emphasise that Marsden must treat the project as secret.[63]

Later that year, Marsden learned of a visit to New Zealand by a Mr G. H. Hall, a representative of the American chemical company Union Carbide who was working in close contact with the United States Government. Marsden learned that Hall was in New Zealand "to assess the probable sources of radioactive minerals such as uranium and thorium". Hall was not secretive about his work: when Marsden eventually met with Hall, he advised Marsden on suitable tools for deep drilling in sands, which was where the highest concentrations of uranium were being found.[64] Hall reported favourably on the possibility of the cheap production of

[60] Marsden to Hon. D. G. Sullivan, 6 July 1944, SIR1, W1414, 74/10, *ANZ;* Marsden to Minister of SIR, 17 October 1945, SIR1, W1414, 74/2/4, *ANZ.*
[61] Personal recollections by Jim McCahon, recorded by McCahon over 14-16 August 1998 as notes for talk to Kaikoura Probus Club; and author's interview with Jim McCahon, Wellington, 16 October 2002.
[62] Author's interview with Jim McCahon, Wellington, 16 October 2002; D. S. Nicholson, Comprehensive report on survey for radioactive minerals, EA2, (box 1948/6B), 111/18/3, part 1, *ANZ.*
[63] Coop to Marsden, 15 November 1944 and R. S. Sayers to Coop, 15 November 1944, both in SIR1, W1414, 74/8 (volume 1), *ANZ.*
[64] Marsden to Minister of SIR, 5 December 1944, Marsden to Nicholson, 13 December 1944, both in AAOQ, W3424, 74/2/1, *ANZ.*

uranium oxide and thorium oxide from New Zealand and inspired Marsden to resume the South Island search for radioactive minerals.[65]

Figure 4.2: Jim McCahon on the South Island uranium survey in the 1940s. *Courtesy Jim McCahon.*

In autumn 1945 a team set up camp at Gillespie's Beach (downstream from Fox Glacier on the West Coast) whose black sands had shown significant levels of radioactivity. Jim McCahon, a young physicist seconded to the DSIR, later recalled the work:

> [It was] very hot, so we worked most of the time nearly naked and, of course, any time a little cloud came over the sun we were free feed for the sandflies. When we had been there for about ten days, Dr Ernie Marsden of the DSIR called in to see how we were getting on. This whole project was a favourite of his. We told him of the sandfly troubles. He went away to his car and came back with a bottle labelled dimethyl phthalate – the stuff that is nowadays called "dimp". He had bludged this from the airforce up in the islands and he gave it to us for protection. It was an absolute godsend.[66]

In March 1945, the DSIR chartered the Government ship *New Golden Hind*, and the secret uranium survey was extended. The ship sailed down the South Island's east coast and around Bluff to investigate the eight sounds from Milford Sound to Nancy Sound. Once in the fiords, the scientists explored the coasts in outboard motor boats, testing the radioactivity of coastal

[65] World War II narrative No. 9, AAOQ, W3424 (box 16), *ANZ*.
[66] Personal recollections by Jim McCahon, recorded by McCahon over 14-16 August 1998 as notes for talk to Kaikoura Probus Club; and author's interview with Jim McCahon, Wellington, 16 October 2002.

rocks with their Geiger counters, but they failed to find any promising sources of radioactive minerals.[67]

The “atomic age” begins

By the end of May 1945, scientists and technicians at Los Alamos had received enough plutonium from the plant at Hanford to begin assembling a plutonium-based bomb. In a matter of weeks they had the makings of the world’s first nuclear weapon. On 16 July, the bomb, codenamed Trinity, in which two masses of plutonium were driven together by an explosive to create a mass greater than critical mass, was tested in a remote corner of the Alamogordo Air Base in the New Mexico desert. The explosion, witnessed by busloads of Los Alamos scientists and other observers, yielded energy close to that of 20,000 tons of TNT, vapourising the steel tower holding the bomb, fusing the desert sand below it into a crater of radioactive green glass, and sending a mushroom cloud 12 kilometres into the desert sky.[68]

The success of the test paved the way for the planned use of nuclear weapons against Japan, just as metallurgists at Los Alamos were assembling the final components in Little Boy, a uranium-based bomb and Fat Man, a second plutonium bomb. On 6 August an American B-29 bomber took off from the American base at Tinian, in the Northern Marianas Islands, and dropped a 3-metre-long bomb containing 60 kg of uranium-235 on the city of Hiroshima. The bomb exploded about 600 metres above the ground, with an energy yield equivalent to 12,500 tons of TNT, producing a rapidly expanding fireball that incinerated everything and everyone within a radius of about 1.6 km, and spread fires across a further 11 square kilometres. The press release issued by the White House later that day described the bomb as “the greatest achievement of organised science in history”. Three days later, an even more powerful plutonium-based fission bomb was exploded over Nagasaki. Burn injuries and radiation affected many of the initial survivors and by the end of 1945 an estimated 140,000 people had died from the Hiroshima bomb and 70,000 from the Nagasaki bomb.[69]

Few New Zealanders would have connected the work of New Zealand scientists and the dropping of the first nuclear bombs, but the day of the Nagasaki bombing, Viscount Bledisloe, New Zealand’s Governor-General from 1930 to 1935, wrote from London to the Minister of

[67] D. S. Nicholson, Comprehensive Report on Survey for Radioactive Minerals, EA2, (box 1948/6b), 111/18/3, part 1, *ANZ*; Personal recollections by Jim McCahon, recorded by McCahon over 14-16 August 1998 as notes for talk to Kaikoura Probus Club.
[68] Badash 1995, pp44-47; Rhodes 1986, p655, 670-678.
[69] Rhodes, pp691, 699-711; 734-740.

External Affairs to congratulate New Zealand, saying "How proud New Zealand must be that the foundations of the amazing discovery concerning latent atomic energy were laid by her own great scientist Rutherford – we tender her our warmest congratulations".[70] An official New Zealand press release, issued on 13 August 1945, linked the atomic bombs to Rutherford's early work, provided information about Marsden's uranium survey, and outlined the role of the New Zealand scientists working in North America, saying "New Zealand should be proud to know that some of her scientists of this generation were at the forefront of this latest development".[71]

Japan agreed to surrender the day after Nagasaki was bombed.[72] The general reaction in New Zealand, and in other Allied countries, was one of jubilation and relief. The war that had taken more than 11,000 New Zealand lives and impacted on every aspect of society was finally over. While it was marvelled at that a single bomb dropped from a great height could cause such devastation, there was initially no widespread awareness of how fundamentally different these bombs were: the conventional bombings of cities like Tokyo, Hamburg and Dresden had produced more casualties than in Hiroshima or Nagasaki, and the longer-term effects of radiation from the bombs were not yet known. Even those who saw the horrific aspect of the new type of bomb were able to put a positive spin on it: *The Listener* editorial of 17 August described the use of the atomic bomb as having "sickened many people and given others a faint gleam of hope", but took the stance that it was "justifiable to hope as well as to shudder": there was hope that the atomic bomb could mean the end of war. There were a few letters to the editor about the bomb – mostly expressing the hope that it could mean an end to war forever – but most New Zealanders were focused on relatives still overseas and on the practical necessities of coping with wartime shortages like how to re-waterproof an old raincoat, or how to make a fowl-house from old sacks and a wooden frame.[73] Some people, however, did realise the enormity of this new scientific and military development. A few days after the bombings, philosophy lecturer Karl Popper addressed a packed lecture hall at the University of Canterbury

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[70] Viscount Bledisloe to Minister of External Affairs, 9 August 1945, in EA1, W2619, 121/1/1, part 1, *ANZ;* Russell Marshall, 'Bledisloe, Charles Bathurst 1867–1958'. *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded on 12 June 2010.
[71] 'New Zealand Participation in Atomic Bomb Development', issued to the press on 13 August 1945, EA1, W2619, 121/1/1, part 1, *ANZ*.
[72] Gowing 1964, p379.
[73] Editorial, "Horror with Some Hope', *New Zealand Listener*, 17 August 1945, p5; Letters from Listeners and Letters to Aunt Daisy, *New Zealand Listener,* August 1945; Michael King, *The Penguin History of New Zealand*, Penguin, Auckland, 2003, pp407-408; Kevin Clements, *Back from the Brink: The Creation of a Nuclear-free New Zealand,* Allen & Unwin/Port Nicholson Press, Wellington, 1988, pp10-17.

with the words “when the first atomic bomb exploded, the world as we have come to know it came, I believe, to an end”.[74]

Robin Williams was holidaying in California with his wife when they saw the news headline announcing the Hiroshima bombing, and he realised it was the result of the project he had been working on. Williams remembers no discussion of moral issues among the British scientists in his team, and soon after he returned to Berkeley the assembled team began to disperse.[75] Williams was the first of the New Zealand team to leave North America, travelling to Cambridge to take a PhD in mathematics.[76] Page, who had earlier described his secondment to the United States as “a chance of a lifetime”, transferred to Montreal to work with Watson-Munro’s team.[77]

Jim McCahon, who had been employed on Marsden’s South Island uranium search, was in the laboratory in Wellington, analysing samples taken in the search, when he heard a radio bulletin announcing the Hiroshima bombing. He later described himself and his colleagues as having been astounded. When the uranium survey was first announced, they had found the German paper detailing the initial discovery of uranium fission in which “they had surmised that this could be used as a source of enormous amounts of energy but … not as an explosion. So we were thinking of nuclear power supplies … but not bombs.”[78]

A Labour Government, under Prime Minister Peter Fraser, was in power in New Zealand when Japan was bombed. There was no big discussion about the atomic bomb in Parliament, but various politicians referred to it, amid debate about other issues, in a mostly positive light. Robert Macfarlane, Labour MP for Christchurch South, had a positive view, accusing people who wrote letters to the newspaper expressing indignation about the use of the bomb of being pacifists, and saying that apart from its use as a destructive weapon, the atomic bomb “might have opened a new era of development for the people of the world and so some good may arise from its invention”. Major Clarence Skinner, a Minister in the Labour Government, spoke proudly of the work of the British and American scientists, who didn’t take long “to show the Japanese scientists who could do the best”. He continued by saying, “A couple of doses of

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[74] Kate Dewes and Robert Green 1999, p9; Glyn Strange, ‘Popper’s A-bomb dilemma’, *Evening Post*, 14 August 1995, p5.
[75] Williams 2001.
[76] Marsden to Minister of SIR, 25 September 1945, SIR1, W1414, 74/10, *ANZ*.
[77] Page to Marsden, 19 September 1944, and Page to Marsden 26 September 1945, both in SIR1, W1414, 74/10, part 1, *ANZ*.

atomic bomb worked the oracle, and now we see the Japanese taking orders from mere mortal men. I join with other members in offering my gratitude for what has happened during the last few weeks – the ending of the war." Another Labour MP, Edward Cullen, had a less positive view and expressed his opinion that the atomic bomb was "a frightful instrument against humanity".[79]

Parliament did, however, take action to control any uranium resources New Zealand might have. Under Marsden's recommendation, and following the advice of the British DSIR, New Zealand's Atomic Energy Act was passed on 7 December 1945 to give the State full ownership and control over uranium and other radioactive elements, with the Minister of Mines having power to control the mining and disposal of uranium-bearing rock and its products.[80] The military and economic importance of uranium was now recognised around the world, and Canada, South Africa, India, Australia and the United States all introduced similar legislation at about this time.[81]

Scientists were quick to realise the dangers of this new weapon. In September 1945 Williams and Page were among 13 British Berkeley scientists, including Wilkins, Oliphant and Massey, who, acting on their belief that "the advent of this new weapon of destruction ought to be the signal for renewed efforts to achieve lasting world peace" signed a letter to British Prime Minister Clement Attlee calling for international control of the use of atomic energy and urging cooperation with Russian and other scientists.[82] This desire for international cooperation with regard to nuclear weapons was widespread among scientists. The same month, Marsden advised the Minister of Scientific and Industrial Research of resolutions passed at a meeting of the New Zealand Council for Scientific and Industrial Research (an advisory council established at the same time as the DSIR) calling for the development and control of atomic energy to come under the aegis of the United Nations, with the results of research available to all people. "Any attempt at secrecy in this epoch-making field of research is fraught with the gravest possible danger to our civilisation", Marsden added.[83] The New Zealand scientists' attitudes were in line with a worldwide movement that included many of the scientists who had worked on the North

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[78] Personal recollections by Jim McCahon, recorded by McCahon over 14-16 August 1998 as notes for talk to Kaikoura Probus Club.
[79] *New Zealand Parliamentary Debates* 269 (1945), pp266, 486, 751-2.
[80] Atomic Energy Act, *New Zealand Statutes*, 1945, pp364-370; World War II narrative No. 9, AAOQ, W3424 (box 16), *ANZ.*
[81] World War II narrative No. 9, AAOQ, W3424 (box 16), *ANZ.*
[82] Letter to Attlee, signed by Williams and others, 19 September 1945, Robin Williams' personal archives.
[83] Marsden to Minister of SIR, 12 September 1945, EA1, W2619, 121/1/1, part 1, *ANZ.*

American nuclear projects. As the New Zealand World War II narrative on atomic energy colourfully put it in 1948, these international groupings of scientists were driven by “fear of the immediate physical consequences of an armaments race in the atomic age, fear of the destruction of civilisation and of the best fruits of the human spirit, fear that science might be shackled by security and other regulations and enfeebled by its prostitution to nationalistic military ends”.[84]

Less than six months after the dropping of the first atomic bombs, in January 1946, New Zealand was one of 51 nations represented at the first General Assembly of the United Nations. The first resolution adopted concerned the establishment of an Atomic Energy Commission, comprising the members of the Security Council, plus Canada, to deal with issues related to the peaceful uses of atomic energy and the elimination of atomic and other weapons of mass destruction.[85] In the general debate in the plenary meeting, the New Zealand representative suggested that control of the Commission should not be left exclusively to the Security Council, as had been suggested, but should rather be the responsibility of the entire General Assembly – this way small countries like New Zealand could continue to be able to have a say on such issues – but this was not heeded.[86] Later that year, the United States presented a proposal known as the Baruch Plan, which called for international inspection of all nuclear-related facilities to ensure they were not working on atomic weapons and stipulated that the United States stop all weapons work and turn over its atomic energy knowledge, and existing weapons, to the United Nations.[87]

While the DSIR scientists’ work on the nuclear bomb finished once the bomb had been used, another group of New Zealanders became involved in the bombs’ aftermath, with New Zealand army engineers involved in the demolition of bomb-damaged buildings and bunkers in Hiroshima. They, along with other personnel from Jayforce – the New Zealand army brigade stationed in Japan from 1946 to 1948 as part of the British Commonwealth Occupation Force – witnessed the devastation and after-effects of the bomb. Some Jayforce personnel later recalled being told to remain inside their trucks or trains when passing close to the zone where the atomic bomb was detonated in Hiroshima, but most people recalled no warnings about the dangers from radiation poisoning. Even people not stationed in Hiroshima would take sightseeing trips to the devastated city, where they would “hunt for souvenirs such as fused glass”, or offer goods for

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[84] World War II narrative No. 9, AAOQ, W3424 (box 16), *ANZ*.
[85] United Nations website, www.un.org/aboutun.milestones.htm.
[86] UN First Assembly Report of the NZ delegation, 14 February 1946, EA1, W2619, 121/1/1, *ANZ*.
[87] John Lewis Gaddis, *The Cold War*, Allen Lane, London, 2005, p54.

sale on the local black market. One officer later recalled eating oysters from a Hiroshima pearl farm.[88]

Back in New Zealand, once the excitement of the end of the war was over, there was a growing awareness that a new age, the "atomic age", had begun. In New Zealand, as in the rest of the Western world, the atomic age was seen as a modern and sophisticated new era. In 1946, among *The Listener* advertisements for pointy bras, laxatives and cork-tipped cigarettes appeared Monterey's advertisements for Atomic Red lipstick. Australian historian Marilyn Lake in 1990 described post-war women as being "invited to step into an alluring, exciting future", enticed in part by a linked rise in advertising and consumerism in which advertisements aimed at women "incited sexual desire and promised its gratification".[89] It seems in appalling bad taste now to link sexuality with weapons that had killed thousands of people, but the Atomic Red lipstick ads promised women they'd be "charged with excitement … devastating … all conquering", saying women who wore the lipstick were chic and daring.

Figure 4.3: Among the advertisements for pointy bras, laxatives and cork-tipped cigarettes appeared Monterey's advertisements for *Atomic Red* lipstick. *New Zealand Listener*, 15 February 1946 and 8 March 1946.

New Zealand scientists' work on nuclear reactors

The New Zealand scientists working on the Manhattan Project had fulfilled their role and moved on, but what of the scientists in Canada? In August 1945, Norman Manssen, one of the men

[88] Laurie Brocklebank, *Jayforce: New Zealand and the Military Occupation of Japan 1945-48,* Oxford University Press, Auckland, 1997, pp4, 95-97, 120-22; Keith Richardson, *Fatal Legacy: A Nuclear Story,* Alexander Turnbull Library Sound Recordings Collection Phono CD9755.
[89] Marilyn Lake, 'Female Desires: The Meaning of World War II', *Australian Historian Studies* 24, 95 (1990), pp267-284.

Marsden had recommended earlier, became available and travelled to Montreal to work with the New Zealand team at Chalk River. In seeking permission to send Manssen, Marsden expressed his view that the experience he and the other scientists would gain on the project "would pay handsome dividends to New Zealand upon their return. It will enable us to proceed upon developments of this new source of energy to our own ultimate economy."[90] Marsden still had plans for a nuclear programme in New Zealand.

As the Montreal project had developed, scientists had made a case for producing a "zero energy pile" – a pile that produces a chain reaction but almost no extra heat or energy. Such a pile would be simple to produce, flexible in its applications, and would have great research value producing neutrons and radiations for use in a range of experiments. It would also provide information that could be applied for the planned larger pilot plant to produce energy. The plan was approved for a zero energy experimental pile, or ZEEP, in which rods of aluminium-sheathed uranium would be placed in a tank of heavy water surrounded by a graphite reflector. Watson-Munro, who was leading the small New Zealand team at Chalk River, was one of six scientists and engineers assigned to the detailed engineering of ZEEP.[91] By September 1945, ZEEP, the first nuclear reactor built outside the United States, was complete and Watson-Munro, with the help of Allan and Fergusson, had played a major role in its construction, particularly by designing the electronic control equipment for the reactor.[92]

New Zealanders' involvement in the development of nuclear energy continued. After the war, the British Government turned their focus to a United Kingdom-based atomic energy research project, and in 1946 Watson-Munro and three of the other New Zealanders – Fergusson, Page and Walker – left Canada for the newly established United Kingdom Atomic Energy Research Establishment in Harwell. The remaining New Zealanders – George, Young, Allan and Manssen – initially remained in Canada to continue work on the pilot pile, which became known as the NRX (National Research eXperimental) reactor. While Young was put in charge of the Montreal workshops, George worked on designing nuclear instrumental equipment, and Manssen supervised the installation and commissioning of the electronic and electrical equipment for the NRX reactor, which went critical in July 1947 and for many years was considered one of the best research reactors in the world. In the United Kingdom, Watson-Munro took charge of the construction of a Graphite Low Energy Experiment Pile, or GLEEP, the first nuclear reactor in

[90] Marsden to Minister of Scientific and Industrial Research, 9 August 1945, SIR1, W1414, 74/10, *ANZ*.
[91] Gowing 1964, pp279-80.
[92] Marsden Editorial Panel 1969, p103-4; Notes by Cockcroft, 10 December 1945, SIR1, W1414, 74/10, *ANZ*.

the United Kingdom, which was completed in August 1947 and was intended for use for experimental purposes as well as the production of radioactive isotopes. Page, also working at Harwell, designed the United Kingdom's first mass spectrograph.[93] Allan and Manssen transferred to Harwell after completing their work at Chalk River.[94]

An atomic pile for New Zealand?

After the war, Marsden started to enact his vision for a nuclear New Zealand. If he couldn't be part of the big science taking place in Europe and America he would make it happen at home. In January 1946 Marsden gained Cabinet approval to establish a new team of 10 scientists at the Dominion Physical Laboratory. Their mission was to carry out fundamental and applied atomic research and advise on atomic energy and the application of isotope techniques to problems in agriculture, health and industry. The same Cabinet decision allowed for the secondment of physicists, chemists or engineers to nuclear organisations in the United Kingdom and Canada to ensure New Zealand kept up to date with new developments and techniques. Under the secondment arrangement, New Zealand would pay the officers' salaries, and in return would receive supplies of artificially radioactive elements, technical information and cooperation and liaison work in connection with the laboratory in New Zealand. An annual budget of £19,000 was allocated to implement these proposals.[95]

Even before this approval was granted, Marsden had organised a second *New Golden Hind* expedition – this one not secret – to complete the initial survey. Dick Willet, of the New Zealand Geological Survey, led the January 1946 expedition that searched the rocks, beaches and gravels in the southern sounds from Preservation Inlet up to Thompson Sound. He took with him geologist Harold Wellman, and three geophysicists, Jim McCahon, Kemp Fowler and Graham Fraser, to operate the Geiger counters and measure the radioactivity of the rocks and dredgings. The bearded scientists and Rarotongan crew supplemented their diet of bully beef, potatoes and pumpkin with fresh fish, crayfish and swan: "Shooting at [swans] from a lurching dinghy is useless; the method is to run down a young one unable to fly and brain it with an oar" reported Fowler. [96]

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[93] Cockcroft to Marsden, 11 March 1947, SIR1, W1414, 74/10, *ANZ*; Marsden Editorial Panel 1969, p103-4; Gowing 1964, p280-1.
[94] Secretary to Brigadier Stevens, 3 April 1947, SIR1, W1414, 74/10, *ANZ.*
[95] Cabinet approval dated 25 January 1946, noted on 17 December 1945 recommendation, EA2, (box 1948/6B), 111/18/3, part 1, *ANZ.*
[96] K. T. Fowler, 'The "New Golden Hind" Looks for Uranium', *The Public Service Journal*, May 1946, pp196-199; Undated press clippings and personal recollections from Jim McCahon, October 2002

Figure 4.4: The *New Golden Hind* sets off from Wellington on its second uranium survey in January 1946. Those standing on the left are Minister of Works Bob Semple, and Minister in charge of the DSIR Daniel Sullivan. Seated in the front are physicist Jim McCahon, geologist Dick Willett, and Harry Allan, Director of the DSIR's Botany Division. In the back are a ship's officer, A. S. C. Wright, Captain Cole, the radio operator, physicist Kemp Fowler, the Minister's secretary, geologist Harold Wellman, Director of the Geological Survey Mont Ongley, and physicist Graham Fraser. Source: Simon Nathan.

Over the course of the two-year uranium survey, the geologists tested the radioactivity of rocks and beaches along nearly 1,600 kilometres of coast; the sands and gravels from more than 100 streams and rivers; and the concentrates from more than 20 sluicing and gold-dredging claims in Nelson, Westland, Otago and Southland.[97] As the only result of the survey, uranium-bearing minerals were found in gold dredge tailings on the West Coast, but their quantity and concentration was deemed too small to permit their economic recovery.[98]

Without a domestic source of uranium, was there still hope for a nuclear reactor for New Zealand? New Zealand might not have had any promising uranium deposits, but it did have a skilled group of scientists, and, as Marsden had pointed out in a September 1945 letter to Edward Appleton, the director of the British Tube Alloys project, "they cannot unlearn the things they picked up from their work with you and cannot well be prevented from using the knowledge …". Marsden had also offered for New Zealand scientists to continue to be seconded to British nuclear projects, in return for "reasonable information received and the possible supply in the next year or two of labelled atoms for experimental work in medical, agricultural

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[97] D. S. Nicholson, 'Wartime Search for Uranium', *NZJST* 36B (1955), pp375-396.
[98] Nicholson 1955; D. S. Nicholson, Comprehensive Report on Survey for Radioactive Minerals, EA2, (box 1948/6B), 111/18/3, part 1, *ANZ*.

and chemical fields".[99] As Marsden had said, the New Zealand scientists could not "unlearn" what they now knew about nuclear energy: following his work on GLEEP and ZEEP Watson-Munro was now one of the world's experts on construction of nuclear piles, and despite the British-American agreement not to share nuclear technology with other countries it was going to be impossible to keep this technology from New Zealand.[100] Aware of this, Cockcroft wrote to Marsden in May 1947. After voicing appreciation of the New Zealanders who had come to the United Kingdom to work on GLEEP, Cockcroft expressed his hope that New Zealand would "build a Gleep, or perhaps something a little more powerful, in your area of the world. Munro would be well able to do this for you, and I should think it would be possible to arrange for the basic materials to be provided".[101] Cockcroft at this time, as part of a policy of an Empire-wide approach to defence science, was also open to the idea of a Commonwealth nuclear reactor to produce plutonium for British bombs.[102]

Before returning to New Zealand, Watson-Munro, in consultation with Marsden, submitted a report to the New Zealand Government on the construction of a low energy atomic pile in New Zealand. The pile was recommended on two grounds: for the production of radioisotopes for industrial and agricultural research; and to serve as the nucleus of an atomic research project.[103] Marsden also believed the pile would provide a "long term contribution to Commonwealth defence".[104] In August 1947, based on Marsden and Watson-Munro's report, New Zealand's newly-established Atomic Energy Research Committee recommended the construction of an Australasian low energy pile in New Zealand.[105] The pile was proposed to be used "for the provision of certain radio isotopes whose life was short and which are needed for medical and research purposes, and to afford, as a general strategic reserve, skill and experience to New Zealand scientists in atomic energy development".[106] In Australia, the Council for Scientific and Industrial Research had already begun its own research into nuclear energy and the Bureau of Mineral Resources was searching for uranium. While Australia was more immediately enthusiastic than New Zealand about embracing nuclear technology – it asked the United Kingdom directly for information on using atomic energy – it did not have the group of

[99] Marsden to Appleton, 29 September 1945, SIR1, W1414, 74/10, quoted in World War II narrative No. 9, AAOQ, W3424 (box 16), *ANZ.*
[100] Galbreath 1998, pp149-151.
[101] Quoted in Marsden to Acting Minister SIR, 13 May 1947, SIR1, W1414, 74/10, *ANZ.*
[102] Wayne Reynolds, *Australia's Bid for the Atomic Bomb*, Melbourne University Press, Melbourne, 2000, pp99, 121.
[103] Report on Atomic Energy (not dated) EA1, W2619, 121/2/1, part 1, *ANZ.*
[104] Draft memorandum by Marsden, 18 September 1947 and A. G. Osborne to Secretary of State for Commonwealth Relations, 26 September 1947, AAOQ, W3424, 74/20/- (1947-55), *ANZ.*
[105] Minutes of meeting of Atomic Energy Research Committee, 26 August 1947, SIR1, 74/13/1, *ANZ.*

scientists experienced in working on nuclear energy that New Zealand now had. Mark Oliphant and a small group of Australians had worked at Berkeley on the electromagnetic separation of uranium for the Manhattan Project but only one Australian engineer had worked on the Canadian nuclear energy project. After helping to set up the British Atomic Energy Research Establishment at Harwell, Oliphant returned to Australia to head a school of nuclear physics at the new Australia National University in Canberra.[107]

The American post-war secrecy led the Commonwealth countries – including New Zealand, Australia and the United Kingdom – to side together, often conducting research on projects without American knowledge. In a way, this encouraged the sense that there was a choice to be made between the United Kingdom and the United States, and New Zealand scientific loyalty was clearly with the United Kingdom. In September 1947 Marsden left his position as secretary of the DSIR to become the DSIR's Scientific Advisor in London. It seems an unlikely move for someone of Marsden's seniority to move from a role as head of department to a liaison role, but his letters over this time reveal some motives. It seems that Marsden, to some extent, felt unappreciated by those above him in the Public Service Commission. He also strongly supported Commonwealth cooperation with regard to defence science, and felt he could play a stronger role in cementing cooperation between New Zealand and the United Kingdom if he was in London. In his personal letters, he mentioned several British requests for a more senior officer to be sent from New Zealand as scientific representative. On top of this was Marsden's already demonstrated desire to be involved in the big science that was happening in the United Kingdom, and with New Zealand having an ambivalent attitude to proceeding with plans for a nuclear reactor, Marsden perhaps felt he could push things along further from the United Kingdom.[108] When Marsden arrived in London, he and Watson-Munro met Lord Portal, head of the Atomic Energy (Review of Production) Committee, to talk about the Commonwealth atomic pile. They discussed the advantages of a small atomic pile in New Zealand for research purposes, to be followed up by a large power production pile in Australia, "capable of producing fissile materials suitable for the manufacture of atomic bombs". At this time, the Atomic Energy Production Organisation was erecting three large atomic piles in the north of England, all

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[106] Shanahan to Ushwin, 18 October 1948, EA1, W2619, 121/2/1, *ANZ.*
[107] Alice Cawte, *Atomic Australia 1944-1990*, New South Wales University Press, Sydney, 1992, pp11-15; Binnie 2006, p15; Reynolds 2000, pp 30, 101.
[108] Marsden's 1948 letters, *MS-Papers 1342-034, ATL*; Marsden to Minister of SIR, 11 June 1947, *MS-Papers 1342-001, ATL.*

capable of producing fissile material for military purposes. It was suggested that it might be strategic to locate one of these in Australia.[109]

Marsden's enthusiasm for New Zealand's assistance to British nuclear defence plans can be seen as incongruous when measured against his prior support for the 1946 Baruch Plan, which called for international inspection of all nuclear-related facilities to ensure they were not working on atomic weapons and stipulated that the United States dispose of its atomic weapons, stop all weapons work and turn over its atomic energy knowledge to the United Nations. In a 1947 speech, Marsden, who advocated atomic energy as being of "untold benefit to the world" said that it was not, however, safe to develop atomic energy on a world-wide scale until there was a practical and enforceable agreement that it would not be used for atomic bombs.[110] No such agreement was put in place and his stated views on atomic weapons seem to conflict with his concurrent plans for development of a nuclear reactor in New Zealand, which he promoted as being of defence significance to the Commonwealth. A reading of his letters, however, suggests that his was a pragmatic approach. At the start of the Cold War, the United States and the Soviet Union were proceeding with development of nuclear weapons, and Marsden believed that a third nuclear power, the United Kingdom (with the support of the Commonwealth), would make for a more balanced and stable world, with "more safety in three strong world groups than two".[111]

On receiving sympathetic responses to the proposal for a New Zealand atomic pile from both Lord Portal and John Cockcroft, who was now director of the Atomic Energy Research Establishment at Harwell, Marsden was tremendously excited. He admitted he had initially thought the reactor proposal was an "ambitious dream", but was now convinced it would be "a statesmanlike step to take at higher levels with enormous repercussions for the good of our country". Marsden, writing from London, believed the reason New Zealand was getting more support than Australia was "partly sentimental, because of its origination by Rutherford, partly practical because of the record of our boys here".[112]

In response to a ministerial request, Marsden and Watson-Munro provided an advisory report, which was agreed to by John Cockcroft, on the construction and use of an atomic pile in New

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[109] Watson-Munro to Shanahan, 17 September 1948, EA, W2619, 121/2/1, part 1, *ANZ*; Margaret Gowing, *Independence and Deterrence: Britain and Atomic Energy 1945-1952: Volume 1 Policy Making*, London, Macmillan, 1974, p36.
[110] E. Marsden, The Atomic Age, unpublished talk to National Dairy Association of New Zealand in 1947, MS papers 1342-269, *ATL*.
[111] Marsden to Taylor, 17 January 1955, MS-Papers 1342-37, *ATL*.
[112] Marsden to Shanahan, 11 December 1947, AAOQ, W3424, 74/20/- (1948-49), *ANZ*.

Zealand. The November 1947 report recommended a graphite uranium pile costing £100,000 to construct and up to £35,000 a year to run. The project would use the skills of the New Zealand scientists who had worked on the North American nuclear programmes and would take one-to-two years to build. They made it clear that the proposed pile "would not produce an atomic bomb but "would contribute substantially in the future to the security of the Commonwealth".[113] The Minister of Scientific and Industrial Research, however, was critical of the report, questioning the need for a New Zealand pile on the basis that radioisotopes were available only from overseas and New Zealand scientists would be best trained in more sophisticated offshore facilities.[114] Marsden and Watson-Munro were not deterred, however, and in March 1948, Watson-Munro expanded on this report, with a paper on "Amplification of Reasons for an Atomic Pile in New Zealand", again outlining the issue of many isotopes being too short-lived to import from overseas, and emphasising the benefits of a pile as a practice run for a future atomic energy project. [115] At this time, New Zealand was having great difficulty securing radioisotopes from overseas because of the very short half-life of some of them, and the large amount of shielding required for some overseas shipments (a 1 lb shipment of radioactive cobalt was brought to New Zealand on a Navy frigate, and was reported as requiring three-quarters of a ton of concrete shielding).[116] The defence applications were also raised, partly from having a centre of nuclear physics away from the northern hemisphere, but also in giving New Zealand scientists expertise to help deal with "an atomic dust attack on a major New Zealand city or water supply".[117] But this time, Henry Tizard, scientific advisor to the British Ministry of Defence, gave the proposal a lukewarm reception, telling Marsden the defence arguments in favour of the pile were weak.[118]

Peter Fraser, the New Zealand Prime Minister, then sought the opinion of the British Prime Minister on the value of the project.[119] Clement Atlee replied favourably, saying the project would be of "advantage to the Commonwealth" and offering the assistance of the United Kingdom Government.[120] Fraser travelled to the United Kingdom in December 1948, and visited the low energy atomic pile at Harwell. Marsden briefed Fraser on his visit to Harwell,

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[113] Marsden and Watson-Munro, An Atomic Pile for New Zealand, EA1, W2619, 121/2/1, part 1, *ANZ*.
[114] Callaghan to Marsden, 28 January 1948, AAOQ, W3424, 74/20/-, 1947-55, *ANZ*.
[115] Amplification of Reasons for an Atomic Pile in New Zealand, by C. N. Watson-Munro, EA1, W2619, 121/2/1, part 1, *ANZ*.
[116] Watson-Munro to Shanahan, 17 September 1948, EA1, W2619, 121/2/1, *ANZ*; *The Dominion*, 26 March 1949, EA1, W2619, 121/2/1, part 1, *ANZ*.
[117] Amplification of Reasons for an Atomic Pile in New Zealand, by C. N. Watson-Munro, EA1, W2619, 121/2/1, part 1, *ANZ*.
[118] Tizard to Marsden, 21 April 1948, AAOQ, W3424, 74/20/-, 1947-55, *ANZ*; Gowing 1974, p33.
[119] Peter Fraser to Clement Attlee, 11 August 1948, AAOQ, W3424, 74/20/-, 1947-55, *ANZ*.

where he would see the GLEEP in action, and meet the five New Zealanders now working there, one of whom was George Page.[121] Marsden also briefed Fraser on the benefits of a low-energy atomic pile, pointing out that while South Africa and Australia could more easily obtain radioisotopes from the United Kingdom, in New Zealand's case a change of aeroplane was involved, resulting in more difficult organisation and the loss of valuable time, having a great impact on important short-lived isotopes of iodine and phosphorus. Marsden added that the pile suggested for New Zealand "is about 10 times as powerful as that of GLEEP ... but will be less bulky, and will involve no danger whatsoever to anyone living near it. A suggested site is near Lincoln College, ie, handy to aerodrome and Medical School and a good distribution centre."[122]

Marsden continued to advocate for construction of an atomic pile in New Zealand.[123] But given his absence from New Zealand, and – despite Atlee's offer of assistance – with limited support from the New Zealand Government for an atomic pile, many of the DSIR's original nuclear sciences team moved into other areas of research. Charles Watson-Munro, George Page and Cliff Dalton eventually moved to the Australian Atomic Energy Commission Research Establishment, where Watson-Munro became chief scientist.[124] The DSIR nuclear sciences team Marsden had established continued, though rather than operating a research reactor they focused on measuring environmental radioactivity, using radioactive tracers, and experimenting with radiocarbon dating.[125]

Conclusion

New Zealand scientists on secondment from the DSIR assisted the development of nuclear weapons in the United States and played a major role in the British nuclear energy programme, first in Canada and then in the United Kingdom. The New Zealand involvement in these projects was initiated by Ernest Marsden, the secretary of the DSIR, using the networks he established as a student of Ernest Rutherford's. After the Second World War, Marsden set up a DSIR nuclear sciences team and completed a DSIR survey of radioactive minerals in the South Island, hoping to find a source of uranium for use in a local nuclear programme. Marsden, with Charles

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[120] Clement Attlee to Peter Fraser, 30 September 1948, EA, W2619, 121/2/1, part 1, *ANZ.*
[121] The other New Zealanders were Rhodes Scholar Cliff Dalton; a Nelson chemist by the name of Hirst; Brown, an Otago University graduate; and Miss Palmer Brown of Otago, who was working on health safety.
[122] Notes for Prime Minister in Connection with Visit to Harwell, 17 December 1948, EA1, W2619, 121/2/1, part 1, *ANZ.*
[123] Marsden to Shanahan, 10 February 1948, AAOQ, W3424, 74/20/-, 1947-55, *ANZ*.
[124] Marsden Editorial Panel in *Sir Ernest Marsden 80th Birthday Book*, p103-4; M. H. Brennan, 'Charles Watson-Munro, 1915-1991', *Australian Academy of Science Biographical Memoirs*, www.science.org.au/academy/memoirs/watson-munro.htm, downloaded 17 September 2008.
[125] Galbreath 1998, p156-165.

Watson-Munro, promoted plans for a research reactor in New Zealand to produce radioactive isotopes and gained British support for their plan. In 1947 Marsden left his position as secretary of the DSIR to become the DSIR's scientific liaison officer in London. From here, he pushed for the establishment of a Commonwealth nuclear reactor in New Zealand.

After the Second World War, most scientists were of the opinion that, as with most scientific information, knowledge about atomic energy should be freely shared between nations and among the global scientific community, regardless of political alliances. The New Zealand scientists who worked on the North American nuclear projects, along with Ernest Marsden, agreed with this. These idealistic plans were not to come to fruition, however. In the years that followed, information exchange came to a halt, with a breakdown in United States-British relations and the start of an international arms race and the Cold War between the United States and the Soviet Union. Information about atomic energy and atomic weapons was top secret as first the Soviet Union, then the United Kingdom, then France and China, began their own development of nuclear weapons.

Chapter 5

Cold War and red hot science:

The nuclear age comes to the Pacific

"As it detonated, I felt the heat and saw the flash through my eyelids and fingers. About half a minute later we were told to face the burst. All cloud cover had gone, and the coloured fireball was climbing rapidly upwards. It was an impressive sight ..."

Maurice Hayman, Operation Grapple, 1958[1]

" … the inhabitants might be advised to eat only coconuts during the period of the tests."

Department of Health recommendation, 1957[2]

Historians have described the 1950s as a golden age of prosperity and optimism, with full employment for men, a baby boom and a rise in consumer culture.[3] A less positive view of the decade describes a culture of conformity where ideological challenges to the right wing hegemony were unwise, free speech was restricted, and fear of communism led to suspicion of anyone with communist ideals being a Soviet agent.[4] While the end of the Second World War was certainly a cause for optimism, the Cold War was now a source of fear. And while the dawning "atomic age" promised a bright new future for the world, it also involved a nuclear arms race. Most New Zealanders, however, initially saw the perceived threat from the Soviet Union and other Communist nations as justification for the nuclear arms race, even when the search for new bomb-testing territories led the Pacific to become what Stewart Firth has called a "nuclear playground".[5]

The first two nations to test nuclear weapons in the Pacific were the United States and the United Kingdom. McIntyre has described New Zealand's post-war period as one of dual dependency on the United Kingdom and the United States, New Zealand's powerful new friend and protector.[6]

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[1] This recollection is of the last Operation Grapple blast on 23 September 1958, from Maurice Hayman, *Those Useless Wings: Operation Grapple*, M. Hayman, Riverton, 1997, p13.
[2] This Department of Health report is referred to in a letter from G. R. Laking, Secretary of External Affairs to Secretary of the Department of Island Territories, 15 April 1957, H1, 26717, 108/11, 1951-57, *ANZ.*
[3] Michael King, *The Penguin History of New Zealand*, Penguin, Auckland, 2003, pp413-5; Phillippa Mein Smith, *A Concise History of New Zealand*, Cambridge University Press, Cambridge, 2005, p175.
[4] Chris Trotter, *No Left Turn: The Distortion of New Zealand's History by Greed, Bigotry and Right-Wing Politics*, Random House, Auckland, 2007, p180-84, 224-5; James Belich, *Paradise Reforged: A History of the New Zealanders From the 1880s to the Year 2000*, Allen Lane, Auckland, 2001, p301.
[5] Stewart Firth, *Nuclear Playground*, Allen & Unwin, Sydney, 1987.
[6] W. David McIntyre, 'From Dual Dependency to Nuclear Free'. In Geoffrey W. Rice (ed), *The Oxford History of New Zealand, 2nd edition*, Oxford University Press, Auckland, 1992, p520.

When it came to their Pacific nuclear testing programmes, however, the strength of the New Zealand-United Kingdom relationship was apparent: the Government offered logistical support to the British nuclear testing programme and New Zealanders took pride in British scientific and military achievements. In contrast, the United States nuclear testing programme was acknowledged, rather than celebrated, as necessary to their maintaining supremacy in the arms race. In both relationships, however, New Zealand's independence is apparent: this chapter will show that New Zealand said "no" to specific American and British requests when it was not politically or economically expedient to say "yes".

The Pacific "nuclear playground"

The wartime cooperation between the United States and the United Kingdom on nuclear weapons and nuclear energy development did not last. The United States Atomic Energy Act of 1946 transferred control of atomic research from a military to a civilian organisation. Following reports of Soviet infiltration into the Canadian nuclear energy project, the Act also prohibited the transfer of nuclear technology to other countries, ending the British-American partnership agreed to in the 1943 Quebec Agreement. The United Kingdom now had to work independently to develop its own nuclear weapons.[7] The United Kingdom had already decided to move its atomic energy research and development programme from Chalk River to Harwell, and now made plans for a weapons development laboratory as well.[8]

Post-war New Zealand was changing politically and was beginning to assert greater independence. Known as a Dominion of the British Empire from 1907, New Zealand now dropped "Dominion of" and was known solely as "New Zealand". With the passing of the Statute of Westminster Adoption Act in 1947, New Zealand Parliament lost its legal sub-ordinance to the Parliament of the United Kingdom and gained control of its own rules of government.[9] New Zealand's first National Government came to power in 1949 under the leadership of Sidney Holland, who remained Prime Minister until 1957.[10]

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[7] Lorna Arnold and Mark Smith, *Britain, Australia and The Bomb: The Nuclear Tests and their Aftermath, 2nd edition*, Palgrave Macmillan, Houndmills, 2006, p6; Ronald E. Powaski, *March to Armageddon: The United States and the Nuclear Arms Race, 1939 to the Present,* Oxford University Press, Oxford, 1987, pp38-40.
[8] Donald Howard Avery, 'Atomic Scientific Co-operation and Rivalry Among Allies: The Anglo-Canadian Montreal Laboratory and the Manhattan Project 1943-1946', *War in History* 2, 3 (1995), pp274-305.
[9] Geoffrey Palmer and Matthew Palmer, *Bridled Power: New Zealand Government Under MMP, third edition,* Oxford University Press, Auckland, 1997, pp3-4; McIntyre 1992, p520.
[10] Barry Gustafson, 'Holland, Sidney George 1893-1961', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded on 8 March 2010.

While the relationship with the United Kingdom was still strong – it was the destination of two-thirds of New Zealand's exports and the source of nearly half of New Zealand's permanent immigrants – the Pacific War with Japan had highlighted New Zealand's need for the United States' protection.[11] A New Zealand legation had opened in Washington in 1941, but the relationship strengthened after 1951, when the ANZUS Treaty was signed. This security agreement between New Zealand, Australia and the United States offered the United States support for their "soft peace" with Japan while giving Australia and New Zealand a guarantee of protection against any Japanese military threat.[12] There was also growing anxiety, particularly from Australia and the United States, about Communist expansion into South East Asia: the People's Republic of China had been formed in 1949 after a long civil war and the most populous country in the world was now Communist.[13]

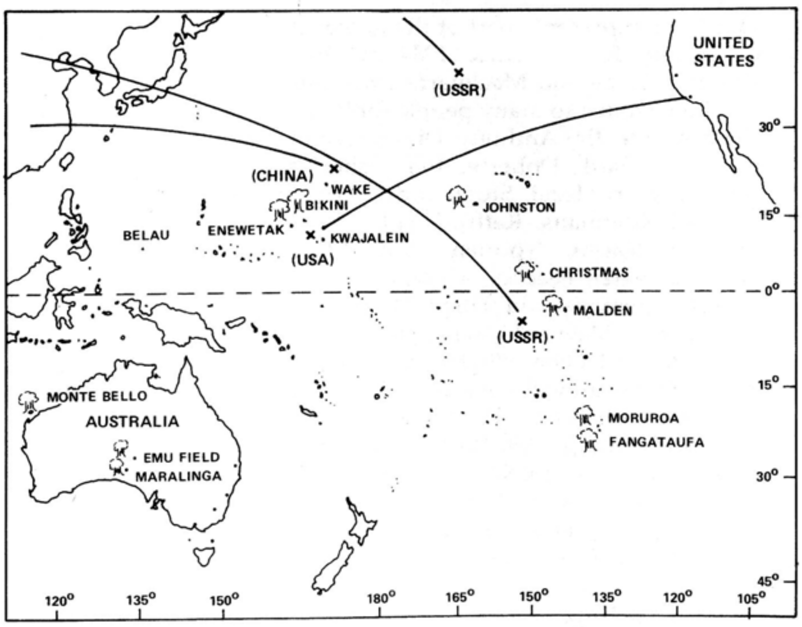

Figure 5.1: In the late 1940s and 1950s the Pacific became what Stewart Firth has called a "nuclear playground" for the nuclear powers. This map shows sites of nuclear bomb tests and major missile trajectories. Source: Stewart Firth, *Nuclear Playground*, Allen & Unwin, Sydney, 1987, p viii. Reproduced with permission.

Despite the importance of the relationship with the United States in protecting New Zealand from Japan or the perceived threat of Communism, when the United Kingdom and the United States began testing nuclear bombs in the Pacific, it was clear that New Zealand's support lay with the United Kingdom.

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[11] *New Zealand Official Yearbook*, Government Printer, Wellington, 1955, p287; King 2003, pp415, 426; Mein Smith 2005, pp77-9, 184.

[12] W. David McIntyre, *Background to the Anzus Pact: Policy-Making, Strategy and Diplomacy, 1945-55*, Canterbury University Press, Christchurch, 1995, pp1-2.

Table 5.1: American atomic weapon tests in the Pacific, 1946-62.

Operation and location (local date)	Magnitude
Bikini Atoll – Operation Crossroads	
1 July 1946	21 kt
25 July 1946	21 kt
Enewetak Atoll – Operation Sandstone	
15 April 1948	37 kt
1 May 1948	49 kt
15 May 1948	18 kt
Enewetak Atoll – Operation Greenhouse	
8 April 1951	81 kt
21 April 1951	47 kt
9 May 1951	225 kt
25 May 1951	45.5 kt
Enewetak Atoll – Operation Ivy	
1 November 1952	10.4 Mt
16 November 1952	500 kt
Bikini and Enewetak Atolls – Operation Castle	
1 March 1954	15 Mt
27 March 1954	11 Mt
7 April 1954	110 kt
26 April 1954	6.9 Mt
5 May 1954	13.5 Mt
14 May 1954	1.7 Mt
Bikini and Enewetak Atolls – Operation Redwing	
17 weapons tested 21 May and 22 July 1956	0.19kt – 5 Mt
Bikini, Enewetak and Johnston Atolls – Operation Hardtack	
36 weapons tested 28 April and 18 August 1958	0.02 kt – 9.3 Mt
Christmas Island and Johnston Atoll – Operation Dominic	
36 weapons tested 26 April and 4 November 1962	40 kt – 8.3 Mt

The United States' Pacific nuclear tests were mostly in the Marshall Islands, in the North Pacific, but some of the tests were of such magnitude that they impacted on surrounding Pacific islands, and distributed fallout throughout the world. Source: Adapted from S. L. Simon and W. L. Robison, 'A compilation of nuclear weapons test detonation data for U.S. Pacific Ocean tests', *Journal of Health Physics* 73, 1 (1997), pp258-264. Downloaded from http://www.hss.energy.gov/HealthSafety/IHS/marshall/marsh/journal/rpt-22.pdf on 26 March 2009.

According to Cold War historian John Lewis Gaddis, victory in the Second World War brought no sense of security to the victors.[14] After the successful deployment of nuclear weapons in the

[13] John Lewis Gaddis, *The Cold War*, Allen Lane, London, 2005, pp36-37; Anne-Marie Brady, 'The War That Never Was: New Zealand-China Relations in the Cold War Era'. In Alexander Trapeznik and Aaron Fox (eds), *Lenin's Legacy Down Under: New Zealand's Cold War*, University of Otago Press, Dunedin, 2004, pp131-151.
[14] Gaddis 2005, p46.

war against Japan, the United States continued to develop nuclear bombs and test them in Nevada, and in new Pacific testing grounds in the Marshall Islands. On 1 July 1946 the United States exploded a nuclear bomb in the atmosphere above a fleet of captured and obsolete warships in Bikini Atoll to determine the effect of an atomic burst on navy ships and personnel. The target fleet of 70 vessels carried thousands of animals – goats, pigs, rats, mice and guinea pigs – to observe the effect of the shockwave and visible, thermal and nuclear radiation. The 21 kt explosion created an enormous fireball that rapidly mushroomed skywards.[15] Most newspaper reports were matter-of-fact about the details of the first Bikini Atoll bomb test, but a week later, a *New Zealand Listener* editorial described the test as "deeply depressing" – the birth of the atomic bomb had not led to the end of war, but to the prospect of more horrible war.[16] The bomb tests were not discussed in New Zealand's Parliament, although Thomas Bloodworth, an Auckland politician and a member of New Zealand's Legislative Council, described the atomic bomb as putting "fear and apprehension into the minds of every thinking man and woman."[17]

This first Pacific nuclear test was followed by another test a few weeks later. New testing sites were found at Enewetak Atoll, a Marshall Islands coral atoll 350 km west of Bikini, and at Johnston Atoll, an uninhabited American territory in the North Pacific, and between 1948 and 1958 the United States tested nearly 70 nuclear weapons.[18] Meanwhile, the Soviet Union had its own nuclear weapons programme and with the explosion of a plutonium fission bomb in the Kazakhstan desert in August 1949 – news of which was received in New Zealand as an inevitability – the nuclear arms race began.[19]

In the United Kingdom, the Atomic Energy Research Establishment at Harwell (where the New Zealand team led by Charles Watson-Munro had developed GLEEP, Europe's first nuclear reactor) continued to research all aspects of atomic energy. New plants were established to produce plutonium and uranium-235, primarily for military purposes. Following Britain's 1947 decision to proceed with building a nuclear bomb, the Atomic Weapons Research Establishment was established at Aldermaston, under the leadership of William Penney.[20]

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[15] W. A. Shurcliff, *Bombs at Bikini*, W. H. Wise, New York, 1947, pp2-3, 84-85, 117-8, 190-1; 'X-Day at Bikini', *New Zealand Listener*, 5 July 1946, pp6-8; Firth 1987, pp1-4.
[16] Editorial, 'A Bomb Falls', *New Zealand Listener*, 12 July 1946, p5.
[17] *New Zealand Parliamentary Debates (NZPD)*, volume 273, 1946, p224; Graham W. A. Bush, 'Bloodworth, Thomas 1882–1974', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded on 11 June 2010.
[18] Simon and Robison, 1997.
[19] Lawrence Badash, *Scientists and the Development of Nuclear Weapons*, Humanity Books, New York, 1995, p79; Gaddis 2005, p35.
[20] Margaret Gowing, *Independence and Deterrence: Britain and Atomic Energy 1945-52, Volume 2, Policy Execution*, Macmillan, London, 1974, pp204-5, 339, 442.

On the other side of the world, New Zealand was assisting Britain's nuclear programme in a project involving the use of Wairakei's geothermal steam to produce heavy water as a moderator for British atomic piles. The project had first emerged in 1945, when, following suggestions made by local authorities, the Government directed the DSIR to investigate the commercial utilisation of the geothermal resources in the Rotorua area. One of the many propositions investigated was the production of heavy water. Following the investigations by a small DSIR team (that included Jim McCahon of the Dominion Physical Laboratory, who had also worked on the wartime uranium survey), Marsden informed the United Kingdom of the possible availability of large quantities of heat for the production of heavy water, and was encouraged to proceed with the studies.[21] By 1947, after two dry years that led to electricity shortages, geothermal power was also emerging as an attractive option for electricity generation. The Wairakei field, next to the Waikato River north of Taupo, was considered the most promising area.[22]

Marsden, now working as Scientific Liaison Officer in London, supported the project. In 1949 he reiterated his earlier suggestion to John Cockcroft,[23] who was now director of the British Atomic Energy Research Establishment at Harwell, that New Zealand's geothermal steam could be used to concentrate heavy water through fractional distillation.[24] Cockcroft was receptive to Marsden's suggestion and a scientist from the DSIR Dominion Physical Laboratory, J. A. (Tony) McWilliams, was transferred to Harwell to study the distillation of the heavy water fraction from naturally occurring water through use of geothermal steam.[25] In March 1952 the New Zealand Government received formal advice that the British authorities attached great importance to the development of additional supplies of heavy water and requested a thorough survey of its potential production in New Zealand be undertaken as a matter of urgency.[26] Later that year, a project development team conducting a shallow drilling and scientific investigation

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[21] n.d. Notes on the Activities of DSIR in connection with the heavy water project, written by W. M. Hamilton, ABHS 950, W4627, 121/2/2, part 2, *ANZ.*

[22] John E. Martin (ed), *People, Politics and Power Stations: Electric Power Generation in New Zealand 1880-1998, 2nd edition,* Electricity Corporation of New Zealand and Historical Branch, Department of Internal Affairs, 1998, p256-259; Iain A. Thain, *A Brief History of the Warakei Geothermal Power Project,* downloaded from http://geoheat.oit.edu/bulletin/bull19-3/art69.htm on 27 November 2004, reproduced from Geo-Heat Bulletin Vol. 19, 3 (1998).

[23] Cockcroft and Marsden had discussed this possibility as early as January 1946. Marsden to Cockcroft, 15 January 1946, MS papers 1342-055, *ATL.*

[24] Margaret Gowing, *Independence and Deterrence: Britain and Atomic Energy 1945-52, Volume 1, Policy Making,* Macmillan, London, 1974, p39; Marsden to Watson-Munro, 20 October 1949, AAOQ, W3424 (box 5), 74/22/-, Vol 1(a), *ANZ*; Watson-Munro to Marsden, 7 November 1949, AAOQ, W3424 (box 5), 74/22/-, Vol 1(a), *ANZ.*

[25] D. W. Fry to Marsden, 14 August 1951, AAOQ, W3424 (box 5), 74/22/-, Vol 1(a), *ANZ.*

[26] Letter from Office of the High Commissioner for the UK in Wellington, 17 March 1952, AAOQ, W3424 (box 5), 74/22/, Vol 1(a), *ANZ.*

programme proved the Wairakei field had steam capable of producing 20 MW of electric power annually.[27]

Marsden continued to encourage the project, liaising between Harwell, the DSIR and the Prime Minister's Department. Distillation experiments continued at Harwell, while in New Zealand, the DSIR focused on assessing the availability of geothermal steam and its corrosive properties and conducting heat transfer tests.[28] Heavy water was required primarily as a moderator – to dampen and control the motions of the high-energy neutrons released from the fuel source – for use in Britain's research reactors. The nucleus of heavy hydrogen, or deuterium, was the optimum size to slow fast neutrons, making heavy water a desirable commodity for controlling nuclear reactions. At the time the United Kingdom was interested in New Zealand's ability to provide heavy water, it was being made commercially in Norway and elsewhere by electrolytic separation, a process that requires large quantities of electricity. Because of its slightly higher boiling point – heavy water boils at 101°C – the heavy water can also be separated out by fractional distillation, a process that requires large quantities of heat. The attraction of the geothermal resource was that nature had provided vast quantities of the hot water needed to produce heavy water – in other locations a hydro or coal-burning power plant would be needed to produce the hot water through electrical means.[29]

Britain had its own nuclear bombs ready to test by 1952. With no domestic space for nuclear testing, however, Britain turned to the Commonwealth and decided on the uninhabited Monte Bello islands off the northwest coast of Australia. Australian Premier Robert Menzies readily agreed to Clement Atlee's request to use the islands. An Australian Government press release issued in 1955 summed up Australia's attitudes to British nuclear testing by saying "England has the bomb and the knowhow; we have the open spaces, much technical skill and great willingness to help the Motherland".[30]

Wayne Reynolds argues that in the post-war period, as Britain developed nuclear weapons without support from the United States, the Empire became vital to British survival, for raw materials, manpower and testing zones. While Australia was happy to offer support, the country, with its vast deposits of uranium, had plans to develop its own nuclear weapons; support for the

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[27] Thain 1998.

[28] A. D. McIntosh to Office of High Commissioner for the UK, 13 June 1952, AAOQ, W3424 (box 5), 74/22/-, Vol 1(a), *ANZ*; J. A. McWilliams's report on Harwell secondment, n.d. but c. June 1953, AAOQ, W3424 (box 5), 74/22/-, Vol 2, *ANZ*.

[29] Martin 1998, pp256-259.

British nuclear programme had a strong element of self-interest in terms of wanting a head start in developing Australian nuclear weapons. Australia had more fear of Chinese communism than New Zealand did, and therefore more of a willingness to come under the protection of the "nuclear umbrella". New Zealand's much lower level of support for the British nuclear testing programme can on the surface be seen to be a result of having less to offer – New Zealand did not have Australia's supposedly "empty" spaces or uranium deposits – but Reynold's argument about nuclear ambitions holds sway. New Zealand had no such nuclear ambitions, and said yes to British requests when it was politically or economically expedient to do so, and no when it was not.[31]

Table 5.2: British Atomic Weapon Tests in Australia

Operation and location (local date)	Est yield
Monte Bello Islands, WA – Operation Hurricane	
3 October 1952	25 kt
Emu Field, SA – Operation Totem	
15 October 1953	10 kt
27 October 1953	8 kt
Monte Bello Islands, WA – Operation Mosaic	
16 May 1956	15 kt
16 June 1956	60 kt
Maralinga, SA – Operation Buffalo	
27 September 1956	15 kt
4 October 1956	1.5 kt
11 October 1956	3 kt
22 October 1956	10 kt
Maralinga, SA – Operation Antler	
14 September 1957	1 kt
25 September 1957	6 kt
9 October 1957	25 kt

Britain's first nuclear test series was held in Australia. Source: Adapted from Lorna Arnold, *A Very Special Relationship: British Atomic Weapon Trials in Australia,* London, HMSO, 1987; and Roger Cross, *Fallout: Hedley Marston and the British Bomb Tests in Australia,* Wakefield Press, 2001.

New Zealand's military assistance to the British nuclear programme should also be seen in the context of other Cold War military cooperation. New Zealand had already played its part in operations and wars to resist the perceived Communist threat, for example by assisting Britain with the Berlin airlift in 1948 and fighting alongside British and Australian soldiers in the

[30] Arnold and Smith, 2006, pp17-20; *Report of the Royal Commission into British Nuclear Tests in Australia*, Australian Government Publishing Service, Canberra, 1985, volume 1, p15.

Korean War from 1950. A degree of cooperation with the nuclear programme was consistent with these actions.[32]

The United Kingdom's first nuclear weapon detonated on 3 October 1952, in the Monte Bello Islands, off the coast of Western Australia. While the United States' Bikini Atoll tests in 1946 were described by *The Listener* as "depressing" and news of the 1949 Soviet test was received as an inevitability, New Zealand's response to the first British test was positive. "Unless the United States has something up her sleeve Britain has taken the world lead in the race for tactical atomic weapons" said *The Dominion* proudly, citing the "unusually large" area of ground level destruction caused by the blast.[33] The newspaper's editorial noted that "British people everywhere [and in the 1950s that included New Zealanders] will doff their hats to the quiet, clever 'back-room boys' who made this achievement possible".[34] The United States did, of course, have something "up her sleeve" – they were already far ahead of the British programme and were about to start testing a hydrogen bomb.

The next British test series, codenamed Totem, was in a desert location 500 kilometres northwest of Woomera in South Australia. After the first shot of the Totem series, on 15 October 1953, the wind blew a narrow radioactive plume to the northeast.[35] Despite the fallout being detected in New Zealand, there was a romantic tone to the local newspaper reports of the blast. An NZPA report published in *The Press* read:

> As the weapon exploded, the whole countryside was deluged with light, dimming the early morning sun. The fireball was lit for a time by vivid internal flashes. It turned into a column of peach-coloured smoke, which soon took on the conventional mushroom shape.[36]

The nuclear tests were of great interest to New Zealand scientists and scientific organisations who made their own attempts to detect radioactive fallout. Following the 1952 explosion four RNZAF aircraft were dispatched from Whenuapai to collect air samples at a distance of 5,600 km from the Monte Bello Islands explosion – three of the four aircraft collected significant radioactivity.[37] Under the tutelage of Charles Watson-Munro, now professor of physics at Victoria University College in Wellington, two graduate students conducted research into atmospheric radioactivity, to determine baseline levels of radon in the atmosphere

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[31] Wayne Reynolds, *Australia's Bid for the Atomic Bomb,* Melbourne University Press, Melbourne, 2000, pp1-4; Brady 2004, p131.
[32] McIntyre 1992, pp528-9.
[33] *The Dominion,* 6 October 1952, p7.
[34] *The Dominion,* 7 October 1952, p6.
[35] Arnold 1987, p63.
[36] *The Press*, 16 October 1953, p11.

and the effects of meteorological conditions of atmospheric radioactivity. Watson-Munro's own research determined that fallout from the 15 October 1953 explosion was transported rapidly to New Zealand on high velocity, high altitude winds, arriving in Wellington from the test zone 3,500 km away the day after the explosion.[38]

Staff of the Dominion X-Ray and Radium Laboratory in Christchurch also built apparatus to detect radioactivity from the tests. Most of the activity collected after the 1953 explosions had a half-life of the order of 30 minutes, indicating that it consisted of the decay products of the radioactive gas radon. This showed that the dangers of radioactive fallout from the explosion were not posed exclusively by products of the explosion – larger radioactive elements produced by the splitting of uranium-235 atoms – but also by radioactivity of their decay products, and *their* decay products in turn.[39]

After another test series at the Monte Bello islands, the British selected a new permanent inland test site at Maralinga, in South Australia, and prepared for Operation Buffalo, which took place in September and October 1956. A further test series, Operation Antler, took place in September and October the following year.[40]

As well as the Australian task force and scientific staff, observers of the first Maralinga test included an "Indoctrinee Force" of some 250 officers, including five from New Zealand, whose role was to observe the test and its aftermath, and pass on their knowledge and experiences to other members of the Armed Forces.[41] The New Zealand military authorities were advised that the officers taking part would be "subject to radiation hazard". The Indoctrinee Force was stationed about 8.2 km from the first blast, with their backs to the explosion. They were instructed to turn around two seconds after the blast, and witnessed the fireball and the emerging mushroom cloud.[42] Following the blast, the indoctrinees, dressed in protective clothing, toured the blast area, examining the effect of the blast on targeted items in the area.[43] One of the New Zealand members of the Indoctrinee Force, Lieutenant Colonel John Burns, later recalled

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[37] *Report of the Royal Commission into British Nuclear Tests in Australia*, 1985, volume 1, pp115-7.
[38] A. de T. Nevill, *Some Observations of Atmospheric Radioactivity*, thesis, Victoria University College, 1952; L. B. Crosthwait, 'A Measurement of Atmospheric Radioactivity at Wellington', *NZJST* 37B (1955), pp382-4; N.V.Ryder and C.N.Watson-Munro, 'The Detection of Radioactive Dust from the British Nuclear Bombs of October 1953', *NZJST* 36B, 2 (1954), pp155-159.
[39] NZ Report to United Nations Scientific Committee on Atomic Radiation, 18 October 1957, H1, 26717, 108/11, 1951-57, *ANZ.*
[40] Arnold and Smith, 2006, pp138, 156-66, 198-201.
[41] Arnold and Smith, 2006, pp144-5.
[42] John Crawford, *New Zealand Observers and Indoctrinees at Nuclear Weapon Tests: 1956-1958*, unpublished New Zealand Defence Force article, 2001, pp1-2.

standing in full combat gear with his back turned when a bomb was detonated. "The heat … was just like the blast from opening the door on a hot oven roast. And the flash was blinding white," he said.[44]

A report issued by the National Archives of Australia in 2001 revealed that along with 70 Australians, two of the New Zealand officers, including Burns, were intentionally exposed to radiation. On 28 or 29 September 1956, a group of indoctrinees entered the fallout zone with the purpose of discovering "what types of clothing would give best protection against radioactive contamination in conditions of warfare".[45] Burns recalled being sent to within half a mile of where the bomb was detonated where, in enclosed rubberised suits, he and his fellow indoctrinees were "marching and crawling and there was a truck passing every so often that would shower us with a bit of dust and dirt to make sure we got some of the fallout".[46] This seems a barbaric and dangerous experiment from a modern perspective. Film badges worn by the New Zealand soldiers, however, showed that each received no more than an annual dose from natural background radioactivity.[47]

The birth of the hydrogen bomb

The Cold War led to an ongoing quest for more powerful bombs. A new type of nuclear weapon, which became known as the hydrogen bomb, was independently developed and tested first by the United States in 1952, followed by the Soviet Union in 1953, and Britain in 1957.

There was a New Zealand connection from the start. In 1934, Ernest Rutherford and two of his Cambridge University colleagues, Mark Oliphant and Paul Harteck, discovered the hydrogen fusion reaction, the basic principle behind the hydrogen bomb. In a letter published in *Nature*, "Transmutation Effects Observed with Heavy Hydrogen", they described that when bombarding concentrated heavy water – water with a heavy hydrogen, or deuterium atom – with accelerated deuterium nuclei, the accelerated deuterium nuclei were fusing with a nucleus of deuterium in the heavy water and forming a helium nucleus. As a product of this reaction, neutrons, heat and an intense burst of gamma radiation were released.[48]

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[43] Arnold and Smith 2006, p164.
[44] *The Dominion,* 15 May 2001, p3.
[45] *The Dominion,* 14 May 2001, p3.
[46] *The Dominion,* 15 May 2001, p3.
[47] Crawford 2001, pp7-8.
[48] Ernest Rutherford, Marcus Oliphant and Paul Harteck, 'Transmutation Effects Observed with Heavy Hydrogen', *Nature* 133, 17 March 1934, p413; Rhodes 1996, p247.

While Rutherford's Cavendish experiment had used more energy than it had produced, scientists determined that under extremely high temperatures, unlimited quantities of heavy hydrogen could fuse into helium, releasing energy in the process. Unlike the fission reaction that created the first nuclear bombs, fusion was an extremely efficient process and the energy output of a fusion bomb could greatly exceed that of a fission bomb.[49]

The United States decided to proceed with the development of a hydrogen bomb in 1950, despite considerable scientific opposition to the project on the grounds that the large potential yield of such a bomb would render it a "genocidal weapon", capable of wiping out entire cities and contaminating large areas with vast quantities of radioactivity. The first prototype hydrogen bombs, which used a fission explosion to ignite a fusion reaction, were developed at Los Alamos and tested at Enewetak Atoll in May 1951. In a more advanced design, the interior surface of the bomb was designed to reflect X-rays and gamma rays from the fission explosion, causing compression and heating of the deuterium fuel. This new design also resulted in extremely high levels of radioactive fission products being blasted into the stratosphere, from where they settled around the globe. This design was first tested in November 1952, in a 10.4 Mt explosion, the largest man-made explosion ever up to that time. The United States conducted another test series at Bikini and Enewetak Atolls in 1954. The largest of these explosions was a 15 Mt explosion on 1 March 1954, which caused unexpected levels of fallout and spread harmful radiation over a large area, necessitating the evacuation of American personnel and native islanders from Rongerik Atoll and other islands. The crew of a Japanese fishing boat stationed 85 miles from the blast were victim to an ash-like shower of fallout causing the crew to become sick from radiation poisoning – one of the crew subsequently died.[50]

In response to the Governor-General's speech upon the opening of Parliament in June 1954, Warren Freer, the Labour MP for Mt Albert, noted that one of the things omitted from the speech, and not mentioned by Prime Minister Holland, was the hydrogen bomb, about which Freer said, "Nothing has more disturbed the minds of the average men and women in the English-speaking world". Freer referred to an earlier statement by Holland that the hydrogen bomb was the greatest promise for peace, but argued that he was wrong, and the stance of the Church leaders was correct: that Easter the leaders of the Anglican and Catholic churches had appealed to Parliamentarians the world over to "exercise some control over this weapon and to

[49] Badash 1995, p81.
[50] Badash 1995, pp83, 87; Lorna Arnold, *Britain and the H-bomb*, Palgrave Macmillan, Houndmills, 2001, pp18-19; Isaac Asimov, *Asimov's Guide to Science, third edition*, Basic Books, New York, London, 1972, pp456-7.

bring the world back to a Christian approach to international problems rather than one of cold war or, in this case, red-hot science". Freer called for Holland to let the New Zealand public know where he stood on the question of "future tests of atomic weapons and hydrogen bombs, or anything more hideous".[51] Internationally, these new hydrogen bombs led people to speculate that a war waged using such weapons could mean the end of civilisation – not only could entire cities be wiped out, but the radiation could make the planet uninhabitable.[52] In New Zealand, concern about the effect of future American tests led the Cabinet to set up a scientific committee to report on the possibility of radioactive contamination of New Zealand and its Pacific island territories. The committee, comprised of Charles Watson-Munro, Bill Hamilton, the secretary of the DSIR, and Miles Barnett, director of the Meteorological Service, as well as three senior representatives of the Armed Services, reported that there was no danger to New Zealand or its territories. Holland issued a reassuring press release, prepared by the committee, about the likely impact of the bomb tests, saying that any deposits would be of "no significance" and would pose "no consequential risk to the inhabitants of New Zealand or its island territories".[53]

Templeton has examined political discussions around the issue of the American hydrogen bomb tests. Following the United States tests, Holland sent personal messages to the British and Australian Prime Ministers, Churchill and Menzies, expressing his concern about the United States tests and the risk of injury or danger to Pacific people and their food sources, and querying as to whether the United States could, in future, be asked to provide warning of such tests. In return, Churchill warned against "any action which might impede American progress", citing their strength in nuclear weapons "as the greatest possible deterrent against the outbreak of a third world war".[54] With the United States nuclear weapons programme now so far ahead of the British programme, the United Kingdom was dependent on American superiority over the Soviet Union.

The United Kingdom continued to develop its own weapons, however, and its interest in heavy water from New Zealand soon took on a new dimension. On a visit to New Zealand in September 1952 John Cockcroft met with Cabinet and the Defence Science (Policy) Committee

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[51] *NZPD*, 303 (1954), pp198-9.
[52] Gaddis 2005, pp64-65.
[53] Atomic and Thermo-Nuclear Tests in the Pacific, 6 April 1954, ABHS 950, W4627/3544, 121/5/2, part 1, *ANZ*.
[54] Malcolm Templeton, *Standing Upright Here: New Zealand in the Nuclear Age 1944-1990*, Victoria University Press, Wellington, 2006, pp65-66.

and made it clear the British wanted heavy water not just to use as a moderator in atomic piles; they were also interested in it from a "defence research angle".[55]

In May 1953 the New Zealand Cabinet approved in principle the construction of a joint New Zealand/United Kingdom combined heavy water and electricity generating plant.[56] The focus now moved to determining the economics of the project and the nature of the agreement between New Zealand and the United Kingdom. The economics were not in favour of a New Zealand plant, however, and in December 1953 the British High Commissioner in Wellington informed Holland that the United Kingdom could no longer participate in the project, citing the possibility that the United States might soon be offering heavy water at "a keen price".[57]

The British atomic energy projects moved from the Ministry of Works to a new agency, the United Kingdom Atomic Energy Authority (UKAEA), in 1954.[58] In March the heavy water project was briefly revived. At a meeting of the British Chiefs of Staff, Sir Norman Brooks, Secretary to the Cabinet, reported plans to improve Britain's capacity to manufacture hydrogen bombs by obtaining thorium from South Africa and heavy water from New Zealand.[59] The next week Marsden was advised that the United Kingdom might reopen discussions on the heavy water project. Loath to put the reasons for the renewed interest in writing, Marsden cryptically and verbosely described it to Hamilton, the DSIR secretary in New Zealand, as "a very special urgent important reason".[60] On 23 April 1954, Viscount Swinton, British Secretary of State for Commonwealth Relations, advised Holland that, on the basis of new cost and supply information, the United Kingdom Government now wanted to proceed with the heavy water project but this time attached great importance to maintaining secrecy.[61] On the same day, Cabinet authorised Holland to tell the British High Commissioner that the New Zealand Government was willing to go forward with the proposed combined heavy water and electricity plant in the Wairakei geothermal area.[62] Although Marsden, in London, knew of the secret plans to develop a hydrogen bomb and of its links to the heavy water plant, it is unclear how widely this was known in New Zealand.[63]

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[55] Minutes of the 16th Meeting of the Defence Science (Policy) Committee, 9 October 1952, AAOQ, W3424 (box 5), 74/22/-, Vol 1(b), *ANZ*. While in New Zealand Cockcroft also inquired as to the availability of bulk supply of electricity for use in a uranium enrichment plant.
[56] Foss Shanahan to Acting Prime Minister, 19 May 1953, AAOQ, W3424 (box 5), 74/22/-, Vol 2, *ANZ*.
[57] Geoffrey Scoones to Sidney Holland, 11 December 1953, ABHS 950, W5422 (box 166), 111/18/3/1, part 1, *ANZ.*
[58] Gowing 1974, volume 2, pp194-66.
[59] Arnold 2001, pp40-45.
[60] Marsden to Hamilton, 24 March 1954, AAOQ, W3424 (box 5), 74/22/-, part 3, *ANZ.*
[61] Viscount Swinton to Holland, 23 April 1954, ABHS 950, W5422 (box 166), 111/18/3/1, *ANZ.*
[62] Note of Cabinet meeting on 23 April 1954 in ABHS 950, W5422 (box 166), 111/18/3/1, *ANZ.*
[63] Report on heavy water, 7 May 1954, ABHS 950, W5422 (box 166), 111/18/3/1, part 1, *ANZ.*

However, when the British Cabinet formally decided to proceed with building a hydrogen bomb, in July 1954, they had abandoned plans to use heavy water from New Zealand for the project.[64] Revised cost estimates from American sources now meant New Zealand heavy water was again considered attractive for their nuclear reactor, rather than hydrogen bomb, programmes and the Wairakei project was back on. In announcing the reestablishment of the joint venture between the UKAEA and New Zealand to produce electric power and heavy water from the steam bores at Wairakei, Holland told Parliament that New Zealand would be making a "worthwhile and unique contribution not only to its own power resources, but also to the development of atomic energy, which, used for peaceful purposes, may well revolutionize the world's industrial processes".[65] Geothermal Developments Ltd, whose shareholders were the New Zealand Government and the UKAEA, was formed in February 1955 to produce electricity and heavy water at Wairakei. Marsden, who had retired from the public service in 1954 and returned to New Zealand, was appointed technical adviser to the Board.[66]

Design work proceeded to the stage where prices for equipment, materials and labour could be accurately estimated but this doubled the cost of the plant, raising the cost of the heavy water it would produce from £44,000 to £90,000 per ton and in January 1956 the UKAEA advised that, faced with the projected price increases, they felt forced to withdraw from the project.[67] Holland expressed regret at "the abandonment of an interesting partnership agreement" but the project was still of value to New Zealand. Holland made it clear that New Zealand would proceed with production of electricity from geothermal steam at Wairakei.[68] John Cockcroft sent a personal letter to Ernest Marsden, expressing his regret at having to abandon the heavy water project. He added "I hope the New Zealand Prime Minister will not feel that he has been too badly let down in our first attempt at New Zealand-U.K. co-operation in the Atomic field. I hope we shall come back later with other projects which will be successful."[69] In April 1956 Geothermal Development Ltd terminated its existence. Plans were revised to construct a larger power station to absorb the steam, which would no longer be needed for heavy water production.[70]

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[64] Arnold 2001, p59.
[65] *NZPD*, 303 (1954) p642.
[66] The *Dominion*, 23 February 1955, ABHS 950, W5422 (box 166), 111/18/3/1, *ANZ; New Zealand External Affairs Review (NZEAR)*, 5, 1 & 2 (1955), p56.
[67] UKAEA to Finance Minister and Geothermal Developments Ltd, 19 January 1956 and F. M. Hanson to Prime Minister, 18 May 1956, ABHS 950, W4627, 121/2/2, part 2, *ANZ*.
[68] Press statement distributed by External Affairs, 26 January 1956, ABHS 950, W4627, 121/2/2, part 2, *ANZ*.
[69] Cockcroft to Marsden, 24 January 1956, ABHS 950, W4627, 121/2/2, part 2, *ANZ*.
[70] F. M. Hanson to Prime Minister, 18 May 1956, ABHS 950, W4627, 121/2/2, part 2, *ANZ*.

While official reports did not state any link between weapons development and Britain's interest in New Zealand's heavy water there was newspaper speculation. Napier's *The Daily Telegraph* suggested in 1955 that "the availability of heavy water (and hence of heavy hydrogen) from New Zealand was an important factor in the British Government's decision to make the H-bomb".[71] Even so, according to Kevin Clements, "no political party expressed moral or political scruples about the possible diversion of heavy water into weapons production".[72]

British H-bomb tests

New Zealand's help was requested for another aspect of the British nuclear programme in 1955. Australian Prime Minister Robert Menzies had ruled out the testing of hydrogen bombs on or near the Australian mainland, so when the United Kingdom began plans to test the hydrogen bomb a new test range had to be found. Scientists from the Aldermaston weapons development laboratory estimated the site should be at least 800 kilometres from inhabited land or shipping lanes. The best options were considered to be "various remote islands or the icy wilderness of Antarctica".[73]

British Prime Minister Anthony Eden was quick to ask for New Zealand's assistance with the testing programme, requesting help obtaining food, stores and fuel; use of the Auckland Naval Base for repairs; and the use of the Cook Islands' Penrhyn Island for a weather and radar station. New Zealand was advised the operation was Top Secret.[74] Holland gave the matter careful consideration and agreed to the British request, saying New Zealand would be "very glad" to provide the facilities requested.[75]

William Penney, who ran the weapons development programme at Aldermaston, discussed the test site with the British Navy, which favoured the New Zealand sub-Antarctic island group the Antipodes Islands – now a World Heritage site home to protected species of albatross, penguins, petrels and seals – some 800 kilometres south-east of New Zealand. Here a bomb could be detonated in a ship anchored close to the selected island.[76] The Navy suggestion was rejected, however, and the United Kingdom chose the Kermadec Islands, another New Zealand territory, this time some 1000 km north-east of New Zealand, as the most promising site. This group of

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71 *The Daily Telegraph*, 23 February 1955.
72 Kevin Clements, *Back from the Brink: The Creation of a Nuclear-Free New Zealand*, Allen & Unwin/Port Nicholson Press, Wellington, 1988, p32.
73 Arnold 1987, pp101-102; Arnold 2001, p95.
74 Eden to Holland, 24 March 1954, ABHS 950, W4627, 121/5/2, part 2, *ANZ;* Arnold 2001, p95.
75 Holland to Scoones, High Commissioner for UK, 6 April 1954, ABHS 950, W4627, 121/5/2, part 2, *ANZ.*

volcanic islands is dominated by Raoul Island, and is now part of New Zealand's largest marine reserve.[77] But in the 1950s, it was just another group of remote islands inhabited only by a small group of men at the weather station.[78]

The decision whether or not to let the United Kingdom use the islands in this way was up to New Zealand Prime Minister Sidney Holland. In a short biographical essay, Barry Gustafson describes Holland as being a "fervent admirer of Britain" and quotes Holland, whose parents were born in England, as describing himself as "a Britisher through and through" who was determined to maintain links with Britain.[79] Some correspondence from 1955 shows, however, that regardless of the strength of Holland's determination to maintain links with Britain, his determination to remain in office, and even serve New Zealand's own interests, was prevalent. Eden made a direct request to Holland, regarding the use of the Kermadec Islands for the British hydrogen bomb tests, in May 1955. Eden described how the weapons could be either exploded on one of the islands from a tower, or fired in a ship anchored near an island, and asked if Holland would agree in principle to the weapons trials so the United Kingdom could investigate the site further. Eden concluded by expressing his earnest "hope that, in the interests of our common defence effort and the importance of the deterrent for Commonwealth Strategy, you will find it possible to agree".[80] Having not received a reply by the beginning of July, Eden sent a prompting letter to Holland, asking for a favourable reply to his May message, adding "I am sure that we can count on your full co-operation in a project that is so important to the Commonwealth and the defence of the Free World".[81]

Despite his "fervent" admiration of Britain and desires to maintain links with the country, it seems that Holland was immediately wary of the British request, and took note of negative publicity surrounding earlier newspaper reports of British plans to test in Antarctica. He also sought the opinion of Marsden (by this time in his retirement but much sought after for his expertise on nuclear and radiation issues) who advised Holland that while an isolated island in the Pacific was "a logical choice" for the proposed weapons test, the Kermadec Islands were not necessarily the best option. He acknowledged the weather was suitable but noted the presence of

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[76] Arnold 2001, p96; Neville Peat, *Subantarctic New Zealand: A Rare Heritage*, Department of Conservation, Invercargill, 2003.
[77] Arnold 2001, p96; Department of Conservation website: www.doc.govt.nz/Conservation/Marine-and-Coastal/Marine-Reserves/Kermadec.asp, downloaded 15 July 2004.
[78] n.d. Brief notes on Kermadec and Pitcairn Groups, ABHS 950, W4627, 121/5/2, part 2, *ANZ.*
[79] Barry Gustafson, 'Holland, Sidney George 1893-1961', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded 8 March 2010.
[80] Eden to Holland, 18 May 1955, ABHS 950, W4627 (box 3544), 121/5/2, part 2, *ANZ.*
[81] Geoffrey Scoones to Holland, 5 July 1955, ABHS 950, W4627, 121/5/2, part 2, *ANZ.*

occasional ships and aircraft in the area and reminded Holland of the Japanese fishermen who suffered radiation sickness after their boat was stationed 135 kilometres from the United States' hydrogen bomb detonation at Bikini Atoll in March 1954. Marsden acknowledged the Government might on the one hand feel a "moral obligation" to cooperate with the British request but on the other hand might "feel that the sacrifice and difficulties in the use of the Kermadecs is questionable". Without bluntly advising Holland to refuse the request, Marsden suggested the Auckland Islands, some 320 kilometres south-south-west of New Zealand, as a preferable alternative to the Kermadecs.[82]

Historian James Belich's recolonisation thesis argues that New Zealand was an ideological and economic semi-colony of Britain until the 1960s. Holland, however, despite his own British birth and deep affection for Britain, appears to have put his own and New Zealand's interests ahead of Britain's. His decision to refuse Eden's request was independent and pragmatic – the National Party had won the 1954 general election with only 43.8 per cent of the vote and their continuance in power could not be taken for granted.[83] On 15 July 1955 Holland warned the British High Commissioner in Wellington that the use of the Kermadecs for nuclear tests would be a "political H-bomb" for New Zealand – not least because they would take place in an election year – and declined the British request.[84] Eden expressed his disappointment at Holland's refusal, reiterating the importance of the planned trials to the "defence of the free world" and advising that if Britain did not find a suitable alternative he might be compelled to ask Holland to reconsider the matter.[85]

As part of the search for an alternative test site, Eden requested New Zealand's permission to investigate Penrhyn Island as an aircraft base and asked if the Royal New Zealand Navy survey ship HMNZS *Lachlan* would assist in a Pacific ground survey.[86] Although still hoping that Holland might change his mind about the Kermadecs, Malden and Christmas Islands, in the Northern Line Islands (now part of the Republic of Kiribati), became the new preferred site and in early 1956 the HMNZS *Lachlan* surveyed the Northern and Southern Line Islands on behalf of the United Kingdom.[87] Holland did not change his mind about use of the Kermadecs, and

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[82] Marsden to Holland, 10 July 1955, ABHS 950, W4627 (box 3544), 121/5/2, part 2, *ANZ.*
[83] Trotter 2007, p236; Belich 2001, p11.
[84] Arnold 2001, p96; Crawford 1998, p133.
[85] Eden to Holland, 2 September 1955, ABHS 950, W4627, box 3544, 121/5/2, part 2, *ANZ.*
[86] Eden to Holland, 2 September 1955, ABHS 950, W4627, box 3544, 121/5/2, part 2, *ANZ.*
[87] Arnold 2001, p98; John Crawford, *The Involvement of the Royal New Zealand Navy in the British Nuclear Testing Programmes of 1957 and 1958,* Headquarters, New Zealand Defence Force, 1989, p6.

on 24 March 1956 Eden formally advised New Zealand that the range for the British hydrogen bomb testing programme would be Christmas Island and Malden Island.[88]

While the public announcement that Christmas Island would be used for the bomb tests did not come until June 1956, on 2 April 1956, following a press leak in the United Kingdom, New Zealand newspapers announced that the "isolated coral atoll in the Pacific" had been chosen as a base for Britain's first hydrogen bomb explosion.[89] Christmas Island, the biggest coral atoll in the world, covered 642 square kilometres with its mixture of land and lagoons. There was already a runway on the island – it was used as an American base during the Second World War – but the British plan was to refurbish the airbase and build the necessary accommodation and facilities. At Malden Island, a new airstrip, a meteorological station and a tent camp would be set up.[90]

There was already opposition to the proposed hydrogen bomb tests. The New Zealand Labour Party, since its first government in 1935, had had a policy of greater independence in foreign policy, and this applied to nuclear testing too.[91] In May 1956, when three Labour MPs asked whether, in view of the conflicting reports on the likely effects of hydrogen bomb tests, Holland would protest at the continuation of nuclear bomb tests in the Pacific. Holland replied that "the development of this branch of the nuclear sciences must continue" and "periodic tests are essential to this work".[92] In a later statement he added, "New Zealand will be helping to ensure that the United Kingdom remains in the forefront in the field of nuclear research".[93] Holland saw continued testing as a positive move for enhancing Commonwealth, including New Zealand, security but, to maintain the support of the New Zealand public, it became a case of Not in My Back Yard. By providing logistical support for the British tests but withholding New Zealand territory, he could keep the balance between maintaining relations with the United Kingdom, and fostering New Zealand pride in helping Britain's military and scientific achievements. A major concern was the risk of upsetting the New Zealand public through fear of fallout and damage to New Zealand territory.

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[88] Eden to Holland, 24 March 1954, ABHS 950, W4627, 121/5/2, part 2, *ANZ;* Crawford 1989, p6.
[89] *The Evening Post,* 2 April 1956 (responding to report in the *Daily Express*), ABHS 950, W4627, 121/5/2, part 2, *ANZ*; Arnold 2001, p102-3.
[90] Arnold, 2001, p103-106.
[91] Malcolm McKinnon, *Independence and Foreign Policy: New Zealand in the World Since 1935,* Auckland University Press, Auckland, 1993, p111.
[92] *NZPD* 308 (1956), pp574-5.
[93] Press statement, 28 May 1956, ABHS 950, W4627 (box 3544), 121/5/2, part 2, *ANZ.*

Holland and his government also showed assertiveness and independence with regard to a controversial United States proposal. As Templeton explains in *Standing Upright Here*, New Zealand firmly rejected a late 1956 United States claim to sovereignty over Penrhyn Island, which had become strategically important to the Pacific nuclear testing programme, pointing out that the island had been New Zealand territory for more than 50 years. The American claim was eventually dropped.[94]

In response to further British requests, New Zealand provided facilities for a weather station and a radio station on Penrhyn Island, and the RNZAF provided transport for several officials associated with the tests. In July 1956, Britain formally requested that two New Zealand frigates be made available to act as weather ships during the 1957 test series.[95] HMNZS *Pukaki* and *Rotoiti* joined the British squadron at Christmas Island in late March 1957. The frigates were tasked with "air/sea rescue, anti-submarine watch, thermal flash monitoring and water sampling to test for radiation contamination" but their main role was to collect meteorological information essential in the vicinity of the test zone.[96] As Maurice Hayman, a radio operator on the HMNZS *Pukaki*, later recalled:

> A canvas hut was erected on the stern, where the balloons were inflated, and then brought out for release, once the transmitter had been attached. The balloon was released at a size of about six feet across. After rising to heights of 50,000 feet or more, it would by then be about the size of a two story (sic) house, before finally bursting. The idea was to monitor the upper levels, forecasting wind speed, direction, temperature, humidity and precipitation up to 100,000 feet as part of an overall weather forecasting system, prior to each burst.[97]

In New Zealand and the South Pacific in general, however, there was growing concern about the effect of radiation from the tests. In response to concerns passed on by the Minister of Island Territories and a Samoan petition to the United Nations over the bomb tests at Christmas Island, Deputy Prime Minister Keith Holyoake advised the New Zealand public that the British Government had assured New Zealand there would be no radioactive hazards to the inhabitants of the Cook Islands, the Tokelau Islands or Western Samoa.[98] If Britain had made the assurance, it seemed, it was good enough for New Zealand. In April 1957, the monthly review journal *Here and Now* reported "there was, in the way Mr Holland solemnly relayed a British assurance that no inhabited islands would be affected by radiation, almost a tone of pride in assisting at

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[94] Templeton 2006, pp73-4.
[95] Crawford 1989, pp6-7.
[96] Sidney Holland, 'Nuclear Test Explosions', text of a radio talk by Holland on 23 May 1957, *NZEAR* 7, 5 (1957), pp17-20; Crawford 1989, p18.
[97] Hayman 1997, p6.
[98] Press statement for publication 28 May 1956, ABHS 950, W4627, 121/5/2, part 2, *ANZ.*

headline-making events".[99] In April 1957 Harold Turbott, Chairman of the Radiological Advisory Council and deputy director-general of Health, responded to an External Affairs request for information on measures to be taken by New Zealand against possible hazard to peoples on Pacific islands under New Zealand's jurisdiction arising from the coming British hydrogen bomb tests. Turbott replied that the Council "is of the opinion that the New Zealand Government must accept the British Government's assurance that there is no danger to our Island Territories" but did suggest that radiation monitoring in the region be extended.[100] The British assurances might have been passed onto the public, but officials did not necessarily accept them. In response to the External Affairs query, the Department of Health suggested "the inhabitants might be advised to eat only coconuts during the period of the tests".[101]

Despite New Zealand's considerable assistance to the United Kingdom, Holland was not given advance notice of the first British hydrogen bomb test, which took place in the atmosphere above Malden Island. It came as a "complete bombshell" to Holland who said his first news of the bomb came from the newspaper.[102] Templeton describes Holland as reacting to the news with "great surprise and anger" and writing to British Prime Minister Harold Macmillan to complain about the lack of notice and advise of the concerns of the New Zealand public about the risk of radiation hazards, to which Macmillan replied with what Templeton describes as acute annoyance. There had been hints that a test would be taking place soon, and Templeton described Holland's reaction as a sign that his "mental powers were beginning to fail". Holland was to retire, for health reasons, months later.[103]

New Zealand did, in fact, have three observers at this first British hydrogen bomb test. On the Royal Navy ship, HMS *Alert*, along with two military observers, was Bert Yeabsley, deputy director of the Dominion X-Ray and Radium Laboratory. Wearing their white anti-flash suits, hoods, glasses and dark goggles, the observers sat on the ship's deck facing away from the blast, turning towards it after 10 seconds. Yeabsley reported being impressed by the way the British were conducting the tests, concluding that the tests "were being made in such a fashion that the possibility of highly active local fall-out was reduced to a minimum and that no person under the

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[99] *Here & Now* 59 (1957), p5.
[100] Turbott to Laking, Secretary of External Affairs, 10 April 1957, H1, 26717, 108/11, 1951-57, *ANZ*.
[101] This Department of Health report is referred to in a letter from G. R. Laking, Secretary of External Affairs to Secretary of the Department of Island Territories, 15 April 1957, H1, 26717, 108/11, 1951-57, *ANZ*.
[102] *The Dominion*, 17 May 1957, p10.
[103] Templeton 2006, p79.

care of the New Zealand Government was liable to suffer radiation damage from the operation".[104]

Figure 5.2: Prime Minister Sidney Holland (right) and his deputy Keith Holyoake, in August 1957, a month before Holland retired and Holyoake became Prime Minister. Photographer Morrie Hill, 1/2-177291-F, ATL, Wellington, NZ.

Britain's Operation Grapple, the codename for the project to test hydrogen bombs in the Pacific, began with three prototype weapons tested in May and June of 1957, detonated at a height of about 2,400 metres, in the atmosphere above Malden Island. Further test series, codenamed Grapple X, Grapple Y and Grapple Z, took place off the coast of Christmas Island in November 1957 and from April to September 1958, with yields peaking at 3 Mt for an explosion on 28 April 1958.[105]

Following the first explosion on 15 May 1957, *The Dominion* editorial noted that Britain had established "her credentials as a member of the thermo-nuclear club".[106] In a radio broadcast a week after the test, Holland assured the public that "the tests are being carried out with the utmost care and regard for the safety of human life", going so far as to say "British scientists seem to have mastered the problem of dangerous fallout associated with previous nuclear tests", though this was probably more a factor of it being a relatively small blast than the British having any control or "mastery" over the fallout. Holland also said that the *Pukaki*, stationed some 50

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[104] Quoted in Crawford 2001, p12; Crawford 1989, p33.
[105] Arnold 2001, pp p143-147, 159-191.

nautical miles from the explosion, reported "that she had a good view and was much impressed".[107]

Table 5.3: Operation Grapple atmospheric tests

Location and date	Est Yield	RNZN positions
Grapple series, above ocean near Malden Is.		
Short Granite, 15 May 1957	300 kT	93-278 km from ground zero
Orange Herald, 31 May 1957	700-800 kT	
Purple Granite, 19 June 1957	200 kT	
Grapple X, Y, Z series, above ocean near Christmas Is.		
Blue Danube, 8 November 1957	1.8 Mt	37-278 km from ground zero
Grapple Y, 28 April 1958	3 Mt	
Pennant, 22 August 1958 (balloon burst over land)	24 kT	
Flagpole, 2 September 1958	1.2 Mt	
Halliard, 11 September 1958	800 kt	
Burgee, 23 September 1958	25 kt	

Source: Compiled by the author from Lorna Arnold, *Britain and the H-bomb*, Houndmills, New York, Palgrave, 2001 and Crawford 1989.

Roy Sefton, a radio operator stationed on the *Pukaki*, recalled the first blast:

> My eyes were closed behind dark glasses, but opened at the flash – and I saw my finger bones. Then there was a rumbling like stampeding horses before the shock wave hit the ship.[108]

Just 15 seconds after the explosion, the *Pukaki* crew were ordered to "open your eyes, stand up and face the burst". Commander Hale, in his report on the explosion, described the view:

> … the fire ball grew in size shaped like a round firy [sic] and turbulent cauliflower changing from an angry deep red streaked with grey to a larger smouldering ball of cloud with a glowing centre … .Between the 2nd and 3rd minutes the terrific up draught of air and cloud soon became apparent by what appeared to be a strikingly white water spout being drawn into the centre of the fire ball, this rising mass increased in volume until the more familiar but equally fantastic shape of the mushroom was evident to everyone.[109]

Maurice Hayman, a telegraphist on the *Pukaki*, recalled a later blast:

> The weather was calm, and I sat down on the quarterdeck dressed in longs, shirt and anti flash gear. The officer in charge gave the order to face to starboard, and we could hear the line countdown on the ship's speakers. With 15 seconds to go we were given the order to close and cover our eyes. As it detonated, I felt the heat and saw the flash through my eyelids and fingers. About half a minute later we were told

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[106] *The Dominion*, 17 May 1957, p8.
[107] Holland 1957, pp17-20.
[108] *The Press*, 10 November 1997, p15.
[109] Crawford 1989, pp30-1.

> to face the burst. All cloud cover had gone, and the coloured fireball was climbing rapidly upwards. It was an impressive sight ...[110]

Following the first test the *Pukaki* sailed within six nautical miles of ground zero to rendezvous with a British ship, though Geiger counter measurements recorded no noticeable radiation in the air or water.[111]

Figure 5.3: Radiation testing on *Pukaki*, c1957. AAO 0029, courtesy Royal New Zealand Navy museum.

All the ships involved in Operation Grapple, however, took protective measures against the possibility of radiation contamination. Parts of the ships could, if necessary, be sealed off to provide an airtight enclosure, and the ships contained wash-down equipment to prevent any unexpected fallout from settling and to wash away any that did. Radiation detection systems were in place on all ships, and protective clothing was supplied by the British authorities on Christmas Island.[112]

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[110] This recollection is of the last Operation Grapple blast on 23 September 1958, from Hayman 1997, p13.
[111] Crawford 1989, p31.
[112] Crawford 1989, p20.

Maurice Hayman, recalling one of the later blasts in the series, said:

> It wasn't clear at that time why everyone not required for duty below deck had to sit up on deck close to the explosion. The correct procedure for the fleet in the event of a Nuclear attack, was to spread out far and wide, close the ship down, and start up outside water sprinklers. A released British Defence Research Policy Committee report dated 20th May 1953, on the Nuclear Weapon Trials, answered this question. It read 'The object of the exercise, is to discover the detailed effects of various types of explosion on equipment, stores, and men with and without various types of protection.' That explains why after the last balloon release, we were not shut down and heading flat out away from the burst.[113]

Holland retired as Prime Minister in September 1957, and was succeeded by Keith Holyoake. As Deputy Prime Minister, Holyoake had already been vocal on nuclear issues, issuing a statement earlier in September, following a visit to New Zealand by the British Minister of Defence, "that New Zealand would not become an atomic power: it would acquire neither atomic nor nuclear weapons and would not become a base for their storage".[114] Holyoake was more personally against nuclear testing than Holland, and in 1958, when he agreed with a British request for New Zealand assistance with the second round of British tests, ended his letter to Macmillan by commenting that a question increasingly being asked by the average citizen in his part of the world was "Why if there is no danger from these tests, do the British and Americans not hold them nearer home?"[115]

Labour, who won the 1958 General Election, had campaigned on opposing all future nuclear testing. Like Holland, the new Prime Minister, Walter Nash, was British – he had been born in England and came to New Zealand as an adult. Templeton has described Nash as always reluctant "to come out in direct opposition to what was presented as a vital British interest". Despite the election promises, Nash agreed to fulfill the National Government's earlier undertaking to support the 1958 British test series and two Royal New Zealand Navy ships offered similar support to that given in 1957.[116] Labour's opposition to nuclear testing did not extend to opposition to other nuclear technologies, however. In 1959, following the 1955 discovery of uranium deposits on the West Coast, the New Zealand Minister of Mines signed a secret agreement in which the UKAEA funded a drilling programme to investigate the region's uranium deposits (uranium prospecting is examined in the following chapter).[117] And it was the Labour Party that advocated a North Island nuclear power station when the National

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[113] Hayman 1997, p18.
[114] Templeton 2006, p82.
[115] Templeton 2006, p83.
[116] Crawford 1989, pp49-50; Templeton 2006, p89.

Government was pushing for a Cook Strait cable to carry electricity from the South to the North Island (see chapter nine).

New Zealand had only minor links to the United States testing programme. In 1957, the New Zealand deputy defence attaché, based in Washington, attended an American nuclear test at Nevada as part of a group of 80 invited observers from countries with defence links to the United States. Again, a New Zealander was invited to and observed an American test at Eniwetok Atoll in July 1958. The New Zealand Chiefs of Staff had noted that the opportunity for New Zealand officers to witness nuclear explosions and study their effects firsthand occurred very infrequently and the opportunity would be of considerable benefit to the officer involved and those he could brief about it. The observer was not of the same opinion, however. After the test, he reported that the limited information provided by the American authorities meant that observation of the test was of limited value to a New Zealand observer. No New Zealand military observed any more American tests.[118]

Opposition to nuclear testing

The possibility of nuclear war was now becoming part of popular culture and books like Nevil Shute's 1957 novel *On The Beach*, and the subsequent film of 1959, had a powerful effect on the public imagination concerning the outcome of a global nuclear conflict. The story, set in 1963 after a nuclear war, is set in Melbourne as people in Australia, New Zealand and South Africa wait for global circulation currents to reach their southern hemisphere homes and bring a deadly cloud of radioactive fallout that will kill everyone. The fact that it was set in the southern hemisphere, and featured the impact of a northern hemisphere war on countries like New Zealand – death would come, but it would be slower with more warning – was a chilling prospect to many New Zealand readers and helped strengthen anti-nuclear sentiment.[119]

In New Zealand, organised anti-nuclear sentiment had begun almost immediately after the end of the Second World War. New Zealand's first Hiroshima Day march was in Christchurch in 1947, organised by the New Zealand Peace Union. The testing of nuclear weapons by the United States, United Kingdom and Soviet Union strengthened anti-nuclear resolve and an international

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[117] Rebecca Priestley, 'The Search for Uranium in "Nuclear-Free" New Zealand: Prospecting on the West Coast, 1940s to 1970s', *New Zealand Geographer* 62 (2006), pp121–134.
[118] Crawford 2001, pp13-15.
[119] Nevil Shute, *On the Beach*, Heinemann, London, 1957; Philip Catton, email to author of 10 June 2010; Richard Hill, personal communication, 11 June 2010; Ruth Brassington, email to author of 28 June 2010.

anti-nuclear movement emerged in opposition to all nuclear weapons. In 1950, the World Peace Congress started collecting signatures worldwide for the Stockholm Peace Appeal, which stated:

> We demand the absolute banning of the atomic weapon, arm of terror and mass extermination of populations [sic]. We demand the establishment of strict international control to ensure the implementation of this banning measure. We consider that any government which would be the first to use the atomic weapon against any country whatsoever would be committing a crime against humanity and should be dealt with as a war criminal.[120]

The Appeal eventually collected 650 million signatures worldwide, more than 20,000 of them from New Zealand. Despite this level of support, anti-bomb protesters were generally thought to have communist sympathies and in 1950 Peter Fraser, Prime Minister of the 1940-49 Labour Government, described the Stockholm Peace Appeal as "just another Soviet weapon".[121]

Despite its initial perceived association with communism, the anti-nuclear movement was fuelled throughout the 1950s by nuclear accidents, like those at Chalk River, Canada in 1952, and at Windscale in the United Kingdom in 1957, and by growing fears about genetic damage caused by radioactive fallout. British and American bomb tests in the Pacific brought the nuclear world closer to New Zealand and gave impetus to the country's nascent anti-nuclear movement. There was widespread opposition to the tests in the Pacific – from church groups, students, women's organisations, Maori, unions and scientists with many groups passing anti-nuclear resolutions and many groups and individuals writing to Holland to voice their opposition, particularly after the first hydrogen bombs were tested.[122] The strongest objection to bomb tests arose from fears about the genetic and health effects of radioactive fallout.[123]

To people calling for an end to the testing of hydrogen bombs, Holland parroted Churchill's reply to his own voiced concerns, that it would be "a great disservice to the free world" for Britain to seek to "impede the progress of our American allies in building up their overwhelming strength in a weapon which provides the greatest possible deterrent against the outbreak of a third world war". Australia and New Zealand followed Britain's lead on this issue, while newly-independent India took an independent stance and called for an immediate halt to all nuclear testing.[124]

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[120] Elsie Locke, *Peace People: A History of Peace Activities in New Zealand*, Hazard Press, Christchurch, 1992, p126, 135.
[121] Locke 1992, p144; *NZPD* 291 (1950), p2144.
[122] F. J. M. Farley, 'The Fewer the Better', *Here & Now*, 60 (Sept 1957), pp11-12.
[123] Arnold 2001, p117.
[124] Templeton 2006, p67-8

Holland responded to New Zealanders' opposition to bomb testing by trying to justify Britain's role in the arms race as essential, and by minimising the harmful effects of fallout. In a May 1957 radio broadcast which followed the explosion of the first British hydrogen bomb, Holland talked about the many letters he received from around New Zealand, both for and against the nuclear tests, in which some people called for the Government to oppose all nuclear testing. While he believed that most of these views were "sincerely held", Holland also cautioned that some of the letters were part of a programme of "Communist propaganda" against nuclear testing. Holland defended his Government's support for Britain's nuclear testing by referring to the "great deal of study of scientific information" they had conducted and because of the vulnerable position of the "Motherland", which must show "those who need to be shown that she has the means to defend herself". But regardless of views about the ethics of bomb testing, the effects of fallout were a ubiquitous concern. Holland described people's major concerns being "that the atmosphere is being poisoned, that food supplies will be contaminated, and that flesh and blood itself are being attacked by unseen, deadly radiations". In response, Holland rightly pointed out that the amount of radiation people were exposed to as a result of nuclear testing was small compared with radiation from cosmic rays or X-rays. Holland's assurances, however, went beyond what he could know from current scientific information. In response to concerns about fallout impacting on Pacific food sources, he assured that the British tests were "high air bursts and the fallout will be negligible and will filter back from the stratosphere without doing harm". While voicing his support for the eventual banning of nuclear testing, Holland stated that "the course being followed by Britain is the right course, and we must continue to support her. Her aim is the security of the Commonwealth and the free world and our safety lies in that security."[125]

Throughout the 1950s, petitions in escalating numbers asked the New Zealand Government to do more to protest against atmospheric and underground nuclear tests, with the Government's response changing depending on who was in power.[126] While Holland's National Government voted against a 1956 United Nations resolution calling for a World Court opinion on the legality of atmospheric testing, in 1959 Nash's Labour Government supported a United Nations resolution condemning nuclear tests, sought a nuclear test ban treaty and helped develop the world's first nuclear weapons-free zone, in Antarctica. After regaining power in 1960, however,

[125] Holland 1957, pp17-20.
[126] Clements 1988, p46.

Holyoake's National Government voted against a United Nations resolution which declared the use of nuclear weapons as contrary to the laws of humanity.[127]

Despite growing opposition to nuclear testing, the arms race continued. In 1957, the same year that Britain was testing its first hydrogen bomb, the Soviet Union was launching the world's first intercontinental ballistic missiles, and, later that year, Sputnik 1, the first artificial satellite. These developments raised the spectre of intercontinental nuclear missiles, or nuclear weapons launched from space. The Soviet president, Nikita Khrushchev, wanted the West to be fearful of the communist superpower. As John Lewis Gaddis wrote, from 1957 through 1961, Khrushchev "openly, repeatedly, and bloodcurdlingly threatened the West with nuclear annihilation".[128] In turn, Khrushchev's threats were used as justification for the United States continuing its nuclear testing programme.

In response to anxiety about fallout, the United States and United Kingdom agreed in 1958 to suspend nuclear testing for a year. Britain never resumed nuclear testing but in 1962 the United States began a new Pacific test series that increased anti-nuclear sentiment in many New Zealanders. By this time, France had become the world's fourth nuclear power, after testing nuclear bombs in French territory in North Africa.[129] Before the 1962 tests, Holyoake let the United States Government know of the likely outcry in New Zealand and in New Zealand's island territories in the Pacific, but for the New Zealand public he issued a press statement blaming the resumption of testing on the Soviet Union – which in 1961 had tested a 50 Mt bomb in the atmosphere – forcing the decision upon the West.[130]

The United States' 1962 bomb tests were conducted at Christmas Island and Johnston Atoll between April and November. A test on 9 July 1962, when a 1.2 Mt hydrogen bomb was launched on a rocket and exploded 320 kilometres above Johnston Island, was a pivotal experience for many New Zealanders. The high altitude test, designed to test the effect of a nuclear explosion on radio and radar communication, disturbed New Zealand's telecommunications systems and created an artificial aurora, described in the *New Zealand Herald* as an intense glow above the northern horizon that spread rapidly across the sky before

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[127] J. Stephen Kos, 'Interim relief in the International Court: New Zealand and the Nuclear Tests cases', *Victoria University Wellington Law Review,* no. 14, 1984, pp357-387 quoted in Kate Dewes and Robert Green, *Aotearoa/New Zealand at the World Court,* The Raven Press, Christchurch, 1999, p10.
[128] Gaddis 2005, p70.
[129] Clements 1988, p43, Templeton 2006, p105-8.
[130] Templeton 2006, pp92, 95.

"the luminous red band widened, and quivering white shafts of light could be seen within it".[131] The *New Zealand Herald* editorial the next day described the eerie glow from the nuclear explosion as doing "more than a hundred protest marches to fill men's minds with dread".[132] David Lange, who would be Prime Minister of a Labour Government from 1984 to 1989, later recalled that:

> … the confusion in the sky that night haunted me as a vision of a man-made apocalypse, a terrifying retaliation of natural forces against the evil of unnatural invasion and a warning that a small country at the edge of the world in the South Pacific was no longer far enough away from the quarrels of the great powers to escape their consequences. It was a shock to realise that the power of nuclear weapons could straddle the world and unleash a threat on an inoffensive country like New Zealand.[133]

The American tests seem to have created mixed feelings in New Zealand. While the test was shocking, the United States was still an ally and the leader in the West's fight against communism. The *New Zealand Herald* acknowledged that the "yearning to see these dreadful engines of destruction abolished must be nearly universal" but also stated that to "clamour for immediate nuclear disarmament flies in the face of reality".[134] Later that year, the New Zealand Atomic Energy Committee, in response to a request from the Prime Minister's Department, commented on the potential impact of high altitude nuclear tests on the ionosphere, and advised that such tests would increase the levels of long-lived radioisotopes such as strontium-90, and recommended that the New Zealand Government "oppose further high-altitude tests unless such tests have the support of and the scientific observations are coordinated by an internationally recognised scientific organisation".[135]

New Zealand supported the United States in other ways and was its ally in a way it was not to France. In the 1960s, New Zealand soldiers fought in the American war in Vietnam – the first war New Zealand had fought independently from Britain. In justifying New Zealand's contribution of 550 men, Prime Minister Holyoake cited resistance to communism as one of the reasons, and said "We must, I believe, range ourselves with our American and Australian allies".[136] In the early 1960s, communism was increasingly being seen as a threat. One of the peaks of this threat – now regarded as the closest the world came to a third world war – was what became known as the 1962 Cuban missile crisis. For years, the United States had had

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[131] *New Zealand Herald*, 10 July 1962, p1.
[132] *New Zealand Herald*, 11 July 1962, p6.
[133] David Lange, *Nuclear Free – The New Zealand Way*, Penguin Books, Auckland, 1990, p11.
[134] *New Zealand Herald*, 11 July 1962, p6.
[135] Templeton 2006, p100.
[136] McIntyre 1992, pp529-532.

intermediate range missiles stationed in Britain, Italy and Turkey, all aimed at the Soviet Union. When Cuba became a communist state, spontaneously and without Soviet intervention, Krushchev took the opportunity to reciprocate, planting Soviet missiles on Cuban soil, aimed at the United States. President Kennedy demanded the immediate removal of the missiles and imposed a naval blockade of Cuba. The crisis was averted when the Soviets agreed to dismantle and remove the missiles in return for the United States agreeing not to invade Cuba.[137]

The scientists' responses

The post-war period saw proposals for a research reactor in New Zealand, a uranium prospecting boom, nuclear testing in the Pacific, and fallout deposition in New Zealand. Politicians were driving decisions about New Zealand's level of support and involvement in these ventures, but what did New Zealand scientists, particularly those working in the field of nuclear physics, make of these developments? Scientists tended to tread a pragmatic path between excitement and interest in the new nuclear science and technology, and growing public fear of radiation and radioactive fallout that was leading to increased opposition to nuclear testing. It is interesting to look at the example of Ernest Marsden, New Zealand's original nuclear advocate, because of the way that his attitude to nuclear weapons and nuclear technology changed over the decades after the Second World War.

At about the same time that he was advising Holland against allowing the United Kingdom to test hydrogen bombs in the Kermadec Islands (though he was happy to recommend the Auckland Islands), Marsden was beginning his own research into the biological effects of background radiation. In his "retirement", which began in 1954, Marsden worked up to six days a week, either from his attic laboratory at his home, or as a guest worker at the DSIR's Dominion Physical Laboratory or the Royal Cancer Hospital in London.[138] He was passionate about this new line of work, telling a colleague "I wish I could start my career again and work on these radiobiological problems".[139]

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[137] Gaddis 2005, pp75-78.; Badash 1995, pp95-96.
[138] W. M. Hamilton to Marsden, 7 March 1957, MS papers 1342-005, *ATL*; Marsden to L. Farrer Brown, 28 March 1960, MS papers 1342-010, *ATL*; L. S. Hearnshaw in *Sir Ernest Marsden 80th Birthday Book*, p75; Ernest Marsden curriculum vitae in *Sir Ernest Marsden 80th birthday book*, p12.
[139] Ethel W. Wood, in *Sir Ernest Marsden 80th birthday book*, p25.

Figure 5.4: Sir Ernest Marsden in June 1961, on board the *Sydney Star* at Bluff, New Zealand, testing the radioactivity of a sample of seawater. Reference number F-153607-1/2, Alexander Turnbull Library, Wellington, NZ.

Marsden liked an audience and received a lot of press coverage – he sometimes talked up the effects of radiation from bomb tests and sometimes minimised them, pointing out that radiation levels from fallout were very low in comparison to natural background radiation.[140] He rightly, however, said the effects of radiation from bomb fallout were not fully understood and deserved further study.[141]

Marsden began speaking out against the testing of nuclear weapons in 1959, after the United Kingdom had completed its nuclear testing programme in Australia and the Pacific. He highlighted the worldwide increase in radioactive fallout resulting from Soviet and American nuclear tests and told the *Auckland Star* "the time has come for an absolute standstill on such atomic explosions to give time for a proper assessment of the damage already done to us and to our children even yet unborn".[142]

This was not the first time Marsden had publicly opposed nuclear weapons. As told in chapter four, he had supported the 1946 Baruch Plan, which had stipulated that the United States dispose

[140] See, for example, newspaper clippings in MS papers 1342-378, MS papers 1342-379, *ATL*.
[141] See, for example, *Evening Post* and the *Dominion* 6 June 1962, MS papers 1342-379, *ATL*.
[142] *Auckland Star*, 8 May 1959, MS papers 1342-386, *ATL*.

of its atomic weapons, stop all weapons work and turn over its atomic energy knowledge to the United Nations. In a 1947 speech, Marsden had said that it was not safe to develop atomic energy until there was a practical and enforceable agreement that it would not be used for atomic bombs.[143] At the same time, however, he promoted the development of a nuclear reactor in New Zealand as being of defence significance to the Commonwealth. And later, in the early 1950s, he supported British plans to develop nuclear weapons, and was keen for New Zealand to assist the British nuclear programme by constructing a nuclear reactor and providing heavy water and uranium.

After the British nuclear programme was concluded in 1958, Marsden declared that New Zealand was partly to blame for the Commonwealth "falling miserably behind in nuclear development". If there was a third nuclear power, he declared, there would be no "bombing competition" between Russia and America.[144] Marsden continued to criticise New Zealand's lack of investment in defence science, including telling Holyoake that New Zealand had been "grossly discourteous and negligent of opportunities to help Britain" in this area[145]; a reference to New Zealand's continued failure to construct an atomic pile.[146]

Why, at the same time as implicating New Zealand in the United Kingdom's failure to keep up with the arms race, was Marsden speaking out against nuclear weapons? As journalist Tony Reid described in a newspaper profile of Marsden, his attitudes to nuclear weapons development were "ambiguous and sometimes contradictory".[147] It is possible that despite his initial personal misgivings about the post-war development of nuclear weapons, Marsden's loyalty to Britain, along with the close involvement of many of his friends and former colleagues in the British nuclear programmes, caused him to push these misgivings aside. Marsden was easily seduced by science – as demonstrated by his willingness in early 1945 to leave his position as head of the DSIR to take a junior physicist's role on the North American nuclear programme – and the development of nuclear weapons was at the forefront of scientific and technological development. Once the British nuclear testing programme was concluded, therefore, and with evidence of increased environmental radioactivity resulting from bomb fallout, Marsden had no hesitation in publicly opposing nuclear weapons.

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[143] E. Marsden, The Atomic Age, unpublished talk to National Dairy Association of New Zealand in 1947, MS papers 1342-269, *ATL*.
[144] *Evening Post*, 6 June 1962, MS papers 1342-379, *ATL*.
[145] Marsden to Holyoake, 14 January 1963, MS papers 1342-016, *ATL*.
[146] In the 1948 report on Amplification of reasons for an atomic pile in New Zealand, Marsden, in response to a query on the cost of building an atomic pile in New Zealand, said 'New Zealand is not contributing her share to either defence science or atomic energy in the Commonwealth'. AAOQ, W3424, 74/20/- , 1947-55, *ANZ*.

Other scientists also had changing attitudes to nuclear issues. Jim McCahon, who had worked on the South Island uranium survey in the late 1940s, then had been seconded to the Atomic Energy Research Establishment at Harwell for two years before joining the Dominion X-Ray and Radiation Laboratory in 1951, continued working in radiation physics but became a lifelong supporter of the Campaign for Nuclear Disarmament.[148] Some scientists involved in the Manhattan and Montreal projects, like Maurice Wilkins, were so appalled by the bomb that they turned away from physics. (In Wilkins' case it was a great move for science, as he went on to share a Nobel Prize in Physiology or Medicine for his work on the structure of the DNA helix.)

After making a number of anti-nuclear statements to the media from 1959 onwards, Marsden began communicating his anti-nuclear weapons sentiments to Holyoake in 1961.[149] In 1963, when the French announced their proposal to move their test site to the South Pacific, Marsden advocated, in a letter to Holyoake, a nuclear-bomb-free southern hemisphere. He pointed out that fallout from nuclear bomb tests had so far impacted more on the northern hemisphere than the southern, and called on Holyoake to announce that New Zealand would not provide any assistance to countries carrying out bomb tests in the southern hemisphere, and suggested he call on other southern hemisphere countries to do the same.[150] In May 1963 the New Zealand Government formally protested to the French Government over their preparations for a nuclear test at Gambier Island.[151] Later that year New Zealand was the fourth country, after the United States, United Kingdom and the Soviet Union, to ratify the Partial Test Ban Treaty, demonstrating, in Holyoake's words, New Zealand's "desire to see an end to nuclear tests that are likely to give rise to contamination of the atmosphere".[152] The signatories to the Partial Test Ban Treaty agreed to prohibit, prevent and not carry out nuclear tests in the atmosphere, in outer space, or under water. While it dealt to fears about fallout it did not mean an end to the further development of nuclear weapons, as testing programmes just moved underground.

While focusing on his research into environmental radioactivity, Marsden continued to speak out against nuclear weapons development and testing. On a visit to South Africa he described the hydrogen bomb as "the most striking example of the possibilities of misuse of modern scientific

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[147] Newspaper clipping, n.d. but c. 1964, and paper not identified in MS papers 1342-387, *ATL*.
[148] Jim McCahon, Author's interview with McCahon, Wellington, 16 October 2002; Andrew McEwan, *Radiation Protection and Dosimetry in New Zealand: A History of the National Radiation Laboratory*, Department of Health, Wellington, 1983, p53.
[149] Marsden to Holyoake, 23 December 1961, MS papers 1342-014, *ATL*.
[150] Marsden to Holyoake, 16 March 1963, MS papers 1342-016, *ATL*.
[151] *NZEAR* 13, 5 (1963), pp25-26.
[152] *NZPD* 337 (1963), pp2695-6.

knowledge".[153] In June 1965 he told *Salient*, the Victoria University student newspaper, "we must do what we can to stop nuclear warfare. We must do what we can to promote nuclear disarmament".[154] New Zealand's nuclear advocate had become a voice of caution.

New Zealand signed the Treaty on the Non-Proliferation of Nuclear Weapons, a treaty in which countries possessing nuclear weapons agreed not to help other states to acquire them, on 1 July 1968.[155] New Zealand now began making diplomatic protests over French tests in the Pacific, monitoring fallout in the South Pacific, and working internationally towards disarmament.[156]

Conclusion

Nuclear bomb testing moved close to New Zealand, to Australia and to islands in the South Pacific Ocean in the 1950s. New Zealand's National Government supported the British nuclear testing programme by offering logistical support in the form of fallout measurement and weather observations, and by providing unwitting test subjects for experiments on clothing to protect against radioactivity. The New Zealand Government was also a partner in a planned joint New Zealand-British project to produce heavy water for the British nuclear programme at Wairakei in the central North Island.

Despite the level of New Zealand support for the British nuclear programme, it was not blind loyalty. There was a national interest in New Zealand's involvement in the planned heavy water plant, as it was associated with an electricity generation plant for local power supply, which went ahead even after the heavy water plant plans were shelved. And in 1955 Prime Minister Sidney Holland took the bold but self-interested step – public opinion was likely to be against the tests – of refusing a British request to use New Zealand island territory for a series of hydrogen bomb tests. The basis of his decision was probably that it would improve his own chances of being re-elected at the next General Election. Despite this, Holland saw the tests as essential to the United Kingdom retaining its position in the arms race, and as well as offering logistical support from the Navy, he spoke to reassure the public that the tests were necessary and they would pose no danger from radioactive fallout. When Holland learned of the first British hydrogen bomb from news reports, rather than being alerted in advance, he felt angry and betrayed.

[153] Newspaper clipping, publication not identified, n.d., but possibly 1961, MS papers 1342-387, *ATL*.
[154] 'Nuclear Testing Potential Danger', *Salient*, 29 June 1965, p14, MS papers 1342-386, *ATL*.
[155] *NZPD*, Vol 355, 1968, p370; Gaddis 2005, p81.
[156] Clements 1988, pp59-62.

By the end of the 1950s Britain was withdrawing from being an imperial superpower to being a European regional power and letting the United States take over as the West’s global superpower. Britain’s last nuclear tests were in 1958. When the United States resumed nuclear testing in 1962, New Zealand did not have the background of assistance with their nuclear programme and so was freer to be critical. Attitudes to nuclear weapons were changing too, with an emerging protest movement highlighting the dangers of radioactive fallout and the madness of stockpiling nuclear weapons reflected in global treaties that New Zealand signed, including the Limited Test Ban Treaty of 1963 and the Nuclear Non-Proliferation Treaty of 1968.

The 1950s might have been economically prosperous, but the country’s milk and meat were now tainted with strontium, nuclear bombs were being tested nearby and despite all the talk about the atomic age bringing prosperity and a scientific utopia, all New Zealand had seen of the nuclear age was radioactive fallout. Still, anti-nuclear sentiments were restricted to opposition to nuclear weapons, and did not extend to opposition to peaceful applications of nuclear technology such as nuclear power and uranium prospecting, which some New Zealanders were now advocating.

Chapter 6

Uranium fever!

Uranium prospecting on the West Coast

"I believe that it is possible we have discovered the second most highly concentrated uranium deposit in the world."

Frederick Cassin, November 1955, Buller Gorge[1]

"It looks as if they've got something all right."

Dr Les Grange, Director of NZ Geological Survey[2]

By the mid-1950s, anti-nuclear sentiment was growing, mostly associated with people's fears about health risks from radioactive fallout from bomb testing. For most people, however, this antipathy towards bomb testing did not cause any ill-feeling about the potential use of nuclear power for electricity generation, or the possibility that emerged in the 1950s that New Zealand might start mining and exporting uranium ore. If anything, the opposite was true: New Zealand's first reported uranium find caused great excitement.

The local reaction to the 1955 discovery of uranium in the Buller Gorge was consistent with its potential as an economic stimulus for the region – a uranium mining industry would provide jobs, wealth and an improvement in local infrastructure. The Government supported companies prospecting in the region, and as well as publishing a booklet that stimulated interest in searching for uranium provided financial and scientific support for companies to investigate and analyse uranium deposits. While there were some concerns about the safety of prospectors working with uranium-rich rocks, and appropriate advice was given on how to ensure their safety, there was no moral or ideological opposition to uranium prospecting in New Zealand, right up to the last investigations in 1979.

Early surveys of radioactive minerals

New Zealand's first attempt at a uranium survey was Ernest Marsden's 1945-46 survey of the fiords and beaches of the South Island, which had found uranium in beach sands but had failed to reveal any promising sources of uranium for mining. Through the 1950s, global demand grew

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[1] *The Press*, 10 November 1955, p12.
[2] *The Press* 15 November 1955, p12.

for uranium to fuel the developing nuclear weapons and energy programmes in the United States and United Kingdom. With world production of natural uranium estimated at 10,000 tonnes per annum,[3] the United Kingdom Atomic Energy Authority (UKAEA) was drawing its uranium supplies chiefly from the Belgian Congo, South Africa, Australia and Portugal while the United States Atomic Energy Commission (USAEC) sourced its uranium domestically and from Canada.[4] By 1955, Australia had uranium mines at Radium Hill in South Australia, Rum Jungle in the Northern Territory and Mary Kathleen in Queensland, with a new agreement to export uranium oxide to the UKAEA.[5]

Two international uranium experts visited New Zealand in 1952. Charles Davidson, chief geologist to the UKAEA, and Robert Nininger, chief geologist to the Atomic Energy Commission of Australia, reported that, in their opinion, it was unlikely there were economic uranium deposits in New Zealand. In saying this they were confirming the New Zealand Geological Survey view based on Marsden's surveys in the 1940s.[6]

There were also approaches from the United States. In April 1954, the Vitro Organization (a large engineering company involved in the construction and operations programmes of the USAEC) advised New Zealand that the USAEC would look with "considerable favor" upon any effort in friendly countries to uncover new deposits of uranium ores, and it would be possible to negotiate "very attractive contracts" with the United States Government. The Vitro Organization stated their interest in working with New Zealand on a national uranium survey and advised that, "it would seem to be very much in the national interest of New Zealand to encourage competent and well-planned efforts in this field of activity".[7] New Zealand, however, already had a plan in motion. On a visit to Australia, Dr Les Grange, head of the New Zealand Geological Survey, met Philip Dodd and Frank Frankovich, from the USAEC, and invited them to New Zealand to help plan a search for uranium. The American geologists were working with the Australian Federal Government, helping to develop the Rum Jungle uranium deposit in the Northern Territory. They visited New Zealand in early 1954 and helped the Geological Survey to plan a new approach to a uranium search.[8]

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[3] J. A. McWilliams, *The Economics of Nuclear Power in New Zealand*, 25 September 1957, ED1, W2673, 2/0/22/5, Part 2, *ANZ.*

[4] Tony Hall, *Nuclear Politics: The History of Nuclear Power in Britain*, Penguin, Harmondsworth, 1986, pp40-41; Notes on World Uranium Position prepared by Australian Bureau of Mineral Resources (undated) in AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*

[5] Alice Cawte, *Atomic Australia: 1944-1990*, New South Wales University Press, Kensington, 1992, pp69-77.

[6] Mines Department report on Uranium Prospecting, 23 May 1960, in AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*

[7] Charles Roggi to G. R. Laking, 19 April 1954, EA1, W2619, 121/2/1, part 1, *ANZ.*

[8] J. A. D. Nash to Secretary of External Affairs, 7 July 1954, EA1, W2619, 121/2/1, part 1, *ANZ.*

Following the advice of Dodd and Frankovich, in December 1954 the Geological Survey enlisted the help of amateur and weekend prospectors in a nationwide search for uranium with the publication of *Prospecting for Radioactive Minerals in New Zealand*.[9] This followed a precedent set in North America where amateur uranium prospecting reached such a scale that some real estate agents offered a Geiger counter free with the purchase of large properties.[10] The Geological Survey booklet provided information on the field properties of radioactive deposits, along with instructions on likely places to find them and, for those unable to buy a Geiger counter – available for £40 each from local electronics suppliers – simple instructions on how to make one.[11]

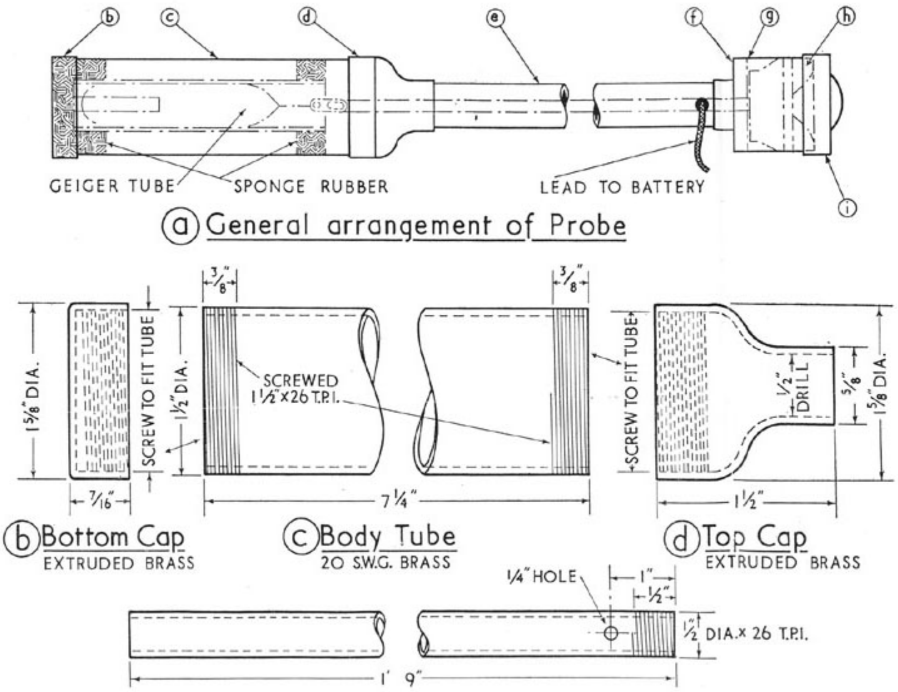

Fig 6.1: Uranium prospecting was promoted as a weekend or summer hobby. Grange advised that "A Geiger counter can be made at home at an expenditure of little more than £10, and thus it is well within the reach of anyone who has ability in mechanical and electrical work. If a significant deposit of radioactive minerals is not found the small financial outlay will not be grudged, and, after all, it will have added interest to the summer holiday." [12]

While Grange advised that the likelihood of finding economic uranium deposits in New Zealand was slim, the potential prize was great. In 1954, uranium ore was selling for between A£1 10s and A£504 per ton, depending on the concentration of uranium in the ore (from 0.1 per cent to

[9] Les Grange, *Prospecting for Radioactive Minerals in New Zealand*, DSIR Information Series No. 8, Government Printer, Wellington, 1954.

[10] *The Press*, 11 June 1954, p3.

[11] File note from 9 October 1956, AATJ 6090, W4897/102, 5/22, part 3, *ANZ*; Grange 1954, p3.

[12] Grange 1954, p8.

10 per cent), and the Atomic Energy Act of 1945 promised the first finder of uranium a financial reward.[13]

Uranium fever on the West Coast

When two elderly prospectors discovered uranium in the road cutting near Hawks Crag, the West Coast experienced a short but intense uranium rush and the hills rang to the sounds of clanging rock hammers and ticking Geiger counters. The prospectors – labourers, businessmen, chemists, miners, and weekend trampers and deerstalkers – were not the only people excited. The uranium finds triggered the collective memory of the West Coast gold rushes of the 1860s, arousing new hope for a return to those prosperous days when packed public houses and dance halls lined the streets and West Coast ports were the busiest in the country.[14]

Uranium was a familiar word in the mid 1950s: it was the fuel for the nuclear reactors that were going to revolutionise electricity generation and change the way people lived. It was the raw material that would take the world, including New Zealand, into the atomic age. Hundreds of eager prospectors acquired copies of *Prospecting for Radioactive Minerals in New Zealand* and bought or made Geiger counters, sending samples of any promising rocks to the Geological Survey or the Reefton School of Mines for analysis. But it was 11 months after the booklet was published, and hundreds of samples later, before a rock was found with any significant radioactivity. One Sunday afternoon at the beginning of November 1955 two veteran prospectors, Frederick Cassin and Charles Jacobsen, were returning home after a day prospecting in the hills above the Buller Gorge. As the story goes, the sprightly septuagenarians had finished their day with a few drinks in the Berlins Hotel and, needing to relieve themselves on the drive home, pulled their truck over to the side of the road next to Batty Creek. Out of force of habit, Jacobsen put the Geiger counter on the rock face. The counter ticked wildly and the needle went off the scale. The excited pair returned to the Berlins Hotel to spend the night, coming back to Batty Creek the next morning to gather rock samples before leaving for Wellington.[15]

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[13] Atomic Energy Act, *New Zealand Statutes*, 1945, pp364-370; D. S. Nicholson, 'Wartime Search for Uranium', *New Zealand Journal of Science & Technology* 36B (1955), p394.
[14] Philip Ross May, *The West Coast Gold Rushes*, Pegasus, Christchurch, 1967.
[15] Reminiscences – C. S. Jacobsen, FMS Papers 4253, *ATL; The Press*, 10 November 1955, p12; *The News*, 28 April 1999, p2; Elaine E Bolitho, 1999: *Reefton School of Mines, 1886-1970: Stories of Jim Bolitho*, Friends of Waiuta in association with Reefton School of Mines and the Bolitho family, Reefton, p113.

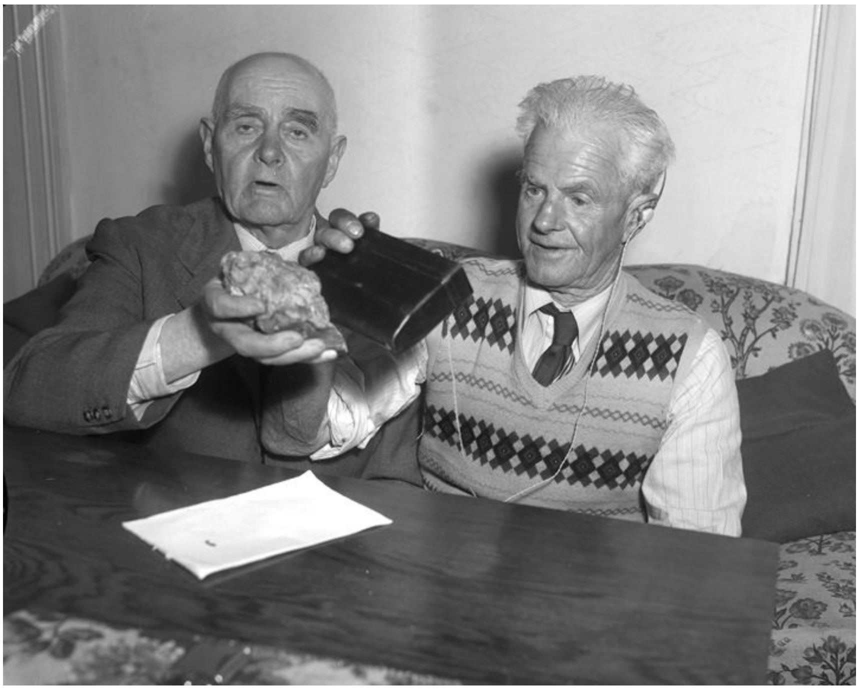

Fig 6.2: Frederick Cassin and Charles Jacobsen holding a Geiger counter to a sample of uranium ore. "I believe that it is possible we have discovered the second most highly concentrated uranium deposit in the world", said Cassin. Source: The Dominion Collection, Alexander Turnbull Library, Wellington, New Zealand. Reference number F-144916-1/2.

Cassin and Jacobsen arrived in the capital on 9 November, armed with their samples of radioactive rock. Their find excited the national and international media, along with other prospectors, especially as Cassin claimed that the reef from which they took the ore registered a radioactive count higher than at Rum Jungle in Australia's Northern Territory or the world's richest uranium mines in the Belgian Congo. "I believe that it is possible we have discovered the second most highly concentrated uranium deposit in the world", *The Press* reported him as saying.[16]

In Wellington, Cassin and Jacobsen met Prime Minister Sidney Holland, who tested their sample with a Geiger counter and congratulated them on their initiative.[17] Newspapers reported that while the rock samples were being analysed, 70-year-old Jacobsen entertained friends and fellow prospectors by holding the Geiger counter against a sample of the yellowish, black-streaked ore, and handing them the earphone. People were unfailingly impressed with the agitated clicking in the earphone coupled with the sight of the indicator needle creeping round to 450 counts per second.[18]

[16] *The Press*, 10 November 1955, p12.
[17] *The Dominion*, 11 November 1955, p12.
[18] *The Press*, 11 November 1955, p12.

A few days later, newspapers reported the Geological Survey's confirmation that the samples tested contained 0.27 per cent uranium and were more than twice as uranium-rich as the Rum Jungle ore.[19]

Cassin and Jacobsen returned to the Buller Gorge to stake out and register their claim. Following the vigorous outdoor work they returned to the Berlins Hotel where they were so busy enjoying their drinks and recounting tales of their find, that a Westport man, James Fair, registered New Zealand's first uranium claim. On Monday 14 November 1955, Fair registered a claim for a 400 hectare block on the south bank of the Buller River on each side of Batty Creek, surrounding but excluding any mineral lease applied for by Cassin and Jacobsen.[20] "The two guys who had found [the uranium] were celebrating still at Berlins," Fair later recalled.[21] Cassin and Jacobsen were just 25 minutes behind Fair, however, and filed their claim at 4 pm that day.[22]

The Geological Survey's Les Grange visited the Hawks Crag site a week after Cassin and Jacobsen's find, firing up the nearby town of Westport. *The Press* reported his visit:

> Quickly assembling a high-fidelity field-rate meter made at the Harwell Atomic Research Station in England, Dr Grange went immediately to the face of rock which the discoverers exposed when they made the find. "That looks pretty good", he said as the needle showed a strong reading on the scale of his instrument. "Hector, it's gone right off the scale!" exclaimed Dr Grange a few moments afterwards, when testing the same roadside rock face a few feet to the right.[23]

Grange estimated the reef to be 900 feet long, 300 feet deep, with an average width of about six feet (approximately 275 metres by 90 metres by 2 metres).[24] Although these dimensions were yet to be verified, Dr Grange said the deposit was a highly worthwhile mining proposition.[25] "It looks as if they have got something all right" he was reported as saying after visiting the site.[26]

Media reports of Cassin and Jacobsen's find gave other prospectors clues on likely prospects and in the days that followed the West Coast swelled in the grip of a uranium rush. Ninety years after the gold rush that led to the European settlement of this rugged area, the hills and river valleys were alive with prospectors eager to find uranium to fuel the developing United Kingdom and United States nuclear programmes. A uranium strike was also an exciting possibility

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[19] *The Press*, 11 November 1955, p12.
[20] *The Press*, 15 November 1955, p12.
[21] *The News*, 28 April 1999, p2.
[22] *The Press*, 15 November 1955, p12.
[23] *The Press*, 15 November 1955, p12.
[24] *The Press*, 16 November 1955, p12.
[25] *The Press*, 16 November 1955, p12.
[26] *The Press* 15 November 1955, p12.

domestically; a local uranium source would, it was thought, make nuclear power all the more affordable for New Zealand. Media reports on the find were unswervingly positive.

While nuclear power was widely perceived to be the hope of the future, and there was talk of an "atomic age", in 1955 uranium was primarily used as fuel for nuclear weapons, like the ones being tested by the United States and the United Kingdom in the Pacific. Amongst all the excitement of the West Coast uranium finds, however, there was no comment that New Zealand might not want to be involved in mining and exporting uranium – the local and national response was completely positive. The uranium find also tied into the nineteenth century notion of New Zealand as a land of natural abundance. While deficient in arable land, the West Coast was already known to be blessed with economic resources such as gold, coal and timber. Uranium was another economic mineral to add to the list.[27]

Uranium-rich deposits continued to be found. By 14 November, there were six reported uranium finds – three in the Paparoa Ranges, one in Buller Gorge, and two close to Reefton – and a new air of hope and prosperity on the West Coast.[28] "Health Hazards from Radioactive Materials" read a headline in *The Press*, reporting from the United Nations Atoms for Peace Conference in Geneva.[29] The warning seemed to go unheeded: hotels made presents of radioactive rock fragments to parting guests; shop windows attracted customers with displays of uranium-bearing rock; and the Berlins Hotel, where Cassin and Jacobsen had spent the night after their uranium find, had its busiest afternoon's trade since the gold rush.[30] *The Press* reported that at Hawks Crag – where Cassin and Jacobsen had said their uranium find was – a rich terracotta ore at the roadside attracted passing motorists, many of whom took home samples of the radioactive rock.[31] A week after the first report of uranium, *The Press* reported a rush on Geiger counters and said the second printing of Grange's *Prospecting for Radioactive Minerals in New Zealand* was almost exhausted.[32] *The Press* reported the mayor of Westport as saying, "The finding of uranium-bearing ore in the Buller Gorge has caused a wave of optimism unknown in the district for more than 50 years".[33]

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[27] Miles Fairburn, *The Ideal Society and its Enemies*, Auckland University Press, Auckland, 1989, p29.
[28] *The Press*, 15 November 1955, p12.
[29] *The Press*, 15 November 1955, p9.
[30] *The Press*, 14 November 1955, p10; *The Press*, 17 November 1955, p12.
[31] *The Press*, 14 November 1955, p10.
[32] *The Press*, 16 November 1955, p4.
[33] *The Press*, 17 November 1955, p12.

The Press also reported:

> There has been an unmistakable air of new liveliness in the main street of Westport during the brilliant weather while the "uranium boom" was at its peak, and there were more cars in the business area on Monday and yesterday than had been seen for years … Businessmen say that business has shown a returning briskness already. Travellers have been getting better orders. Hotels were crowded out yesterday, and some guests were required to go elsewhere or accept makeshift accommodation … Hotel talk is unceasingly on the subject.[34]

While excitement reigned on the West Coast, Wellington-based scientists were continuing to examine the uranium find. The quality was there, but was it there in sufficient quantity to make extraction economically viable? For minerals like uranium that are distributed throughout a rock, rather than concentrated in seams (as many precious metals are), exhaustive processing is required and for a uranium deposit to be economic it would have to exist in quantities and proportions that offset the cost of extracting the uranium from the host rock. The location of the deposit – its depth, geographic spread and distance from where it would be used – would also be a factor.

Fig 6.3: Even the local ice-cream factory got into the act, offering "uranium ice cream" to West Coasters in November 1955. *Grey River Argus*, 23 November 1955, p5.

Meanwhile, a DSIR technical report put a damper on the initial excitement. On 23 November, only nine days after the first uranium claim was registered, more detailed analysis showed that Cassin and Jacobsen's initial sample had anomalously high levels of uranium; further samples from the same location contained one-quarter to one-hundredth of the first sample's levels.[35] While New Zealand's first uranium find was reported as being "not commercial", the DSIR

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[34] *The Press*, 17 November 1955, p12.
[35] *The Press*, 24 November 1955, p14; Report by Dominion Laboratory, 18 November 1955, CABH 3391, CH58, 6/27, 1955-62, *ANZ CHCH.*

report said it gave a valuable lead as to further places and rock types in which to search.[36] On learning of the DSIR's report, Cassin refused to lose enthusiasm, with newspapers reporting his declaration that the Government report was "too silly for words", given that no boring tests had been carried out. He intriguingly told *The Press* that it appeared people had been asked to "soft-pedal" about it because of "international complications".[37]

Cassin and Jacobsen's uranium find had initially attracted interest from Australian mining companies – the prospectors told reporters they had been offered "unlimited funds" to develop the strike – but following the DSIR report that the lode was of no commercial significance the Australian companies withdrew support.[38] Cassin and Jacobsen did no further prospecting of their claim; if overseas interests would not buy their claim they could at least wait for their promised reward under the Atomic Energy Act. Their attitude did not impress the Geological Survey: as Dick Willett, the director of the Survey expressed it, some prospectors were "content to find a piece of radioactive rock, peg a claim and wait for the State to either present them with a reward or hope for some overseas group to buy them out."[39]

Finders of Australia's uranium deposits had received up to £25,000 each. Cassin and Jacobsen were not so lucky. In 1956, they were each awarded £100 under the Atomic Energy Act. In making the reward, the Minister of Mines noted that "whilst it was disappointing that the early reports were not more encouraging as to the commercial value of the area, the discovery was important in renewing interest by prospectors".[40] Cassin and Jacobsen were reportedly "bitterly disappointed" at the value of the reward – they said that as a result of earlier discussions "at Ministerial level" they had been expecting at least £10,000.[41]

Prospecting for uranium continued. In May 1956, prospectors employed by Buller Uranium Limited, a subsidiary of the Nelson company Lime and Marble Limited, reported three finds of radioactive boulders and outcrops in the lower Buller Gorge.[42] Uranium Valley, a company set

[36] *The Press*, 24 November 1955, p14.
[37] *The Press*, 24 November 1955, p14.
[38] E. H. Brooker to Minister of Mines, 23 August 1957, CABH 3391, CH58, 6/27, 1955-62, *ANZ CHCH; The Press*, 11 November 1955, p12*; The Press*, 24 November 1955, p14.
[39] R. W. Willett to Secretary of DSIR, 26 July 1956, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[40] Minister of Mines to F. Cassin, 20 April 1956, CABH 3391, CH58, 6/27, *ANZ CHCH.*
[41] E. H. Brooker to Minister of Mines, 25 June 1957, CABH 3391, CH58, 6/27, 1955-62, *ANZ CHCH.*
[42] Statement issued by Lime and Marble Ltd, 18 May 1956, CABH 3391, CH58, 6/28, 1955-56, *ANZ CHCH*, reported in *The Press*, 19 May 1956.

up by two Westport men, found uranium in carbonaceous shales at the Fox River mouth and in the Paparoa Ranges inland from Punakaiki.[43]

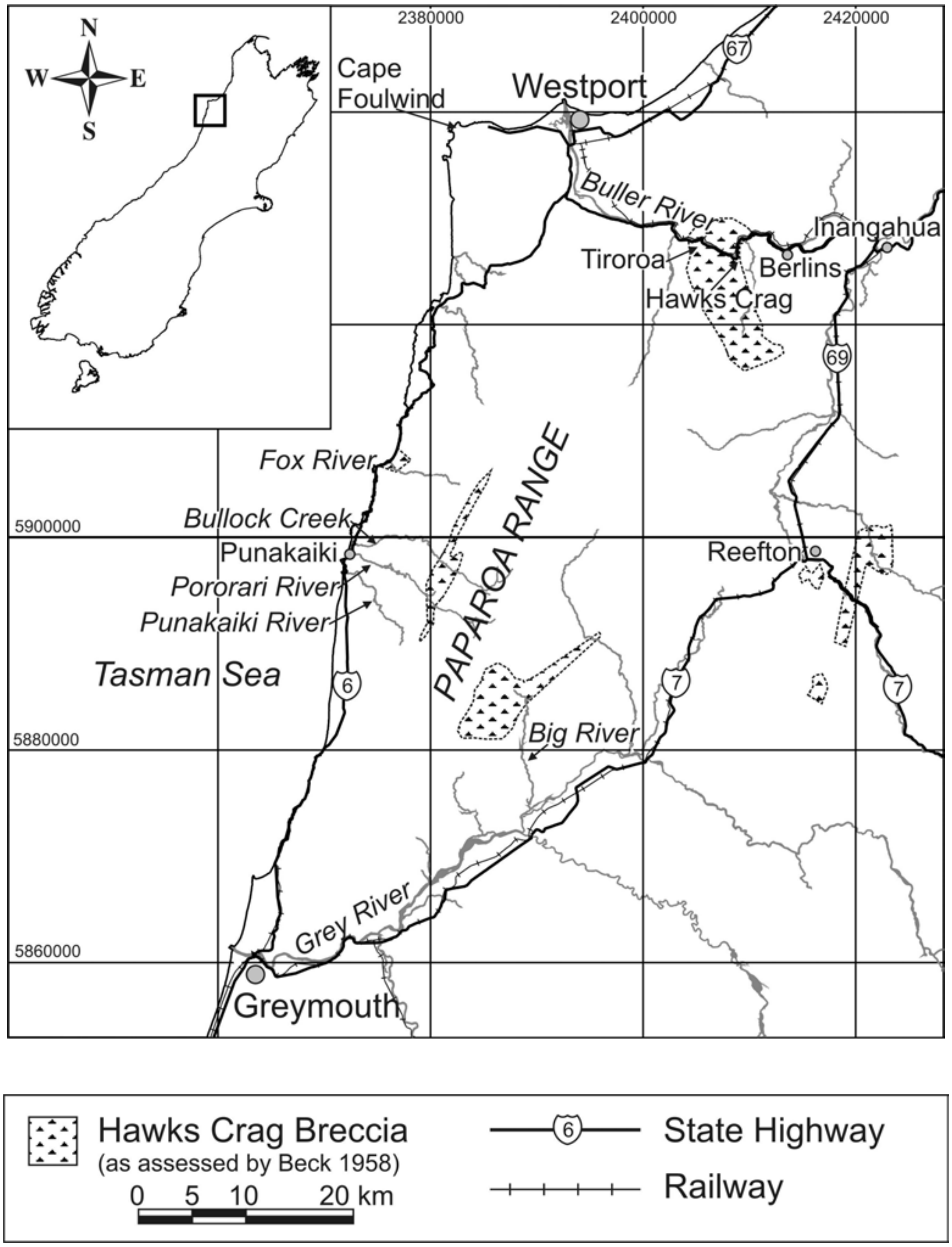

Fig 6.4: Map showing distribution of the uranium-bearing Hawks Crag Breccia on the west coast of the South Island of New Zealand. Uranium was found in the Buller Gorge, at the Fox River mouth and up Bullock Creek in the Paparoa Ranges. Source: Adapted from Beck et al, 1958.

Uranium was back in the news. Just a week after these new finds were reported, Professor Gordon Williams, Dean of the University of Otago School of Mines and Metallurgy (also the holder of a mineral prospecting warrant for a Buller Gorge claim), told a mining conference that

[43] All references to the Fox River Mouth claim are from CABH 3391, CH58, 6/38, *ANZ CHCH* unless otherwise cited All references to the Paparoa claim are from CABH 3391, CH58, 6/39, *ANZ CHCH* unless otherwise cited.

uranium “twice as good” as any ore found previously had been discovered in the Buller region and that there was now “a distinct possibility of an underground uranium metal mine in New Zealand”.[44]

Unlike the Cassin and Jacobsen find, the 1956 discoveries held up under scrutiny. Over the next four years, the New Zealand Government spent more than £35,000 on the West Coast search for uranium, mostly to fund the prospecting efforts of Buller Uranium and Uranium Valley.[45] The money from most of the government grants was to be contingently repayable – if the companies ever went into extraction and production of uranium oxide the money would have to be repaid.[46] Geological Survey and Mines Department staff, who were also working in the area, supported the prospectors.[47] There was no question of the government opposing or not supporting uranium prospecting – uranium was a globally desirable mineral that could boost New Zealand’s economy, and was treated just as any other economic mineral would be.

Fig 6.5: Helicopter landing at Benney’s Landing, site of Buller Uranium’s prospecting camp on the north side of Buller Gorge, October 1956. Source: Photographer Tas McKee, from Lloyd Jones collection.

[44] *The Press*, 16 August 1956, p10.
[45] Report to Minister of Mines from Under-secretary for Mines, 9 March 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ*
[46] Undated Mines Department report on Mineral Prospecting Warrants, AATJ 6090, W4897/102, 5/22, part 3, *ANZ*
[47] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*

In the Buller Gorge names like "Uranium Creek" and "Radioactive Creek" started appearing on maps. Buller Uranium used money from their parent company, Lime and Marble, along with their government grants, to cut tracks in the steep Buller Gorge bush, make clearings for helicopter airdrops, and establish and provision four uranium-prospecting camps and to run a field telephone from the main camp to the trunk line hear the Buller River.[48] A free government grant was used to cover the cost of an October 1956 helicopter airlift to transport materials and equipment to a new camp at "Benney's Landing", named after the Under-Secretary of Mines, 400 metres above sea level, between Uranium and Bullen Creeks on the north side of Buller Gorge. In this area of cleared scrub prospectors built a sapling platform as a landing stage for a helicopter to fly in material for the camp, and built a hut above the escarpment faces where uranium-bearing material had been found. Buller Uranium received a further contingently repayable government grant of £5000 to trace the extent of the mineralised zones through further exploration and sampling of deposits.[49] Prospectors expanded their search, tramping through the rainforest each laden with a geological hammer, a slasher, a compass, a Geiger counter and a scintillometer, an electronic device used to measure gamma radiation.[50] In 1957 and 1958 the Government provided £18,100 to construct a jeep track from Tiroroa Siding to the uranium area high above the north side of Buller Gorge.[51]

Uranium Valley built huts at two locations in the Paparoa Ranges, carrying supplies by helicopter, packhorse and on the backs of the prospectors to bases at Bullock Creek and Pororari. In both the Buller and Paparoa locations rock faces were cleared of vegetation and blasted to expose unweathered rock so as better to trace the radioactive seams. The work was hard – the conditions were rough, the weather was wet, and measles, influenza, and blood poisoning plagued the prospectors.

Uranium was in and out of the news throughout the late 1950s, but once the initial optimism for a uranium mining industry was proved unfounded, public enthusiasm abated. In January 1957 *The Press* report that "Rich uranium reserves, conservatively estimated at between £10,000,000 and £20,000,000, but probably worth twice as much" had been discovered in the Buller Gorge made only a few column inches on page 13 of the newspaper.[52] Ernest Marsden remained

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[48] All references to the Buller Uranium claims are from CABH 3391, CH58, 6/28, *ANZ CHCH*, unless otherwise cited
[49] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ*, Undated Mines Department report on Mineral Prospecting Warrants, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[50] *The Weekly News*, 26 September 1956, CABH 3391, CH58, 6/28, 1955-56, *ANZ CHCH.*
[51] Various file notes in CABA 3140, CH130/Box 40, 16/1/85, *ANZ CHCH*
[52] *The Press*, 31 January 1957, p13.

characteristically enthusiastic, however, and in June 1957 *The Dominion* covered his address to the Hutt Valley Chamber of Commerce at which he was reported as saying that within a few years West Coast fields would be producing enough uranium to run a nuclear reactor in New Zealand. Ever optimistic, Marsden saw the issue of nuclear power for New Zealand as being a question of "when", rather than "if", predicting that New Zealand would be running its first nuclear reactor in 10 years' time.[53]

Rewards under the Atomic Energy Act

As the number and significance of the uranium finds grew, so did dissatisfaction with the Government's level of support for uranium prospecting, and the paltry rewards offered under the Atomic Energy Act of 1945. Lime and Marble Limited, who had put the most money and effort into a systematic prospecting programme, criticised the lack of information about market prospects, and said the 1945 Atomic Energy Act, which was passed before any uranium was found in New Zealand, did not meet present conditions. "Unlike Australia, USA, or Canada", said Lime and Marble head Tas McKee, "there is no Government buying agency offering guaranteed prices or mine development allowances, and bonus payments. Furthermore, there have been no tax concessions available such as … the Australian provisions which … allow complete remission of income tax for all profits from uranium until 1965". McKee concluded by saying, "it seems fairly certain there will be no investments of private overseas capital in New Zealand uranium until terms as attractive as in Australia are offered".[54]

Lime and Marble, along with the Mines Department, the DSIR and Otago University, were consulted in framing The Atomic Energy Amendment Bill, which was passed in October 1957.[55] The Atomic Energy Amendment Act, modelled largely on the Australian legislation, took away the confiscatory provisions of the 1945 Act, and gave the owner the right to sell uranium ore at current market prices, either to the Minister of Mines or, with the Minister's permission, to other parties. The Act also established a schedule of rewards for discoveries of uranium.[56] In February 1958, the Government approved rewards for three West Coast uranium discoveries. The first payment was of £400 each to Charles Jacobsen and the estate of the late Frederick Cassin, in acknowledgement of the significance of their first find of uranium in the Buller Gorge. At the same time as the Jacobsen and Cassin reward was increased, £200 rewards were given to

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[53] *The Dominion*, 6 June 1957, p12.
[54] Lime and Marble to Goldfields and Mines Committee, 16 July 1957, AATJ 6090, 3/38, part 3, *ANZ.*
[55] *New Zealand Parliamentary Debates* 311 (1957), p678.

Hamilton company director Robert O'Brien for his discovery of uranium at Kawatiri on the upper Buller River, and jointly to James Dowd and Lloyd McAlister (of Uranium Valley) for discovering uranium in Hawks Crag Breccia at the Fox River mouth.[57] In April 1958 Cabinet approved rewards of £200 to Uranium Valley for their June 1957 discovery of uranium at Bullock Creek (in 1961 this reward was increased by £800 to £1000 in recognition of the potential value of the find) along with £1000 to Lime and Marble for their discoveries north of the Buller River and £200 for their finds in the Big River area.[58]

United Kingdom Atomic Energy Authority

In April 1958 the UKAEA, who had heard about New Zealand's uranium finds from Ernest Marsden, advised they would like to send a geologist to New Zealand to meet with representatives of the companies prospecting for uranium in the Buller Gorge.[59] Colin Campbell, the UKAEA chief geologist, visited the West Coast in late 1956 and produced a report that concluded there was a possibility of locating a deposit of commercial grade.[60] In a radio broadcast on 10 December Campbell stated he thought the Buller Gorge area showed promise as a uranium mining field, adding "it will be a splendid chance for the New Zealand metal mining industry to get on its feet and to put this country 'on the map' as a producer of the newest kind of fuel – the raw material for nuclear energy."[61]

To assist in the development and exploration of the area, in February 1957 the UKAEA sent a geologist, K. Beer, to the West Coast.[62] By this time, the Geological Survey had two staff mapping stratigraphy and structure in the Buller Gorge, along with a Wellington-based petrologist working full time on mineralogy.[63] While the prospecting of private companies resulted in confidential reports, the DSIR geologists published the results of their research, adding to the body of knowledge about the local geology and prospecting methods.[64] Under the guidance of West Coast inspector of mines Lloyd Jones, a survey party from the Mines

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[56] Atomic Energy Amendment Act 1957; *New Zealand Parliamentary Debates* 311 (1957) pp678-694; AATJ 6090 3/38, part 3, *ANZ.*
[57] Cabinet approval of February 1958, AATJ 6090, W4993/25, 5/22/2, *ANZ.*
[58] Cabinet approval of 21 April 1958, AATJ 6090, W4993/25, 5/22/2, *ANZ.*
[59] D. M. Cleary to A. D. McIntosh, 12 April 1956, EA1, W2619, 121/2/1, part 1, *ANZ.*
[60] D. M. Cleary to A. D. McIntosh, 12 February 1957, ABHS 950, W4627/3534, 12/2/4, *ANZ.*
[61] Radio broadcast transcript reproduced in E. H. Brooker to Minister of Mines, 25 June 1957, CABH 3391, CH58, 6/27, 1955-62, *ANZ.*
[62] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[63] W. M. Hamilton to Minister in charge of SIR, 15 February 1957, ABHS 950, W4627/3534, 12/2/4, *ANZ.*
[64] See, for example, A. Wodzicki, 'Radioactive Boulders in Hawks Crag Breccia', *New Zealand Journal of Geology and Geophysics (NZJGG)* 2 (1959), pp385-93; A. Wodzicki, 'Geochemical Prospecting for Uranium in the Lower Buller Gorge, New Zealand', *NZJGG* 2 (1959), pp602-12.

Department was surveying all outcrops and preparing accurate plans of the mineralised portions of the breccia to assist Buller Uranium in their search. Even so, the Mines Department later said Beer was the first to sample the deposit on a "systematic basis". Samples he cut were analysed at the Dominion Laboratory but gave very poor results.[65]

J. B. Richardson, a UKAEA mining engineer who came to New Zealand to offer assistance and advice on uranium prospecting, followed Beer. As a result of Richardson's report, the UKAEA agreed to finance sampling operations in the Buller Gorge, provided they would be given first right of refusal over any uranium found in New Zealand.[66] In January 1958 the *Greymouth Evening Star* reported that as a result of the Richardson report, "a new prosperity is expected for the West Coast".[67]

After protracted negotiations between Buller Uranium and the UKAEA, a confidential agreement between the Crown, the UKAEA and Buller Uranium was signed on 11 March 1959.[68] The agreement arranged for the UKAEA to carry out a three-stage investigation of the uranium deposits in that area, with each stage contingent on success in the previous stage. As part of stage one, they set up an office and laboratory in Westport and in January 1959 Bill Hill arrived to be their resident geologist. Unfortunately, however, this lengthy delay, caused by some issues Buller Uranium had with the proposed agreement, meant that by the time the agreement was signed the market for uranium was deteriorating. A Mines report later said that the UKAEA "was persuaded to spend time and manpower on investigating the New Zealand uranium potential at a time when it was already assured of all the supplies it needed for some years ahead, and at a time when some other countries had more substantial claims for their resources to be investigated".[69] The *New Zealand Herald* added that, by this time, "the Authority had lost much of its interest in the deposit but felt that they had committed themselves and were determined to fulfil their contract even if it was only implied".[70] It can be seen as representative of the closeness between the two countries that it was almost seen as a given that New Zealand would offer its uranium supplies first to the United Kingdom – but only if they were not needed domestically. In turn, the United Kingdom felt a responsibility to New Zealand even after they no longer had an immediate need for new uranium sources.

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[65] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[66] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[67] *Greymouth Evening Star*, 29 January 1958, CABH 3391, CH58, 7/134, 1958-1982, part 3, *ANZ CHCH.*
[68] A copy of the agreement is held in AATJ 6090, W4993, 23/2/1220/1, *ANZ.*
[69] *New Zealand Herald*, 7 September 1960, AATJ 6090, W4993, 23/2/1220/1, *ANZ.*
[70] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*

The UKAEA funded the extension of Buller Uranium's access road on the north side of Buller Gorge, at the end of which prospectors set up a camp with bunkhouse, drilling equipment and a rock crusher. The stage one drilling programme ran from September 1959 to March 1960. Ten short adits, or tunnels, were drilled by jackhammer, and once a clean rock face was exposed, a two-ton sample of rock was blasted out of the rock face onto collecting tarpaulins mounted on wooden frames. The rock was put into drums then passed through a rock crusher, and sent to the Geological Survey who broke the sample up for analysis by New Zealand and British scientists.[71] The results were disappointing: as a Mines Department report stated, the results confirmed that "instead of the persistent mineralized horizon that had been assumed, there was only a series of small, thick lenses of mineralized material spaced widely apart and, in general, of low grade".[72] Accordingly, effective 15 August 1960, the UKAEA terminated their agreement.[73]

Fig 6.6: Lime and Marble staff pose outside the adit on the south side of the Buller Gorge, in 1960. Source: Jock Brathwaite, reproduced with permission.

Prospecting, meanwhile, was continuing in other areas. Lime and Marble, with more government funding, set up a new camp and drilled an adit on the south side of Buller Gorge[74] which

[71] W. G. Hill, *Report of an Investigation into the Buller Gorge, New Zealand*, UKAEA Metals Branch, Hill, AATJ 6090, W4993/262, 23/2/1220/1, *ANZ* .
[72] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[73] UKAEA to Minister of Mines, 22 July 1960, AATJ 6090, W4993/262, 23/2/122/1, *ANZ.*
[74] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*

immediately yielded uranium oxide levels higher than those found in the UKAEA programme north of the river.[75]

Uranium glut

By 1960, however, there was a glut of uranium on the world market, and prospects for sale of any New Zealand-sourced uranium oxide were poor. Since New Zealand's search for uranium began in 1954, uranium had gone from relative scarcity to abundance on the global market. At the same time, the predicted rapid climb in the use of nuclear reactors for electricity generation had not eventuated. This, along with some countries' stockpiling of uranium for defence purposes, contributed to a reduction in demand for uranium – to the extent that some overseas mines had closed. Western production of 43,000 tons per annum – coming mainly from the United States and Canada with lesser amounts from South and Central Africa, Australia and France – was exceeding demand, most of which still came from the military. Uranium-producing mines in the West held contracts for delivery of uranium oxide concentrates to the UKAEA and the USAEC under which the prices paid for uranium incorporated amortization of the mines and treatment plants. When the contracts expired in the 1960s, any new producers of uranium oxide would have to compete with producers with fully amortized plant, who were predicted to be able to drop the price of uranium from $8-10 per lb to as low as $4 a lb of uranium oxide (this meant that to make ore grade, any uranium-bearing material would have to be a persistent and consistent deposit containing at least 0.4 per cent uranium oxide). In Australia, exploration for and development of uranium prospects was virtually at a standstill and the Australian Bureau of Mineral Resources advised New Zealand not to consider establishment of a uranium mining and treatment industry until there was evidence of firm contracts at a suitable price.[76] In the previous five years, the New Zealand Government had spent £36,902 on financial assistance to uranium prospectors (with a further £17,775 contributed by the UKAEA) and prospecting results did not warrant further expenditure.[77] In March 1960 the Mines Department recommended that no further government money be spent on uranium prospecting.[78]

[75] Lime and Marble to Minister of Mines, 14 September 1960, AATJ 6090, W4993, 23/2/122/1, *ANZ.*
[76] Mines Department report on Uranium Prospecting, 23 May 1960, AATJ 6090, W4897/102, 5/22, part 3, *ANZ;* Notes on World Uranium Position prepared by Australian Bureau of Mineral Resources (undated) in AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[77] Memo for Cabinet from F. Hackett, Minister of Mines, 23 May 1960, AATJ 6090, W4897/102, 5/22, pt 3, *ANZ.*
[78] Report from P. M. Outhwaite, Under-secretary for Mines, to Minister of Mines, 9 March 1960, and Notes on World Uranium Position prepared by Australian Bureau of Mineral Resources (undated), AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*

West Coasters, along with prospectors such as Tas McKee of Lime & Marble Ltd, were disappointed to the point of scorn with the Government decision. Gordon Williams sided with the angry locals, and was reported as saying that the newly explored south side of the Buller Gorge was "undoubtedly a most exciting prospect by any standard".[79] In a letter to Williams, the Minister of Mines responded by saying, "It seems to me that uranium has in New Zealand become invested with rather mystic attributes and, as you yourself have mentioned, publicity in the press has contributed to this situation. When all is said and done the assessment of a uranium prospect must be based on the same fundamental mining engineering principles as are applied to any other mineral deposit and this seems on occasion to have been lost sight of."[80]

Companies involved in prospecting on the West Coast opposed this. On 23 March 1960 Buller Uranium and Uranium Valley consolidated their opposition to the recent Government decision and took a deputation to the Minister of Mines. The Minister heard their complaint and asked for a written submission.[81] Lime and Marble and Uranium Valley responded by jointly preparing a proposal for a comprehensive exploration and prospecting plan for the Buller/Paparoa uranium province. The plan included expansion of consultant and laboratory services, drilling, radiometric surveys, geological mapping, mineralogical and petrological work and field prospecting and was expected to cost around £250,000. They said that "if the programme suggested is adopted it will be in line with what has been carried through in other Commonwealth countries, where Government actively encourages prospecting."[82] But when Cabinet met on 20 June 1960, on the recommendation of the Minister of Mines, they declined the requests for additional prospecting funds and for the companies' proposal for a uranium prospecting and exploration programme.[83]

Lime and Marble continued to push for an expanded exploration programme and proving of the West Coast uranium deposits. In December 1960 Tas McKee suggested that New Zealand seek a mission from the International Atomic Energy Agency to visit New Zealand in connection with its uranium deposits[84] and in 1963 Lime and Marble's chairman suggested to Clarence Beeby, New Zealand ambassador to France, "that New Zealand approach EURATOM [the European

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[79] *Greymouth Evening Star*, editorial, 18 March 1960, in AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[80] Minister of Mines to Dr Gordon J. Williams, 4 May 1960, in AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[81] Transcript of Deputation to Minister of Mines, 23 May 1960, in AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[82] Proposal for a Regional Exploration and Prospecting Plan for Buller/Paparoa Uranium Province, 6 May 1960, in AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[83] Secretary of the Treasury to Minister of Finance, undated, AATJ 6090, W4897/102, 5/22, part 3, *ANZ.*
[84] J. T. O'Leary to Under-Secretary of Mines, 13 December 1960, in AATJ 6090, 4897/102, 5/22, part 4, *ANZ.*

Atomic Energy Community] with a proposal to carry out a proving programme, in return for which they gain an option to buy the output of a mutually acceptable mining company".[85]

Renewed interest in West Coast uranium

Lime and Marble retained their interest in uranium prospecting. When the New Zealand Electricity Department's 1964 Power Plan flagged a first nuclear power station in the 1970s, Lime and Marble resumed their push to prove the Buller Gorge uranium deposit.[86]

Since the 1955-60 programme of exploration, some New Zealand officials, including those at the Mines Department, had suggested it would be possible for New Zealand to manufacture its own reactor fuel by processing uranium-bearing ores to uranium oxide in New Zealand. This was considered by the Electricity Department to be an attractive proposition, given that the 1966 Power Plan estimated a future nuclear power station spending £5-6 million a year on imported uranium fuel.[87] Furthermore, based on known reserves, a world shortage of uranium was predicted in the 1970s. If new deposits of the present minimum grade were not found then lower grade or less extensive deposits – like those known to exist in the Buller Gorge – might become commercial to work.[88] Globally, there was increasing optimism in the uranium industry and the search for new uranium deposits was intensifying. As forecasts of future nuclear power capacity were revised upwards, so were the predicted requirements for uranium. In 1967, 120,000-170,000 MW of installed nuclear electricity generating capacity was forecast for 1980, meaning that some 500,000 tons of uranium needed to be found by 1981. As the result of projected demand, global exploration was at an all-time high.[89]

The drive to resume investigations of New Zealand's uranium deposits intensified. In February 1966 the New Zealand Atomic Energy Committee recommended to the Minerals Resources Committee that "in view of the increasingly wide knowledge and predictions for the future demands for uranium, a full appraisal of the New Zealand deposits should be given priority".[90] In August 1966 a party of six of Australia's leading nuclear scientists visited New Zealand for a week. The leader of the group, Mr M. C. Timbs, reportedly provoked locals and the media by predicting that world price for uranium could reach US$30 within 10 years, making West Coast

[85] R. C. Bradshaw to C. E. Beeby, 25 July 1963, in AATJ 6090, 4897/102, 5/22, part 4, *ANZ.*
[86] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1964.
[87] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1966, p11.
[88] P. M. Outhwaite to Secretary, AEC, 22 July 1966, AATJ 6090, W4897/102, 5/22, part 4, *ANZ.*
[89] Figures are USAEC projections published in *Chemical and Engineering News*, 13 November 1967; other figures are in *Mining Journal* 10 May 1968, both in AATJ 6090, W4897/102, 5/22, part 5, *ANZ*
[90] J. T. O'Leary to Under-Sec of Mines, 28 July 1966, AATJ 6090, W4897/102, 5/22, part 4, *ANZ.*

deposits economic; saying it might be possible for New Zealand to supply Australia with heavy water made at Wairakei and for Australia to supply New Zealand with uranium; and saying "both Australia and New Zealand were on the threshold of nuclear power and a lot of expertise had to be developed. Exchange visits were made on the highest possible level and these would be stepped up." This made the front page of *The Press* – the fact that someone from overseas was proclaiming New Zealand's prospects for uranium mining was taken a lot more seriously than a New Zealander making the same claim.[91] In October, the New Zealand Geological Survey put forward to the Mineral Resources Committee a four-year proposal (1967-70) to recommence and extend the investigation into New Zealand's uranium deposits.[92]

In mid-1966, Uranium Valley had applied to renew their mineral prospecting warrant over the Bullock Creek-Pororari River area, necessitating the Mines Department to review its policy with regard to uranium prospecting. While previous prospectors had not discovered any economic uranium deposits on the West Coast, more work needed to be done to either conclude that such deposits did not exist or to identify lower grade deposits, or high-grade deposits of smaller extent, that might become economic if uranium prices were to rise. Uranium Valley's application was for the one area where, in the opinion of the Mines Department, more work was needed – the uranium mineralisation was different and not well understood, and more advanced prospecting, including drilling, was required.[93]

The Mines Department, however, knew that Uranium Valley Limited did not have the necessary financial and technical competence to undertake such a programme, so recommended to the Mineral Resources Committee that uranium prospecting officially recommence, with the first stage being financial support for Uranium Valley's investigation of the siltstone beds of the Hawks Crag Breccia exposed in the Pororari River. Other money was made available for additional reconnaissance work, and for more detailed investigations of the South Buller Gorge.[94] It is important to note that financial assistance to mining operations, in the form of loans and grants, was part of standard Mines Department practice, but the total amounts loaned or granted were not great, and the relative support for the uranium prospecting, as compared to other mining operations, was significant.

[91] *The Press*, 18 August 1966, AATJ 6090, W4897/102, 5/22, part 4, *ANZ.*
[92] NZGS Uranium Investigation Proposals, October 1966, AATJ 6090, W4897/102, 5/22, part 4, *ANZ.*
[93] P. M. Outhwaite to Mineral Resources Committee, 3 October 1966, AATJ 6090, W4897/102, 5/22, part 4, *ANZ.*
[94] P. M. Outhwaite to Mineral Resources Committee, 3 October 1966, AATJ 6090, W4897/102, 5/22, part 4, *ANZ.*

The following year, on the invitation of Lime and Marble, which was now a 50 per cent shareholder in Uranium Valley as well as parent company of Buller Uranium,[95] Australian company CRA Exploration purchased an option to look for new uranium locations in the Buller Gorge, Pororari River and the Fox River mouth areas. Between April and September 1967 CRA spent $A37,299 on exploration, including an extensive helicopter scintillometer survey to measure radiation intensity. The survey found no new uranium prospects – rather it confirmed that the main mineralised areas had been located by previous ground surveys. CRA determined that mining these areas would not be economical. [96]

In October 1968, following requests from Lime and Marble, the Ministers of Mines and Finance approved grants of $17,887.20 to drive two adits at Uranium Valley's Paparoa sites (the grant being on the basis of $4 for every $1 spent by the company) and a further $8,340 to drive a 300-foot (about 90 metres) adit on a claim held by Buller Uranium in the Buller Gorge.[97] By now, the health effects of working with radioactive materials were more widely known and the Ministry of Health's National Radiation Laboratory provided radiation monitoring badges for prospectors working in the adits. Drillers were alerted to "the necessity for good personal hygiene both bodily and with respect to clothing" and, to avoid the cancer-risk of inhaling radioactive rock particles with their cigarettes, were told that "hand rolled cigarette smoking" should be "limited to cigarettes rolled before commencement of a shift".[98]

While the tunnelling revealed no immediate possibility of economic mineralisation in the Pororari area, the adits driven in the until-now neglected south Buller area indicated ore-grade material that warranted further investigation. Buller Uranium proposed a south Buller drilling programme at a cost of $65,280.[99] The Mines Department supported the proposal, and on 12 October 1970 Cabinet approved a contingently repayable grant of up to $41,640 for Buller Uranium, at the rate of one government dollar for every dollar the company spent.[100] Because this new subsidy rate (previous grants had been at $4 : $1) left a greater financial burden on the company, they sought outside help and reached an agreement for a joint venture whereby Carpentaria Exploration Co (an Australian company owned by Mt Isa Mines) would fund and

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[95] Lime and Marble to Mines Department, 14 August 1968, in CABH 3391, CH 58, 6/39, 1959-78, *ANZ CHCH.*
[96] CRA's six-monthly report on MPW 14553, 21 February 1968, CABH 3391, CH58, 6/39, 1959-78, *ANZ CHCH;* R. Klaric, *Uranium Exploration of Buller Gorge, Pororari River and Fox River Mouth Areas, New Zealand,* CRA Exploration Co Ltd, Ministry of Economic Development New Zealand, unpublished mineral report MR1250, R, 1967.
[97] Mines Department to Buller Uranium, 14 October 1968, CABH 3391, CH58, 6/39, 1959-78, *ANZ CHCH.*
[98] B. D. P. Williamson, NRL, to Lime and Marble, 31 October 1968, AATJ 6090, W5152/129, 12/46/1051, *ANZ.*
[99] J. C. Braithwaite to Under-secretary for Mines, 23 February 1970, AATJ 6090, W4897/242, 23/2/1220, *ANZ.*
[100] Cabinet Memo CM 70/42/19, 30 September 1970, AATJ 6090, W4897/242, 23/2/1220, *ANZ.*

supervise the drilling in return for an option over mining rights.[101] Drilling started in early 1971 and two shifts of drillers operated a diamond drill 24 hours a day for nearly two months.[102] Stage one of the programme was completed by August 1971, when drill core assays were sent to Australia for analysis.[103] Once again, the results from the drilling were not encouraging and a planned second stage did not proceed.[104]

Growing international interest

Investigations until now had tended to progress when global demand for uranium was high, and come to a standstill when demand was low, or, in the case of international companies, when they had better prospects in other countries. As a result, the West Coast's uranium deposits had still not been proven – no-one knew with any certainty the full geographical extent or concentration of New Zealand's uranium reserves.

One salient fact was that the growth in demand for uranium never seemed to catch up with projections. In 1971, contracts were being signed at US$5 a lb of uranium oxide; almost half the price received in 1968. Demand for uranium depended on growth of the nuclear power industry, which tended to lag behind projected growth because electricity generation by conventional oil- and gas-fired power stations continued to be cheaper than that produced by nuclear power.[105] At the same time, several uranium-producing countries had built up significant uranium stockpiles and it was feared that they would put this on the market at even lower prices.[106]

Looking to the future, however, a predicted shortfall of recoverable uranium in the Western world of one million tonnes by 2000 meant that substantial new uranium deposits needed to be under development by the mid-1980s.[107] West Coasters remained optimistic about their uranium reserves. Aware of the new demand projections, in June 1972 Mr Blanchfield, MP for Westland, asked the Minister of Fuel and Power, "what preparations have been made to utilise the uranium deposit in the Buller Gorge". Mr Gander replied that the Government had no proposals to

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[101] Mines Department to Solicitor General, 1 June 1971, AATJ 6090, W4897/242, 23/2/1220, *ANZ.*
[102] File note in AATJ 6090, W5152/131, 12/46/1156, *ANZ.*
[103] File note in CABH 3391, CH58, 6/28, 1957-1979, *ANZ.*
[104] Buller Uranium to Mines Department, 16 November 1971, AATJ 6090, W4897/242, 23/2/1220, *ANZ.*
[105] *Mining Journal*, 3 December 1971, AATJ 6090, W4897/102, 5/22, part 5, *ANZ.*
[106] *Mining Magazine*, September 1971, AATJ 6090, W4897/102, 5/22, part 5, *ANZ.*
[107] Australian Atomic Energy Commission 22nd Annual Report 1973-74, p10, AATJ 6090, W4897/102 5/22-1, part 1, *ANZ.*

recover uranium from the Buller Gorge, reiterating that the region's uranium concentrations were too low to be considered an economic source of uranium.[108]

Some international companies disagreed. In keeping with the growing global demand for uranium, companies from Italy, the United States and Germany contacted New Zealand officials to express their interest in prospecting for uranium in New Zealand.[109] Closer investigations, however, revealed that the most promising uranium provinces were already held by Lime and Marble and their subsidiaries. In April 1973 the German company Uranerzbergbau-GmbH & Co KG (Uranerz) approached Lime and Marble.[110] Uranerz was a government-financed company searching for uranium supplies for West Germany. In October that year representatives of Lime & Marble and Uranerz met with the New Zealand Government. Following negotiations with Lime and Marble, Uranerz was prepared to prospect areas in the Buller Gorge and Paparoa Ranges.[111]

In their first year in New Zealand, Uranerz planned a $150,000 prospecting programme including aerial surveys and surface exploration. In the drafted joint venture agreement Uranerz would have financial responsibility for the venture and Lime and Marble would be given the option to take up to 40 per cent of the equity capital when the uranium was mined. The plan was to mine the ore and treat it close to the site, exporting the extracted uranium oxides.

In 1974 the Government approved the joint venture, subject to New Zealand equity in any mining operation being set at a minimum of 50 per cent, and the negotiation of suitable terms for export of the uranium concentrate. Negotiations continued throughout 1975, with particular emphasis on the amount of uranium ore that would be available for export. At this time, serious consideration was being given to the need for nuclear power to contribute to New Zealand's growing electricity demand; the discovery of a supply of uranium in New Zealand would impact on the choice of nuclear reactor. Based on current demand projections and the installation of a natural uranium fuelled reactor, the Commissioner of Energy Resources recommended that in the event of a major uranium discovery, a supply of at least 5,000 tonnes should be reserved for local use.[112] In the longer term, the New Zealand Electricity Department estimated that 20,000 tonnes

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[108] *Greymouth Evening Star*, 29 June 1972.
[109] File note in AATJ 6090, W4897/102, 5/22, part 5, *ANZ.*
[110] Lime and Marble to Secretary of Mines, 14 June 1973, AATJ 6090, 3/38, part 3, *ANZ.*
[111] The Mines Department files on dealings with Uranerz are in AATJ 6090, W4897/102 5/22-1, part 1, and AATJ 6090, W4897/103, 5/22-1 parts 2, 3 and 4, *ANZ.*
[112] Commissioner of Energy Resources to Secretary of Mines, 2 May 1974, AATJ 6090, W4897/102 5/22-1, part 1, *ANZ.*

of uranium would be needed to meet the 30-year lifetime needs of thermal reactors planned to come on line before 2000, with the expectation that fast breeder reactors – that produce more fissile material than they consume – would be introduced in 2000.[113]

After further negotiations with Uranerz it was proposed they could export 25 per cent of the first 10,000 tonnes of uranium concentrate produced and 50 per cent thereafter. In March 1977 Uranerz agreed to the export formula provided the New Zealand Government purchase uranium from Uranerz at world market prices. New Zealand Treasury, aware that the price of uranium had been very unstable with recent steep price rises, were concerned that "New Zealand could be faced with a rapidly escalating price which it would have to pay for an indigenous resource – and which would not bear any relationship to costs of production in New Zealand."[114] Concerns were also raised over New Zealand's obligations under the Nuclear Non-Proliferation Treaty.

At the same time, Australia was grappling with the issue of uranium mining. In September 1977 the Australian Council of Trade Unions, led by Bob Hawke, confronted the Australian Liberal-National Coalition Government with a demand for a referendum to decide whether uranium mining should go ahead at the Ranger mine in Kakadu National Park, as the Government was proposing, but the Government rejected their demand outright. The Australian Labor Party was also voicing dissent. In a televised statement on 4 September 1977, Labor Party leader Gough Whitlam attacked the Government's decision, implying that the course Australia was following could add to the risk of nuclear war. He also said that the decision would add to poisonous nuclear wastes for which no safe disposal and storage technology had been devised.[115]

Back in New Zealand, negotiations between the Government and Uranerz continued and agreement on an export formula was finally reached in early 1978. Uranerz began their on-ground investigation programme in March. After five years of negotiating, Uranerz' involvement with the West Coast uranium was short-lived. The results of two months' fieldwork were disappointing and they surrendered their prospecting licence in 1979.

Conclusion

Starting in 1955, and continuing for more than two decades, New Zealand individuals and mining companies prospected for uranium and the New Zealand Government offered them

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[113] P. W. Blakeley to Secretary of Mines, 6 December 1974, AATJ 6090, W4897/102 5/22-1, part 1, *ANZ.*
[114] Treasury report on Cabinet Paper dated 10 June 1977, AATJ 6090, W4897/103, 5/22-1, part 3, *ANZ.*
[115] Australian High Commission to Secretary of Foreign Affairs, 22 September 1977, AATJ 6060, W4897/103, 5/22-1, part 4, *ANZ.*

substantial financial support. The reason the discovery of uranium in New Zealand did not lead to the establishment of a uranium mining industry was economic. Uranium was found in various locations on the West Coast of the South Island but never in quantities that would make its extraction economically worthwhile.

This study has found no opposition to more than two decades of uranium prospecting, which could have led to an industry providing uranium to the UKAEA or to a planned nuclear power plant north of Auckland. As demonstrated in chapter five, the 1950s and 60s saw growing opposition to the testing of nuclear bombs, particularly after the British nuclear testing programme was completed in 1958. This antipathy to bomb testing, however, did not extend to efforts to establish an industry mining uranium, which as well as being fuel for nuclear energy generation was used in nuclear weapons.

Uranerz's investigations in the late 1970s turned out to be the last focused investigation for uranium in New Zealand. After 25 years and hundreds of thousands of dollars spent looking for and attempting to prove the West Coast's uranium resources, no economic deposits were ever found. At the time that Uranerz abandoned their search for uranium, the mineral was no longer considered important for New Zealand – a substantial natural gas field had been discovered in offshore Taranaki, and nuclear power stations had been deleted from the New Zealand Power plan in favour of gas turbines. It would not be until after the introduction of New Zealand's nuclear free legislation that mining radioactive minerals would be seen in a sinister light.

Chapter 7

There's strontium-90 in my milk:

Safety and public exposure to radiation

"The early pioneers learned by bitter experience that they were using potentially lethal agents, and many of them paid with their lives for the knowledge they had gained in exploring this new field. But their death was not in vain and their suffering helped to guide those who came after them."

George Roth, director, Dominion X-Ray and Radium Laboratory, 1952[1]

"While my mother tried on several pairs of shoes herself I would be 'playing' with my feet in the X-ray machine. I had such fun; I can still see those little metatarsi going in, out, in again. I didn't ever want to leave the shop. To see parts of your own skeleton was a major childhood event and it was a sad day for children's psyches when such a fun thing had to stop."

Ruth Brassington, 2005[2]

While attitudes to the possibility of a uranium mining industry and nuclear power generation in New Zealand were positive, there was, at the same time, a growing awareness of radiation hazards. Most public concern was focused on hazards from radioactive fallout from the nuclear weapons being exploded in the Pacific but, as awareness about the genetic effects of radiation grew, this concern extended to other exposures to radioactivity. Hermann Muller had in 1946 won a Nobel Prize for his discovery that X-rays could cause genetic mutations.[3] By the late 1950s it was acknowledged that there was no safe threshold below which radiation did not threaten genetic damage, and some fission products – including strontium-90, strontium-89, caesium-137 and iodine-131 – could cause an increase in a population's rates of bone cancer, leukaemia, throat cancer and other cancers. The realisation that any radiation exposure was hazardous focused attention on unnecessary X-rays, and nuclear accidents, like the 1957 Windscale disaster, in which a nuclear reactor caught fire in one of Britain's two plutonium production reactors, raised concerns about the safety of nuclear power generation.[4]

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[1] George Roth, *Radiation Hazards: A Survey*, Department of Health, Wellington, 1952, p1; H1, 26717, 108/11, 1951-57, *ANZ.*

[2] Recollection from Ruth Brassington, 2005. Written for the author.

[3] Alexander Hellemans and Bryan Bunch, *The Timetables of Science: A Chronology of the Most Important People and Events in the History of Science*, Simon and Schuster, New York, 1988, p500.

[4] Tony Hall, *Nuclear Politics: The History of Nuclear Power in Britain*, Penguin, Harmondsworth, 1986, pp59-64; Richard G. Hewlett and Jack M. Holl, *Atoms for Peace and War, 1953–1961*, University of California Press,

Radiation protection legislation

The Health Department took the initial lead in warning New Zealanders about the risks from exposure to radiation. From the 1920s, the Department of Health had been drawing the attention of New Zealand's hospitals and medical practitioners to international X-ray and radium protection recommendations. In 1947 the DSIR's Tracer Elements Committee, which was set up to deal with health and safety issues arising from the use of cyclotron-produced radioactive isotopes being imported from the United States, circulated a document called "Procedures for Supply and use of Radioisotopes in New Zealand", along with copies of a USAEC circular on "Health Protection in Handling Radioisotopes".[5] The American guidelines required: workers to wear film badges; the monitoring of the blood count of workers; weekly laboratory checks for radiation contamination; the safe storage of radioactive material; and safe waste disposal. In 1948 the committee circulated copies of a British manual on "Control of Health Hazards from Radioactive Materials".[6]

It was not until the 1940s that New Zealand had its own legislation concerning radiation protection. As covered in chapter 3, the Electrical Wiring (X-Ray) Regulations, which were introduced in 1944, required the registration of all X-ray plants and set out technical requirements for the safety of X-ray equipment. The Radioactive Substances Act 1949**,** which was drawn up after collaboration between the Dominion X-ray and Radium Laboratory and the College of Radiologists, required a licence from the Minister of Health to use, own or sell radioactive substances or irradiating apparatus. The Act also set up a Radiological Advisory Council to provide the Government with specialist advice on all matters concerning radiation and to licence people controlling radioactive substances and radiation-emitting apparatus for medical, scientific or industrial purposes. The Council consisted of three radiologists, a senior member of the DSIR, a nominee of the University of New Zealand, a health physicist and the Deputy Director-General of Health, Harold Turbott, as chairman.[7]

The Radiological Advisory Council, which had its first meeting in April 1950, recommended that the Minister of Health issue Regulations under the Act. The Radiation Protection

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Berkeley, 1989, pp340-341; Lorna Arnold, *Britain and the H-bomb,* Palgrave Macmillan, Houndmills, 2001, pp112-4.

[5] Tracer Element Committee Procedure for Supply and Use of Radioisotopes in New Zealand, 14 November 1947, SIR1, 74/13, volume 1, *ANZ*; DSIR Health Protection in Handling Radioisotopes, SIR1, 74/13/1, *ANZ.*

[6] Control of Health Hazards from Radioactive Materials, SIR1, 74/13, volume 2, *ANZ.*

[7] Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, HI, 26758, 108/11, 1957-58, *ANZ*; C. C. Anderson, 'The Development of Radiology in New Zealand', *Australasian Radiology* 10

Regulations 1951 were not prescriptive and included no code of practice, but said that no person shall be subjected to a maximum permissible exposure (except in the case of a patient being exposed for medical reasons) and that the licence holder is responsible before the law for any breach of the Regulations.[8] So while the Regulations advised practitioners on what not to do, how they arranged to meet with these requirements was up to them. In 1951 the Department of Health issued the detailed Recommendations for Protection from Radiation Hazards which was distributed to hospitals around New Zealand. The publication described X-rays as “potentially lethal agents” that “should be treated accordingly” and gave recommendations on how to set up rooms containing irradiating apparatus, and how to protect medical staff from X-rays and radioactive substances.[9]

The Radiological Advisory Council was proactive in promoting safety and in 1952 issued a survey of radiation hazards in New Zealand. The publication, written by George Roth, director of the Dominion X-Ray and Radium Laboratory, informed practitioners about the type of hazards associated with working with radiation. Roth pointed out that although there were 650 X-ray plants in use in New Zealand, there were only 45 qualified radiologists or radiotherapists, meaning that most X-ray plants were operated by people “who cannot be expected to have expert knowledge of the potential dangers of X-ray work and of the methods which make it safe to use ionising radiations”. While acknowledging that most radiation workers were conscious of the need for protection, he said there were still some radiation workers who “either believe that they are personally immune from the injurious effects of excessive exposure to ionizing radiation or even profess to deride the idea of danger altogether”.[10] Roth wrote of two general practitioners and one radiologist who died as the result of radiation injuries as well as about a dozen cases of “self-inflicted radiation injuries of various degrees of severity” in X-ray workers, including radiologists, radiographers, medical practitioners, the matron of a small hospital, a chiropractor, a dentist and a university student.[11]

(1966), p306; Radioactive Substances Act 1949, *New Zealand Statutes Reprint 1908-57, volume 13*, Government Printer, Wellington, pp97-112.

[8] Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, H1, 26758, 108/11 1957-58, *ANZ.*

[9] Department of Health, Recommendations for Protection from Radiation Hazards, August 1951, H1, 108/11, 1951-57, *ANZ.*

[10] G. E. Roth, *Radiation Hazards: A Survey*, Department of Health, Wellington, 1952, H1, 26717, 108/11, 1951-57, *ANZ.*

[11] G. E. Roth, ‘The Problem of Radiation Safety’, *The New Zealand Radiographer* 1, 4 (1949), pp3-14 *;* G. E. Roth, *Radiation Hazards: A Survey*, Department of Health, Wellington , 1952, H1, 108/4, 1951-1957, *ANZ.*

Dominion X-Ray and Radium Laboratory

The Department of Health had taken on greater responsibility for radiation protection in 1951, when it took over most functions of the Dominion X-Ray and Radium Laboratory from the British Empire Cancer Campaign. The Department of Health put more resources into the laboratory and between 1950 and 1953 its staff increased from seven to 22, under the directorship of George Roth. Jim McCahon, one of the physicists involved in the 1945-46 uranium surveys, was appointed physicist in charge of the radioactive substances section. Following his work making and operating Geiger counters for the DSIR's uranium survey, McCahon had gained an MSc in physics from Otago University. He had then been seconded to the Atomic Energy Research Establishment in Harwell, England for two years, where he had gained experience in radiation instrumentation and the measurement of radioactive materials.[12]

The Dominion X-Ray and Radium Laboratory worked closely with radiation workers in hospitals and private practice, taking the approach that radiation safety "cannot come about by laws and regulations alone: it can only be achieved through the intelligent co-operation of the radiation workers themselves, who have realized the nature of the hazard, and the importance of taking adequate precautions".[13] The Laboratory's specific roles included monitoring and controlling the importation of all radioactive substances for all users in New Zealand. It also carried out the routine processing of about 20,000 radiation test films annually. The Laboratory's diagnostic section looked after radiation protection at the country's X-ray plants, with staff visiting each installation at least once every three years to measure the level of scattered radiation, check protective barriers, make output measurements and make recommendations for improvement in practice and technology. The radioactive substances section inspected the premises of anyone wanting a licence to import and use radioactive material, was responsible for the safe use of radioactive substances in clinical, industrial and research work in New Zealand, and supplied all the radon used in New Zealand from its radon extraction plant. As described in Andrew McEwan's history of the Laboratory, the remote-controlled radon plant allowed for the radon gases emanating from a radium solution to be trapped and compressed into tiny gold tubes. During the 1950s, the Laboratory fulfilled 60 to 90 orders per year for radon supplied for medical use in needles, seeds, phials of ointment and special applicators. The demand for radon declined through the late 1950s and 60s, and the radon plant was closed in 1967, by which time

[12] A. C. McEwan, *Radiation Protection and Dosimetry in New Zealand: A History of the National Radiation Laboratory,* New Zealand Department of Health, Wellington, 1983, p53.
[13] G. E. Roth, *Radiation Hazards: A Survey*, Department of Health, Wellington, 1952, p3, H1, 26717, 108/11, 1951-57, *ANZ.*

supplies of radioactive gold-198 seeds were available from Lucas Heights in Australia. The therapy section made regular visits to the country's X-ray therapy installations to calibrate equipment and advise on problems in radiophysics.[14]

X-rays and medical

Despite growing public concern about exposure to radioactive fallout from bomb tests, the New Zealand population's greatest exposure to artificial radiation came from X-rays. As the potential dangers of radiation exposure came to light, the use of X-rays came under closer scrutiny, particularly the non-medical use of X-rays, for example, in shoe shops.

Table 7.1: Number of registered X-ray plants in New Zealand on 31 March 1957.

Purpose for which X-ray plants are used:	Ownership		Total
	Public	Private	
Radiographic or fluoroscopic	219	95	**314**
Therapeutic	25	28	**53**
Dental	52	486	**538**
Chiropractic and naturopathic (diagnostic)	-	51	**51**
Shoe fitting	-	78	**78**
Veterinary	4	19	**23**
Industrial	6	1	**7**
Miscellaneous purposes (educational, research, testing, demonstrations, etc.)	20	-	**20**
TOTAL	**326**	**758**	**1084**

Source: Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, H1, 26758, 108/11, 1957-58, *ANZ* .

By 1957 New Zealand had 60 radiologists, 1,084 X-ray plants, 1,089 persons licensed to use X-ray plants for specified purposes, and 311 people licensed to use radioactive substances in specified amounts.[15] Turbott boasted that New Zealand's radiation protection legislation was "the most effective within the Commonwealth, if not the world". He was right in saying that

[14] Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, HI, 26758, 108/11, 1957-58, *ANZ;* McEwan 1983, pp58-9, 77.
[15] Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, HI, 26758, 108/11, 1957-58, *ANZ.*

New Zealand was a world leader – in 1958 only Sweden and New Zealand had a full record of diagnostic X-ray installations.[16]

While safety concerns about X-rays had so far been focused on radiation workers, there was growing awareness of the potential risk to those receiving the X-rays. The total radiation dose received from a diagnostic X-ray had dropped dramatically since X-rays were first used, but there were still X-rays being taken which had dubious benefit. In the middle of the twentieth century, tuberculosis was still one of the diseases most likely to kill New Zealanders (after heart disease, stroke and pneumonia) and an X-ray screening programme was introduced in an effort to curb the epidemic.[17] The screening programme used mass miniature radiography (MMR), a cheap form of X-ray photography in which up to one hundred 1-inch chest X-ray pictures could be taken every hour. MMR was introduced to New Zealand in 1941, when 2,204 Wellington factory workers and secondary school students were screened, and an active tuberculosis rate of 0.6 percent was discovered. The first mobile X-ray unit was introduced in 1947 and by 1957 there were nine miniature X-ray units travelling around New Zealand by caravan, taking an annual total of 242,332 miniature X-ray pictures, and identifying 383 new cases of tuberculosis.[18] That same year, the question of mass chest X-rays as a method of finding new tuberculosis cases was reviewed by the College of Radiologists. The review committee stated, "[i]n the case of routine X-ray examinations of the chest, the small dose involved is justified provided that a significant number of new cases is being discovered".[19]

In the United States, however, the Public Health Service recommended in November 1957 that the mass X-ray method of finding tuberculosis cases be discontinued. In Australia, the National Radiation Advisory Committee recommended in July 1958 that there be an immediate reduction in the amount of radiation being spread by the medical use of X-rays, including a review of the need for mass chest X-ray surveys.[20] In New Zealand, however, MMR continued into the 1970s. In 1969, the Department of Health advised medical officers of health that MMR programmes be concentrated on "high risk" groups – identified as including Pacific Islanders, Maori, freezing workers and psychiatric patients – with every town with a population of 100,000 or more being

[16] H. B. Turbott to Minister of Health, 16 May 1957, H1, 26717, 108/11, 1951-57, *ANZ.*
[17] Department of Health Annual Report, *Appendix to the Journal of the House of Representatives*, 1951, volume 3, H-31, p22.
[18] F. S. Maclean, *Challenge for Health: A History of Public Health in New Zealand*, Government Printer, Wellington, 1964, p374-5; Lynda Bryder, 'Tuberculosis in New Zealand'. In A. J. Proust (ed), *History of Tuberculosis in Australia, New Zealand and Papua New Guinea*, Brolga Press, Canberra, 1991, p86.
[19] From file record of conversation between G. E. Roth and *New Zealand Herald*, 22 April 1958, H1, 26758, 108/11, 1957-58, *ANZ.*
[20] File notes in HI, 26758, 108/11, 1957-58, *ANZ.*

visited at least every six months.[21] A 1972 issue of *Health*, the magazine of the Department of Health, cheerfully advised that "all persons over the age of 15 years have an annual X-ray". By this time, the 370,370 people X-rayed over the previous year had resulted in 102 active cases of the disease being found.[22]

Genetic studies, by now, had revealed the particular vulnerability of the developing cells of children and foetuses to radiation damage, but the risks of radiation were still not fully understood or quantified. One use of medical X-rays that was becoming controversial was X-rays of pregnant women, which though sometimes used in New Zealand were never standard practice. In 1957 Australian newspapers reported that the Australian Atomic Energy Commission had advised the Federal Government that "the exposure of pregnant women to X-rays may incline the child in later life to the disease of leukaemia".[23] In June 1957 it was reported that a decision of the Board of the Sydney Women's Hospital meant that expectant mothers were no longer receiving routine X-rays.[24] In New Zealand, while foetal X-rays were never routine, it was considered safe well into the 1970s for pregnant women to have general X-rays. In 1971 the Department of Health responded to queries from MMR staff about X-raying pregnant women by saying "there is no risk to the unborn child at any stage in pregnancy during the taking of an X-ray on a MMR Unit. The only radiation involved would be scattered radiation and it is doubtful whether this would even reach the uterus."[25] Children had, however, long been recognised as being vulnerable, with the Department of Health in 1958 recommending against the routine mass X-raying of children. The main stated concern about children being X-rayed was radiation received to the gonad area.[26] It is curious, therefore, that in 1958 it was recognised that an MMR chest X-ray could affect the gonads of a child but in 1971 it was not acknowledged that an MMR X-ray of a pregnant woman's chest could affect the foetus. Another major childhood source of radiation exposure was from dental X-rays, and in 1957 the Radiological Advisory Council met with representatives of the Dental Association of New Zealand, to take steps to ensure that "radiation received by school children dental X-rays was reduced to a minimum". There was public concern on the issue, but in July 1957 newspapers responded to the

[21] Department of Health memo 1969/189, issued by B. W. Christmas, 26 August 1969, CABI, CH91, 13/704, 1953-71, *ANZ CHCH.*
[22] *Health* 24, 3 (1972), p16.
[23] From a newspaper report in a Sydney newspaper in H1, 26717, 108/11, 1951-57, *ANZ.*
[24] *The Press*, Monday 3 June, 1957, p7.
[25] Department of Health memo 1971/147, issued by Dr. M. C. Laing, 12 July 1971, CABI, CH91, 13/704, 1953-71, *ANZ CHCH.*
[26] Department of Health memo 1958/132, issued by G. O. L. Dempster, 11 June 1958, CABI, CH91, 13/704, 1953-71, *ANZ CHCH.*

Council's move by reporting that parents "need have no fear of allowing their children to undergo dental X-rays".[27]

A major non-medical use of X-rays took place in shoe shops. In the 1940s and 50s X-ray fluoroscopy devices called pedascopes were the norm in many Western shoe shops, allowing the customer to look at the bones of their feet inside a given shoe, to see how well it fitted. There was no medical benefit from the use of pedascopes, and children used them to play with as well as for having their shoes fitted. Ruth Brassington, born in 1943, recalls using a pedascope in Christchurch:

> It was towards the end of the 1940s when I first recall placing my feet in an X-ray machine in a shoe shop. That was what we did when we tried on new shoes (all real leather, made in England), to see if there was room left in front of our toes for growth. Not only did my mother and the shop assistant look down the viewing tube to check my feet; the tube height was adjustable so children could get it low enough to look down themselves. While my mother tried on several pairs of shoes herself I would be "playing" with my feet in the X-ray machine. I had such fun; I can still see those little metatarsi going in, out, in again. I didn't ever want to leave the shop. To see parts of your own skeleton was a major childhood event and it was a sad day for children's psyches when such a fun thing had to stop.[28]

By the time of Roth's 1952 survey of radiation hazards in New Zealand it was well known that "excessive exposure to radiation may affect the growth of bones and thus interfere with the normal foot development of children who are fluoroscoped repeatedly when being fitted with new shoes".[29] In 1952 the Radiological Advisory Council approved a warning notice to all owners of shoefitting X-ray plants, advising them of the hazards associated with these machines.[30] In a 1954 interview about radiation hazards with the *New Zealand Listener*, the American Nobel Prize-winning chemist and nuclear critic, Linus Pauling, called shoe-fitting X-ray plants "really terrible, a crime".[31] Nonetheless, their use continued – a 1957 survey counted 78 shoe-fitting X-ray machines in New Zealand.[32] Controls were introduced, however, and in February 1957 Roth reported that "[a]ll shoefitting plants have been reduced in their output to less than about 15 r/min at the level of the foot. They have been equipped with time switches which limit the exposure to about 7 seconds and make it impossible to give a further exposure during the next 35-40 seconds; overlapping lead-rubber aprons have been fitted over the aperture into which the customer puts his foot, and warning notices have been affixed to the shoefitting

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[27] *The Dominion*, 13 July 1957, *The Evening Post*, 11 July 1957, H1, 26717, 108/11, 1951-57, *ANZ.*
[28] Recollection from Ruth Brassington, 2005. Written for the author.
[29] G. E. Roth, *Radiation Hazards: A Survey*, Department of Health, 1952, H1, 108/4, 1951-57, *ANZ.*
[30] T. A. Ward to Director-General of Health, 17 September 1952, H1, 26717, 108/11, 1951-57, *ANZ.*
[31] Linus Pauling, 'Atomic Power and Radiation Hazards', *New Zealand Listener*, 18 December 1959, pp6-7.

X-ray plants, prohibiting their use by children".[33] Through the rest of the 1950s and into the 1960s, shoe-fitting X-ray machines were kept under regular surveillance and by 1964 there were only 16 machines still in use. The last machines were removed from shoe shops in 1969.[34]

The Department of Health kept up to date with international practice with regard to radiation protection and updated legislation and regulations as appropriate. The Radiation Protection Act of 1965 was followed by the Radiation Protection Regulations 1973 and the Transport of Radioactive Materials Regulations 1973.[35]

Monitoring radioactive fallout

Although the contribution of radioactive fallout to an individual's annual radiation dose was low in comparison to radiation from X-rays, it was an emotive issue, as fallout was associated with bomb testing, and it was a new phenomenon about which little was known. Concern about fallout was widespread and not limited to the emerging peace movement. While many of the fission products deposited in New Zealand and around the world had short half-lives and soon decayed to harmless non-radioactive isotopes, longer-lived radionuclides, such as isotopes of caesium and strontium, were also produced in high yields in the explosions.[36]

Concerns about radiation risks led to industrial action. In 1956 waterside workers in Wellington declined to unload a Japanese vessel until it had been tested for radiation. (The test results were normal.)[37] In 1957 the Otahuhu Branch of the Amalgamated Society of Railway Servants passed a resolution asking that all fish landed from commercial craft be tested for radioactivity.[38] In 1961 the Auckland Combined Waterfront Union passed a resolution requesting the Department of Health ensure that suitable equipment be provided in Auckland to conduct immediate tests on any radioactive material coming into the Port of Auckland, and that a competent person be available to conduct tests.[39] There was some official information to counter these fears of

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[32] Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, HI, 26758, 108/11 1957-58, *ANZ.*
[33] Report to UN Scientific Committee on the Effects of Atomic Radiation, 17 February 1958, HI, 26758, 108/11 1957-58, *ANZ.*
[34] McEwan 1983, p84.
[35] McEwan 1983, p96; Radiation Protection Act 1965, *Bound Reprinted Statutes, volume 10*, Thomson and Brookers, Wellington, 2005, pp961-988; Radiation Protection Regulations 1973 and Transport of Radioactive Materials Regulations 1973, *Statutory Regulations 1973*, volume 1, Government Printer, Wellington, 1974, pp234-261; 292-328.
[36] Murray Matthews, *Radioactive Fallout in the South Pacific: A History. Part 1: Deposition in New Zealand,* National Radiation Laboratory, Christchurch, 1989, p1.
[37] Editorial, 'The Deadly Dust', *New Zealand Listener,* 29 June 1956, p4.
[38] File note in H1, 26717, 108/11, 1951-57, *ANZ.*
[39] B. W. Christmas to Director-General of Health, 22 August 1961, H1, 27361, 108/11, 1958-61, *ANZ.*

radioactivity. An article in *The Press* pointed out, for example, that the British population was receiving much more radiation from the medical use of X-rays than from the atomic energy programme or fallout from bomb tests.[40]

Table 7.2: Important fallout radioisotopes and their half-lives.

Radioisotope	Half life	Emitter
Strontium-90 (^{90}Sr)	28 years	B
Strontium-89 (^{89}Sr)	52 days	B
Caesium-137 (^{137}Cs)	30 years	gamma
Iodine-131 (^{131}I)	8 days	B and gamma
Barium-140 (^{140}Ba)	12.8 days	gamma

Initial fallout measurements in New Zealand were led by scientific curiosity, but as concerns grew about the impact of radioactive fallout products on humanity, more widespread and systematic surveys emerged. In February 1955 the USAEC released a report on radioactive fallout hazards, identifying the main radioactive hazard as strontium-90, but noting that there was no cause for concern from existing fallout levels. The British Himsworth Report, submitted in May 1956, highlighted the hazards to human beings of ionizing radiation from *all* sources – natural, medical, industrial and military – but also carried a warning about strontium-90, alerting that it could reach harmful levels if nuclear bomb tests continued. Many of the fallout monitoring projects of the 1950s therefore focused on measuring levels of the fallout product strontium-90.[41]

The General Assembly of the United Nations had, in 1955, established a Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) to examine the effects of radiation on human beings and their environment. The initial intention of setting up the Committee was to deflect a proposal calling for the end to all nuclear explosions, but the Committee endured, and presented several influential reports compiling radiation information from contributing countries.[42]

New Zealand was involved in several international programmes to monitor radioactive fallout, some of them in cooperation with the countries responsible for the bomb testing. From 1953 to

[40] C. H. Waddington, 'Atomic Power and its Hazards', *The Press,* 1 June 1957.
[41] Arnold 2001, pp112-22.
[42] External Affairs briefing paper on Peaceful Uses of Atomic Energy for the 1957 Prime Ministers' Conference, 14 June 1957, EA1, W2619, 121/2/1, part 1, *ANZ;* UNSCEAR official website at www.unscear.org/unscear/en/about_us/history.html downloaded 15 December 2009

1966, as part of a project cooperating with the USAEC, the United States Department of Agriculture measured strontium-90 levels in soils from several New Zealand locations, providing a record of fallout levels in New Zealand. Staff from the DSIR Soil Bureau took the soil samples and forwarded them to the United States for analysis.[43] This monitoring was part of the wider USAEC Project Gabriel, a secret survey to evaluate the radioactive hazards from the fallout of debris from nuclear weapons detonated in warfare. The survey, which began in 1953, looked at the distribution of strontium-90 by monitoring soil, air and water at about 150 American and international stations.[44]

As part of a worldwide monitoring programme, the Environmental Measurements Laboratory of the United States Department of Energy began monthly measurements of strontium-90 in rainwater at Wellington in 1959. The USAEC also contracted the Institute of Nuclear Sciences to measure concentrations of various fission products – including strontium-90, caesium-137 and barium-140 – in Wellington rainwater. This monitoring took place from 1959 to 1970. The Institute of Nuclear Sciences continued its own measurements until 1984, by which time levels of these radionuclides had become undetectable. As part of its worldwide fallout monitoring programme, the United Kingdom Atomic Energy Authority monitored strontium-90 in Ohakea rainwater from 1955 to 1965, with caesium-137 monitored after that.[45]

Other monitoring programmes were locally initiated. As part of the International Geophysical Year programme in 1957, the DSIR set up a number of stations in and about New Zealand to collect rainwater and determine its radioactivity. Monthly rainwater collections were sent to the Dominion Physical Laboratory for evaporation, processing and counting.[46] At the end of 1958, the Dominion X-Ray and Radium Laboratory took responsibility for the DSIR network of eight monitoring stations, in New Zealand (Auckland, Wellington, Havelock North, Greymouth, Christchurch and Invercargill), Fiji and Campbell Island, which they used to continue measuring levels of strontium isotopes and total beta activity. In 1962 sites were added at Kaitaia, New Plymouth and Dunedin. Monitoring by the National Radiation Laboratory (the name of the Dominion X-ray and Radium Laboratory from 1963) continued until 1985, by which time

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[43] Matthews 1989, p2; Minister of External Affairs to Acting High Commissioner for New Zealand in London, 4 March 1960, H1, 27361, 108/11, 1958-61, *ANZ.*
[44] USAEC, Report on Project Gabriel, July 1954, downloaded from www.hss.energy.gov/HealthSafety/IHS/marshall/collection/data/1hp1b/5674_.pdf on 15 December 2009.
[45] Matthews 1989, pp2-3.
[46] Roth to Deputy Director-General of Health, 31 July 1957, H1, 26717, 108/11, 1951-57, *ANZ.*

detectable levels were very low, and monitoring was reduced to the stations at Kaitaia, Hokitika and Rarotonga.[47]

Willard Libby, the American scientist who pioneered radiocarbon dating, wrote to Athol Rafter, Director of the DSIR Division of Nuclear Sciences, in July 1957. In his role with the USAEC, Libby asked Rafter if he would collect samples associated with Project Sunshine, a secret study of worldwide radioactive fallout patterns that involved the analysis of radionuclides in samples of soil, plants and animals, and, in some cases (though not, as far as I have discovered, in New Zealand) human bones and teeth.[48] The USAEC contract with the Institute of Nuclear Sciences stated that the aim of the project was "to study the nature of the precipitation mechanism and the variation of local rates of precipitation with seasons," with results to be given to Libby in order "to help settle questions of global atmospheric circulation".[49] The contract was actually concerned with the transport of radioactive debris about the globe. The Division of Nuclear Sciences was already monitoring several radionuclides and Libby's request involved little extra effort on the part of the Division. The USAEC accepted the Division of Nuclear Sciences' request for support, supplying capital items to the value of US$12,880. The programme involved collecting rainwater at Gracefield, near Wellington, and after each rain determining the concentration of strontium-90, caesium-137 and barium-140. One of these radionuclides, barium-140, has a half-life of only 13 days, and detection was designed to try to show the speed of fallout from recent bomb tests. The contract expired in 1962.[50]

The International Atomic Energy Agency (IAEA) also funded some fallout monitoring carried out by the Institute of Nuclear Sciences. In 1962, The Institute of Nuclear Sciences applied for funding for a project to investigate the distribution of the radionuclides strontium-90, caesium-137, cerium-144, zirconium-95, promethium-147 and antimony-125 in a series of ocean water profiles and surface water stations in the South Pacific. A further aim of the research was to measure the assimilation of some radionuclides by marine organisms.[51] The IAEA funding paid for equipment to the value of US$9,780 and supplies of US$2,660, which were used to measure radioactive elements in the water of the South Pacific, to allow distribution patterns of fallout from nuclear tests to be studied and correlated with measurements already being made of other radioactive elements, such as carbon-14 and tritium. Although not part of the research contract,

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[47] Matthews 1989, p3.
[48] UNSCEAR official website at www.unscear.org/unscear/en/about_us/history.html downloaded 15 December 2009; W. A. Joiner to Minister in charge of SIR, 30 June 1958, SIR1, W1414, 74/27/6, *ANZ.*
[49] Annual Report: AEC Contract AT(30-1)-2167, 13 May 1959, SIR1, W1414, 74/27/6, *ANZ.*
[50] Contract AT(30-1)-2167, SIR1, W1414, 74/27/6, *ANZ*; *The Dominion*, 10 October 1961.
[51] IAEA contract 164/RB, SIR1, 74/38, *ANZ.*

the DSIR noted that the equipment would also allow the Institute to study the build-up of radioactive substances, particularly strontium-90, in the teeth of young children. By this time, the Dental Research Institute had an extensive collection of teeth of children living in known areas of known soil types. In 1963, William Hamilton, head of the DSIR, advised the Minister of DSIR that it was proposed "to cooperate with the Dental Research Institute and Soil Bureau, in an update study of this important and dangerous fission product".[52] The Institute of Nuclear Sciences contract was renewed on 8 April 1964 for another $2,600 for supplies.

Some fears of fallout were vague and generalised, but the way strontium got into the food chain and could find its way into human bones was a source of more concrete fears about human health, particularly in children. New Zealand had long prided itself on producing enough milk, meat and agricultural produce to feed itself and export to Mother England. Milk from the country's dairy herd was promoted as an essential foodstuff for infants and daily milk had been provided free to kindergarten and primary schoolchildren since 1937. In the 1950s, however, it was revealed that New Zealand's milk, credited with building "better babies and strong bodies, bones and teeth in growing children"[53] was also providing New Zealand children with daily doses of radioactive strontium-90 and caesium-137. These new radioisotopes – they did not exist on earth before the hydrogen bomb tests that started in 1952 – were mistaken by the human body for calcium and stored in bones alongside calcium.

The Dominion X-Ray and Radium Laboratory/National Radiation Laboratory monitored strontium-90 and caesium-137 – and occasionally strontium-89 and iodine-131 – in milk samples from nine New Zealand regions from 1961 onwards. Results showed that concentration of strontium-90 and caesium-137 in cows' milk peaked in 1965, with the highest levels recorded in any one month being from Westland and Taranaki in 1965. During the peak fallout period of 1963-66, levels of strontium-90 and caesium-137 in New Zealand averaged about 40 per cent of northern hemisphere levels, but in later years, after 1966, levels of caesium-137 were similar to those in the northern hemisphere, meaning that in New Zealand, caesium-137 rather than strontium-90, was the fission product responsible for giving humans the biggest radiation dose.[54]

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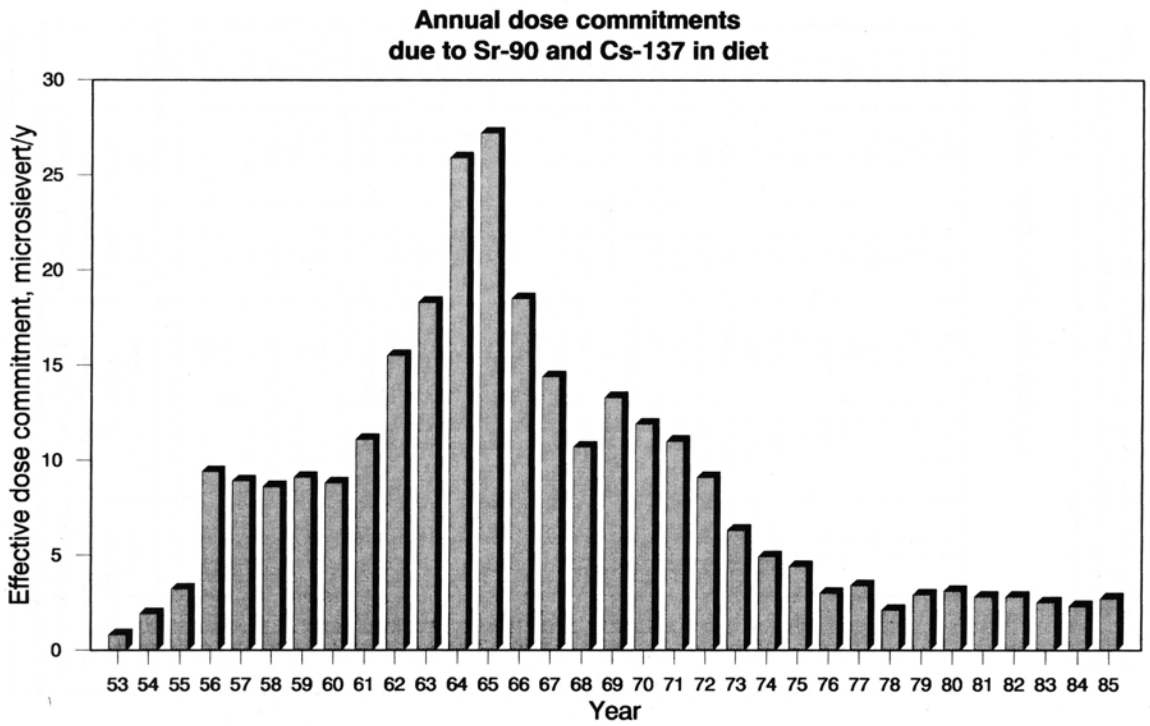
[52] W. M. Hamilton to Minister of SIR, 24 January 1963, SIR1, 74/38, *ANZ.*

[53] Philippa Mein Smith, 'New Zealand Milk for "Building Britons"', in Mary P. Sutphen (eds) and Bridie Andrews, *Medicine and Colonial Identity,* Rutledge, London and New York, 2003, pp79-102.

[54] Department of Health notes on fallout in New Zealand, 12 October 1960, H1, 27361, 108/11, 1958-61, *ANZ;* Matthews 1989, p3; Murray Matthews, *Radioactive Fallout in the South Pacific: A History. Part 3: Strontium-90 and Caesium-137 Deposition in New Zealand and Resulting Contamination of Milk,* National Radiation Laboratory, Christchurch, 1993, pp110-3.



Fig

Figure 7.1: This graph shows the annual dose New Zealanders received from dietary strontium-90 and caesium-137 from 1953 to 1985. The peak levels of strontium and caesium uptake in 1964 and 1965 coincided with the deposition of fallout from the Phase 2 weapons tests by the United States and the Soviet Union. Source: Murray Matthews, *Radioactive Fallout in the South Pacific: A History. Part 3: Strontium-90 and Caesium-137 Deposition in New Zealand and Resulting Contamination of Milk,* National Radiation Laboratory, Christchurch, 1993, p106.

Public awareness of the dangers of strontium-90 increased after November 1959 when Australia's ABC News reported that the New Zealand soil survey had revealed a startling increase in strontium-90 between 1953 and 1958.[55] The next month, the *New Zealand Public Service Journal* outlined how strontium-90 arrived in the soil from fallout from bomb tests, travelled from the soil to pasture grass, from the grass to cows' milk, and from milk to lodge in human bone where it remained radioactive for years and could cause bone tumours, leukaemia and other diseases. Commentaries about the significance of the levels of strontium found in New Zealand varied. The reported results showed that strontium levels at one of the collection sites, at Claremont, had trebled between 1956 and 1958. While the Acting Prime Minister, Jerry Skinner, assured the public there was "nothing to fear", the director of radiophysics at Wakari Hospital, described the figures as "alarming".[56] Strontium levels peaked in 1965. In 1967, at the request of the Education Boards, the Government dismantled the free milk in schools scheme.[57] Coincidentally, this was just two years after the levels of strontium-90 and caesium-137 peaked in New Zealand's milk.

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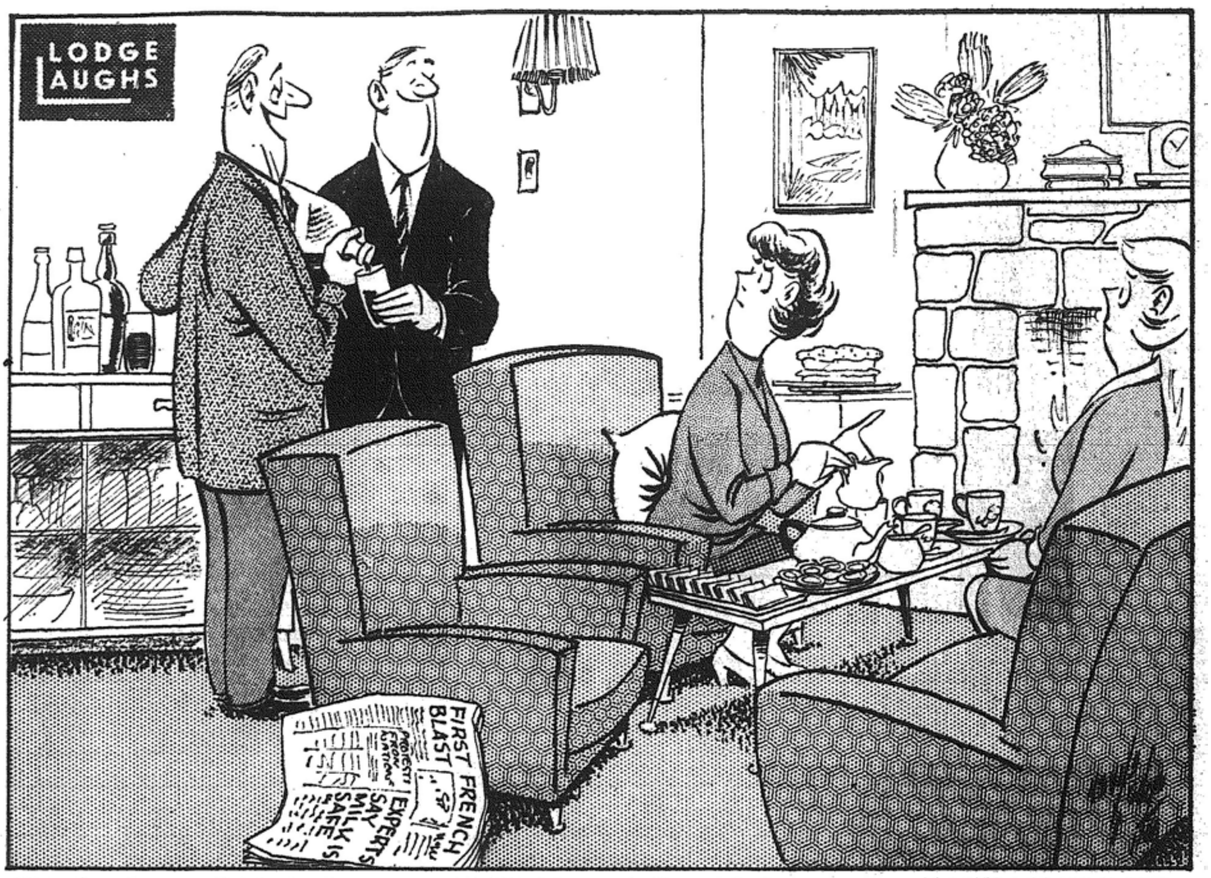
[55] High Commissioner for New Zealand in Canberra to Minister of External Affairs, 10 November 1959, in H1, 27361, 108/11, 1958-61, *ANZ.*
[56] 'New Zealand Strontium-90 Figures "A warning"', *New Zealand Public Service Journal,* December 1959, p8.
[57] Mein Smith 2003, p90.



"Charlie and me won't take tea for supper, we'll stick to beer—don't want to take any chances on the milk being radioactive."

Fig

Figure 7.2: This Neville Lodge cartoon, from 4 July 1966, followed reports of the first French nuclear test in the Pacific. *Evening Post*, 5 July 1966, p14.

In New Zealand, the Dominion X-Ray and Radium Laboratory/National Radiation Laboratory tried to point out the minimal impact of fallout as compared to natural radiation sources. In 1962, for example, Bert Yeabsley, acting director of the Dominion X-Ray and Radium Laboratory, responded to concern about radioactive fallout from the National Council of *Parent and Child* magazine by saying "there is no cause for alarm; indeed when the true facts are realised there is no cause for even mild concern". He said that the fission product strontium-90 added "less than 1 per cent to the total radioactivity in our soil".[58]

The public, however, was becoming more aware about the hazards of radioactive fallout and wanted better access to information. In 1960 the Public Servant's Association (PSA) requested from the Prime Minister that the results of tests of radioactive fallout be published.[59] The PSA continued to pressure the Department of Health in this regard, and in 1961 the Department of Health agreed to issue statements on radioactive fallout in New Zealand, presenting the findings

[58] H. J. Yeabsley, 'No Danger in N.Z. from Atomic Fallout', *Parent and Child* 3, 5 (1960), p26.
[59] NZPSA to Rt Hon W. Nash, 27 September 1960, H1, 27361, 108/11, 1958-61, *ANZ.*

to date and the health implications of the present levels. This was followed by quarterly reports on fallout measurements together with annual summaries analysing the situation.[60]

By the 1960s, opposition to these Pacific nuclear tests was widespread. Britain stopped testing in 1958, and the United States' last Pacific tests were in 1962, but France began its Pacific testing programme in 1964. The New Zealand Government's official position was now against nuclear testing in the Pacific and New Zealand scientists were playing an increasing role in providing public information about bomb tests and fallout levels. In November 1965 Athol Rafter, of the DSIR's Institute of Nuclear Sciences, boasted that were the French Government to carry out secret atmospheric nuclear testing in the Pacific, New Zealand would know about it within days.[61]

Other sources of radiation

In addition to fallout, X-rays and natural background radioactivity, another source of radiation exposure was luminous paint, which was still often used in watches and in some industrial plants. Roth made an informal survey of Auckland watchmakers in 1949 to investigate the use of radioactive luminous paint in repairing luminous watch dials and hands. It was Roth's observation that watchmakers were not aware of the dangers, were taking no precautions, or were secretive about having radioactive paint.[62] Despite there being non-radioactive luminous paints available after the Second World War, use of radioactive luminous paints continued in New Zealand into the 1950s.

An article published in the *New Zealand Horological Journal* in 1960 outlined the Dominion X-Ray and Radium Laboratory's work with watchmakers regarding radiation protection, including a survey of radiation hazards involved in the use of radioactive paints by watchmakers. The survey, which estimated that the average New Zealand watchmaker spent five to 10 minutes per week engaged in radium dial painting, said that no cases of radium poisoning had yet been recorded in New Zealand and concluded that there was "no significant hazard to watchmakers in New Zealand through the use of radium activated luminous paint either from the actual luminising itself or from the repairing of watches and clocks with radioactive luminous paint".

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[60] File notes in H1, 27361, 108/11, 1958-61, *ANZ.*
[61] *Evening Post*, 3 November 1965.
[62] Roth to Dept of Health, 18 October 1949, H1, 45543, 108/7/1, 1944-61, *ANZ.*

The laboratory did, however, make plans to measure radon in the breath of people known to have worked with, or who were currently working with, radium, including some watchmakers.[63]

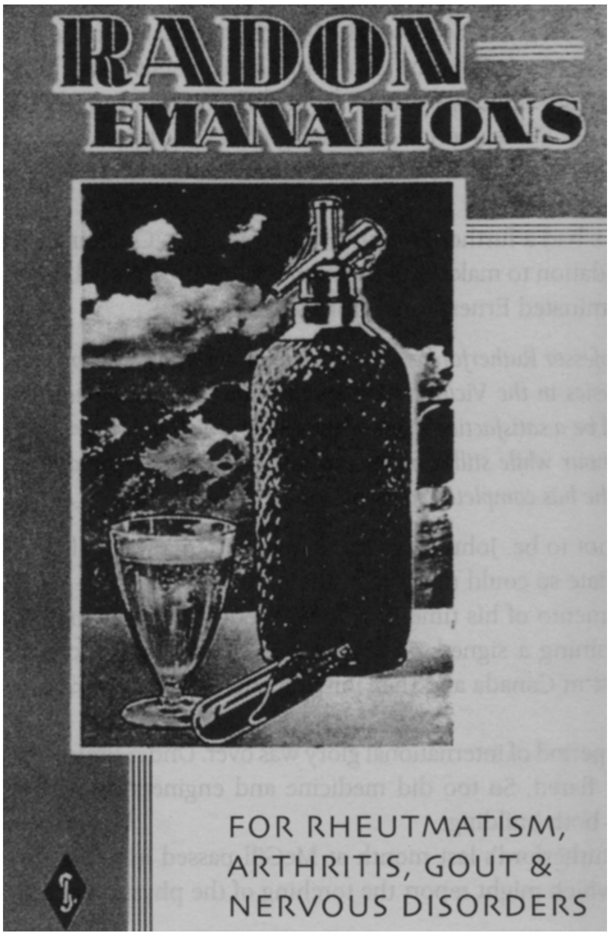

Figure 7.3: An early advertisement for a siphon system with a radon bulb – along with carbon dioxide a small amount of radon gas was added to the water. Source: John Campbell, *Rutherford: Scientist Supreme*, AAS Publications, Christchurch, 1999, p304. Reproduced with permission.

Not all exposure to radiation was accidental or a side-effect of something good. Despite all the publicity to the contrary, there were still people who believed in the health-giving benefits of radiation. In 1954, more than 20 years after radon water and other radium-based "health" products had been shown to be harmful and potentially deadly, the Dominion X-Ray and Radium Laboratory learnt that a Wellington firm, Messrs Claude W. Batten and Co., were advertising Radon Sparklets Bulbs, a product to add to their syphon system to make radioactive water. The advertisement for Radon Sparklets Bulbs stated that:

> Radioactive water, consumed as a table water, is of considerable value in increasing the vitality and healthy state of the system. It is an **all-round tonic** and invaluable as a treatment for **rheumatism, arthritis and nervous disorders.** By using RADON SPARKLETS BULBS with a Sparklets Syphon, Radioactive Water can be prepared at home. Each bulb contains a

[63] B. D. P. Williamson, 'Luminous Paint: No Significant Hazards Detected', *N. Z. Horological Journal* 14, 4 (1960), pp6-9; B. D. P. Williamson, "luminous Paint' *N. Z. Horological Journal* 17, 5 (1963), pp17-23.

> fixed quantity of the essential radioactive element which is the source of Radon (Radium Emanation), so that benefit normally obtained by residence at a Spa can now be conveniently and inexpensively procured without interference with the ordinary routine of daily life.[64]

The laboratory tested samples of Radon Sparklets Bulbs and found they contained 0.5-10 micrograms of radium. This made the bulbs “radioactive substances” under the Radioactive Substances Act 1949 and Radiation Protection Regulations of 1951. Under the Act, it was prohibited to manufacture, sell, import or export any radioactive substance without the consent of the Minister of Health. The laboratory advised the supplier not to let any more Radon Sparklets Bulbs, a product the English manufacturer had stopped making, leave the premises, pointing out that it was not the radiation detectable externally from the bulbs that was likely to cause hazards, but that “in making the radon-activated water the contents of the bulb may become dislodged and enter the water used, making possible the ingestion of radium”. The amount of radium contained in the bulbs was considered enough, over time, to cause death if lodged permanently in the human body. Apart from the danger of radium being ingested by the user, the spent bulbs were also considered a serious health hazard because they contained unsealed radium which could become widely distributed.[65]

Natural environmental radiation, or background radiation, was also beginning to be better understood. Ernest Marsden continued his own research into environmental radioactivity, with much of his interesting and unusual research attracting coverage in the daily press. His most publicised findings came from his research into Niue Island, where a DSIR Soil Bureau study had showed the island’s soil had unusually high levels of radioactivity.[66] This prompted Marsden to further research and he found the radioactivity of food grown on the island to be up to 100 times normal.[67] His findings caused quite a stir internationally, with the popular press picking up on Marsden’s assertions that Niueans were a master race. Not only were they taller, much happier and less prone to disease than other races, he was reported to have said, selective breeding had led to the population building up a resistance to radiation which would be advantageous in the event of a nuclear war.[68] Despite criticism of his theory, Marsden persisted,

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[64] Advertising flyer, H1, 26717, 108/11, 1951-57, *ANZ*.
[65] G. E. Roth to Messers Claude W. Batten and Co, 7 April 1954, H1, 26717, 108/11, 1951-57, *ANZ*.
[66] M. Fieldes, ‘Radioactivity of Niue Island Soils’, *New Zealand Soil News*, 3 (1959), pp116-120, MS papers 1342-270, *ATL*.
[67] Marsden to Dr S. Biesheuvel, 18 August 1960, MS papers 1342-011, *ATL*.
[68] E. Marsden, ‘Radioactivity of Soils, Plants and Bones’, *Nature* 187, 4733 (1960), pp192-195; *Daily Express* (Sydney), 12 April 1961, MS papers 1342-377, *ATL*.

stating in 1962, "My contention that the people of Niue Island would be better off in a nuclear war than the rest of us is a good story and I'm sticking to it!"[69]

Another of Marsden's high-profile projects was his investigation into the radioactivity of tobacco. By the 1960s, links between cigarette smoking and lung cancer had been established. Marsden saw the striking increase in British deaths from lung cancer as being possibly linked to increased imports of Southern Rhodesian tobacco, which he had found to have high levels of polonium-related radioactivity.[70] In 1965, at Marsden's request, the DSIR's chemistry division developed a new type of cigarette filter to reduce the amount of polonium inhaled when smoking cigarettes.[71]

Despite his seemingly eccentric scientific pursuits, Marsden maintained his international scientific connections and was held in high regard by the physics community. While working on his retirement projects he corresponded with some of the top Commonwealth nuclear scientists – including John Cockcroft and William Penney in the United Kingdom, and Charles Watson-Munro in Australia – using his connections to call in favours for advice or equipment that may otherwise have been difficult to obtain. In return, Marsden was known to send eminent scientists parcels of New Zealand lamb, to arrive just in time for Christmas.[72] In 1961 he was invited to be President of the Rutherford Jubilee International Conference in Manchester, a gathering of 500 of the world's leading physicists to commemorate the fiftieth anniversary of the discovery of the atomic nucleus.[73]

Radioactive waste

In the years before the atmosphere and the oceans were considered part of the biosphere that sustains all life on the planet, if radioactive waste was out of sight, it was out of mind. In 1955, when it was expected that New Zealand would soon have nuclear power stations for electricity generation, it was suggested that any atomic waste generated could be sealed in concrete blocks and dropped into the Kermadec Trench. At this time, oceanic trenches were believed to be troughs of stagnant water and were considered suitable burial grounds. Even so, this was considered to be only be a short-term solution, until the technology existed to shoot the nuclear

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[69] The *Dominion*, 17 April 1962, MS papers 1342-381, *ATL*.
[70] Ernest Marsden, 'Some Aspects of the Relationship of Radioactivity to Lung Cancer', *New Zealand Medical Journal* 64, 395 (1965), pp367-376.
[71] The *Dominion*, 15 October 1965, MS papers 1342-377, *ATL*.
[72] For example, in December 1962 Marsden sent lamb to John Cockcroft, Nobel Prize winner and ex-director of the UKAERE at Harwell and J. S. Mitchell of the University of Cambridge. Cockcroft to Marsden, 21 December 1962 and Mitchell to Marsden, 29 December 1962, MS-papers-1342-015, *ATL*.

waste into space "and let it revolve around the world, doing no harm to anyone or anything".[74] Suggestions like this did not arouse concerns, as consigning radioactive waste to the deep ocean trenches or outer space meant it was considered to be far from having any harmful influence on humanity.

At the Second United Nations Conference on the Peaceful uses of the Atom in 1958, however, Soviet scientists gave a paper on "Discharging radioactive wastes into deep water ocean depressions". They dealt particularly with the Kermadec Trench and from their observations concluded that the water in the trench was in contact with the general oceanic circulation and was not therefore a safe place to dump radioactive wastes. By this time, it was estimated that the United States had dumped about 10,000 curies[75] of nuclear waste into the Atlantic Ocean as well as some into the Pacific Ocean. The United Kingdom admitted to dumping 500-600 curies of nuclear waste in more than 2,000 fathoms of water in the Atlantic, an amount of radioactivity that was described at the 1958 conference as considered "perfectly trivial". Low-level waste was also being pumped into the Irish Sea as effluent from the United Kingdom's Windscale nuclear power plant.[76]

While the marine disposal of radioactive waste was an issue for discussion by the 1950s, it was still acceptable. In 1956, the United Nations held its first conference on the Law of the Sea, out of which came four conventions covering territorial zones, continental shelf and the high seas. Article 25 of the 1958 Convention on the High Seas, which finally came into force in 1962, stipulated that "Every State shall take measures to prevent pollution of the seas from the dumping of radio-active waste".[77] Note the convention did not outlaw the dumping of radioactive waste in the sea, it was just concerned with pollution as a result of such dumping, and, as marine disposal was still considered the best thing to do with radioactive waste, New Zealand continued to dump radioactive waste into the sea until 1976.

New Zealand's use of nuclear material was for medical and industrial applications only and created only low-level radioactive waste. While it was insignificant in comparison to the level of waste produced by the production of nuclear power or weapons, it still had to be disposed of

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[73] John B. Birks in *Sir Ernest Marsden 80th birthday book*, p26.
[74] *Manawatu Daily Times*, 10 January 1955.
[75] A curie is a unit of radioactivity, being roughly equal to the activity of one gram of radium.
[76] J. V. Scott, Report on the Second United Nations Conference on the Peaceful uses of Atomic Energy, ED1, W2673, 2/0/22/5, part 2, *ANZ;* Ritchie Calder, 'Burying Live Atoms is as Expensive as Burying Dead Pharoahs', WHO Special Feature, November 1958, H1 26758, 108/11, 1957-58, *ANZ.*
[77] Full text of the Convention on the High Seas Done at Geneva, on 29 April 1958, downloaded from http://sedac.ciesin.org/entri/texts/high.seas.1958.html on 14 December 2009.

safely. This low-level waste took the form of contaminated articles such as gloves and equipment, and used or damaged pellets of isotopes like caesium-137, cobalt-60, strontium-90 and radium. For many years, this waste was dumped into the Hikurangi Trench, just east of Cook Strait.[78] Sealed radioactive sources were embedded in concrete in 20-litre steel drums. The 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter was a global convention to protect the marine environment from human activities. With the adoption of the requirements of the Convention in New Zealand's Marine Pollution Act 1974, a special dumping permit was required for such disposals. This procedure was followed once in 1976, since when such waste has been stored at the National Radiation Laboratory in Christchurch.[79]

Table 7.3: Nuclear waste (sealed sources) dumped at sea up to 1976

Nuclide	**Total disposals at sea up to 1976**
Cobalt-60	23 GBq
Strontium-90	3.2 GBq
Caesium-137	1.0 TBq
Radium-226	17 GBq
Americinium-241	190 GBq

Radioactive waste disposed at sea in New Zealand, with activity measured in becquerels (Bq), the SI unit of radioactivity that replaced the curie. One Bq is equivalent to one nucleus decay per second. Source: M K Robertson, *Radioactive waste disposal – policies and practices in New Zealand,* National Radiation Laboratory Report 1996/2, February 1996.

New Zealand was also, briefly, involved in the transit of American radioactive waste through New Zealand. When the United States installed a nuclear power station at McMurdo Base in New Zealand Antarctic Territory in 1961, in accordance with Article V of the Antarctic Treaty, radioactive waste from the reactor had to be returned to the United States for disposal. New Zealand had earlier been involved in the initial transport of nuclear material to the Antarctic reactor in the summer of 1961-62. The reactor was installed at the American base at McMurdo Sound, where, previously, half of all freight shipped to the base was fuel for generators, space heaters and vehicles.[80] The reactor's radioactive fuel cores, and a start-up source had to be replaced several times over the life of the reactor, so uranium-235 and uranium-238, as well as

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[78] Cindy Beavis, 'Handling "Hot" Rubbish', *New Zealand Listener*, 22 October 1976, pp16-17.
[79] M K Robertson, *Radioactive Waste Disposal – Policies and Practices in New Zealand*, National Radiation Laboratory Report 1996/2, February 1996, p14
[80] Dian Olson Belanger, *Deep Freeze: The United States, The International Geophysical Year, and the Origins of Antarctica's Age of Science*, University Press of Colorado, Boulder, 2006, p399; Dean Calcott, 'Strontium Powered, Antarctica's Nuclear Past is Little Known', *The Press*, 27 December 1996, p14.

neutron sources of mixed polonium and beryllium, were shipped through Lyttelton on their way to the American Antarctic base. The spent fuel – uranium-235 and uranium-238 – as well as many barrels of low-level radioactive waste similarly stopped in Lyttelton on their way back to the United States for disposal.[81] Under the Radioactive Substances Act 1949 the Department of Health had the right to enter any ship carrying radioactive substances. However, as the Department of External Affairs pointed out, a confidential exchange of notes between New Zealand and the United States on 24 December 1958 stated:

> As a matter of international courtesy, the NZ authorities will exempt from inspection, search or seizure of United States Government property, including official mail and documents, entering, located in or leaving New Zealand in connection with United States operations in Antarctica.[82]

The Dominion X-ray and Radium Laboratory expressed concern over safety of the reactor fuel and neutron source being transported through New Zealand ports, and the return of spent fuel elements and of waste radioactive material, but they did agree to waive inspection rights provided they were given a schedule of any nuclear materials and waste being shipped through New Zealand, and assurance that the shipments were in accordance with the IAEA Regulations for the Safe Transport of Radioactive Material.[83]

The Antarctic reactor was plagued with problems, however, and by 1967, earlier plans to add nuclear power stations at American bases at Byrd Station and the South Pole Station had been shelved.[84] The reactor had been operating for a decade when a routine inspection in 1972 revealed a crack in a water tank used to provide radiation shielding. Further investigations revealed that some of this water had leaked into surrounding insulation and the soil below the reactor. As it was too expensive to import the equipment required to more fully test and repair the damage, the reactor was decommissioned.[85] To comply with Antarctic Treaty provisions, as well as the dismantled reactor being removed from Antarctica, so was any soil showing traces of radioactive contamination. In the years following the reactor shut down, more than 70 tonnes of contaminated soil from underneath and around the site of the reactor were removed and shipped back to the United States, via Lyttelton. The main radioactive contaminant was caesium-137, but the level of contamination was mostly so low that the shipments were exempt from approval or

[81] Various letters and file notes in CABI, CH56, 23/20/1, 1961-66, 1967-68 and 1969-75.
[82] Quoted in letter from External Affairs to Director-General of Health, 2 June 1961 in H1, 27361, 108/11, 1958-61, *ANZ.*
[83] H. J. Yeabsley to Director-General of Health, 4 July 1961, H1, 27361, 108/11, 1958-61, *ANZ;* McCahon to External Affairs, February 1967, CABI, CH56, 23/30/1, 1967-68, *ANZ CHCH.*
[84] *The Press*, 30 November 1967, CABI, CH56, 23/20/1, 1967-68, *ANZ CHCH.*
[85] File note by Jim McCahon, NRL, 24 August 1976, ABQU 632, W4452, 108/5/6, *ANZ.*

inspection by the National Radiation Laboratory.[86] In 1975, Robert Mann, an Auckland biochemistry lecturer and director of the Environmental Defence Society, brought the shipments of radioactive soil to the attention of the media, who responded with headlines like "Hush-up Over Deadly Cargo: Minister Asked to Explain". One of the key points Mann and others were making was in relation to the New Zealand Electricity Department's plans for a nuclear power station to provide electricity to Auckland. Mann told the *Christchurch Star* that the Government's "casual" attitude to the nuclear reactor and its "potential dangers" on Antarctic soil did not bode well for "attitudes and policies regarding its plans to set up a nuclear plant here on the mainland in 1979".[87] The Minister of Health of the Labour Government, Thomas McGuigan, who was also the MP for Lyttelton, downplayed the significance of the shipments, saying there was never any risk and accusing Mann of using "scaremongering tactics".[88]

Some of New Zealand's own nuclear waste was disposed of in landfills, like contaminated laboratory equipment from Victoria University buried at Wilton Tip (now Ian Galloway Park) in the early 1960s. As Rachel Barrowman recounts in her history of Victoria University of Wellington, in 1961 a technician trying out a new Geiger counter discovered certain rooms in the university's physics department, which had been used by early physicists such as Charles Watson-Munro, recorded high levels of radioactivity, most likely as a result of careless handling of radium-226. Technicians from the Dominion X-Ray and Radium Laboratory surveyed the department and removed some contaminated material which, as was standard practice at the time, was encased in concrete and dumped at sea. Two years later, a new radiation monitor revealed further evidence of contamination and a more comprehensive clean-up was ordered. Radioactive contamination was discovered on furniture, equipment, floors, walls, dust and papers. To complicate matters, in 1963 Ron Humphrey, a physics lecturer who had been working in the contaminated rooms, died of leukaemia after a two-year illness, and his family were suing the university for compensation. The department was carefully decontaminated and all contaminated material, including a large workbench, was removed to a nearby garage in Waiteata Road, pending a possible court case over Humphrey's death. When the case was settled out of court, the material was trucked to the Wilton tip. The cause of Humphrey's leukaemia was

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[86] M. Norrish, Statement on Shipment of Contaminated Soil from Site of Former United States Nuclear Reactor at McMurdo Sound, 6 December 1976, ABQU 632, W4452, 108/5/6, *ANZ;* Belanger 2006, p399.
[87] 'Hush-Up Over Deadly Cargo', *Christchurch Star*, 20 September 1975, p1.
[88] *Evening Post*, 22 September 1975, ABQU 632, W4452, 108/5/6, *ANZ.*

not determined, but post-mortem analysis of his bones – the place where ingested radium becomes concentrated – showed his radium levels were within the normal range.[89]

The story made front page news in Wellington's *The Dominion* when the story broke in 1963, with a headline "Radiation Danger Discovery". The reporting, however, was straightforward: there was no scaremongering or sensationalism and the Dominion X-ray and Radium Laboratory was treated as an authority on the matter. Waiteata Road residents were concerned, however, and a complaint was made to the Health Department, to which Turbott provided the assurance that even if a person were in the same room as the materials in the garage, they "would not be hazardous to a person not in direct contact with them".[90] Attitudes were to change over the coming decades, however. When the same issue attracted media attention during building renovations in 1988, by which time New Zealanders had embraced the nuclear-free policy, the story again resulted in front page headlines – this time they read "Radiation leak: official cover-up" – as well as reports and interviews on radio, television and in newspapers around the country.

Nuclear civil defence

While New Zealand was never a primary nuclear target and did not see the need to adopt the level of civil defence measures of countries like the United States, where many cities had fallout shelters beneath city streets and homeowners built backyard nuclear bunkers, safety from nuclear explosion or fallout did become an issue for New Zealand's military and civil defence. From a twenty-first century perspective it is clear that the greatest threats to twentieth century New Zealand came in the form of earthquakes, cyclones and floods. But it was, in fact, preparedness for a nuclear attack that instigated New Zealand's first civil defence schemes and the eventual establishment of a Ministry of Civil Defence.

The Local Authorities Emergency Powers Act of 1953 was enacted after similar British and American legislation, and was prompted by Cold War fears of the perceived danger of nuclear attack.[91] Civil Defence next became an issue after the New Zealand Government's White Paper *Review of Defence 1958* stated that:

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[89] Rachel Barrowman, *Victoria University of Wellington, 1899-1999: A History*, Victoria University Press, Wellington, 1999, pp164-5; Rebecca Priestley, 'Material Evidence', *New Zealand Listener*, 27 August 2005, pp36-37.
[90] The *Dominion*, 3 July 1963, p1; 5 July 1963, p2.
[91] Ministry of Civil Defence, *Civil Defence in New Zealand: A Short History*, Ministry of Civil Defence, Wellington, 1990, downloaded from napier.digidocs.com/userfiles/file/cd_short_history.pdf on 10 February 2010.

> … The safeguarding and educating of the civil population against the nuclear effects of war must, for the first time, become an essential part of national defence plans. The geographical position of New Zealand no longer affords the country security from the worst impact of a global conflict. A nuclear war and the hazards to civilian population of radioactivity will not necessarily be confined to the countries of the main combatants. Radioactivity knows neither frontiers nor distance and the contamination of nuclear weapons could assume world-wide proportions. … The defence plan must also take into account the possibility of a direct attack on this country with nuclear or non-nuclear weapons. Even a single submarine with guided missiles would offer a considerable threat to our shores.[92]

By now, even countries like New Zealand, remote from the northern hemisphere nuclear powers, were feeling threatened: intercontinental ballistic missiles had first been launched in 1957, the Soviet Union had launched Sputnik 1, the first artificial satellite, and the United States was building submarines capable of firing nuclear missiles.[93] Nevil Shute's 1957 book *On the Beach* had had a profound impact on society and there was growing awareness that the southern hemisphere, New Zealand included, would not escape the effects of a nuclear conflict.[94]

The Ministry of Civil Defence was set up in 1959, within the Department of Internal Affairs, but responsible to the Minister of Defence. The threat of nuclear attack was the Ministry's primary concern. A 1959 publication, *Civil Defence in New Zealand*, declared the most likely nuclear targets to be Auckland, Wellington, Christchurch and Dunedin. The threat from nuclear weapons was considered very real, and the booklet described the effects of nuclear weapons as devastating "property and personnel by heat, blast and direct radiation over a circular area" with "residual radiation from the fall-out … fatal to persons exposed to it without protection for 24 to 48 hours, while beyond that exposed persons would be made ill from radiation sickness and some might die". While evacuation of potential targets was considered the civil defence priority in the event of a nuclear attack, the booklet also mentioned the need for fallout shelters "of relatively simple type such as slit trenches and Anderson-type frames[95] partially sunk into the ground, with a cover of 3ft of earth". Shelter policy, it advised, would be the subject of future planning and advice.[96] The Civil Defence Act of 1962 designated preparing for and coping with armed attack and natural disaster as the main functions of the Ministry. After 1963, however,

[92] Suggested Organization of Radiological Monitoring and Recontamination Services for the New Zealand Civil Defence Organization, submitted to the Radiological Advisory Council at its meeting on 3 December 1958, HI, 26758, 108/11, 1957-58, *ANZ.*
[93] Ministry of Civil Defence 1990.
[94] Nevil Shute, *On the Beach,* Heinemann, London, 1957.
[95] An Anderson frame was a Second World War type bomb shelter.
[96] Ministry of Civil Defence, *Civil Defence in New Zealand,* Department of Internal Affairs, Wellington, 1959, pp5-6, 13.

with the signing of the Limited Test Ban Treaty, the Ministry's functions began to tend towards natural disaster preparedness rather than nuclear attack.[97]

Figure 7.4: This Army Department map shows fallout zones for a nuclear bomb drop on Wellington city. Source: AD 66 34 Misc 26, Atomic bombing of Wellington, map 1, *ANZ*.

[97] George Preddey, *Nuclear Disaster: A New Way of Thinking Down Under*, Asia Pacific Books: Futurewatch, Wellington, 1985, p147; Ministry of Civil Defence 1990.

Nuclear ship visits were also considered a civil defence issue. In 1958 Roth wrote that "[p]ossible hazards arising from, e.g. a collision with a nuclear powered ship in or near the Harbour, are such that only the most compelling economic or military reasons would justify the entry of a nuclear powered ship into the Port of Auckland".[98] Nonetheless, Walter Nash's Labour Government had in 1960 seen fit to accept a visit of the USS *Halibut*, an American nuclear submarine, to Auckland and Wellington. This first nuclear ship visit was followed in 1964, under Keith Holyoake's National Government, by visits from American nuclear-powered cruisers USS *Longbeach*, USS *Bainbridge* and the aircraft carrier USS *Enterprise*.[99] In 1967, Jim McCahon wrote to the Department of External Affairs on the issue of nuclear ship visits, pointing out that nuclear-propelled vessels "carried a very small risk of an accident which could affect people and installations on the shore" and suggested it was reasonable to require indemnity for the entry of a nuclear-powered ship into New Zealand waters.[100] In 1971 Holyoake's Government advised the United States that a condition of future visits from nuclear-powered ships would be that the United States agree to accept liability in the event of a nuclear accident, and a New Zealand Code of Practice for Nuclear Powered Shipping was prepared by the New Zealand Atomic Energy Commission. But by the time the United States agreed to accept liability, in 1974, a new Labour Government, under Bill Rowling, chose to continue the ban on nuclear-powered ships.[101]

New concerns about New Zealand becoming a nuclear target arose in 1968, when it was revealed that it was going to host a radio transmitter to be used for communication purposes by the United States' fleet of nuclear submarines. In June, *The Press* revealed that United States Navy engineers, working with officials from New Zealand's Lands and Survey Department, the Ministry of Works and the Post Office, had inspected three possible sites for a transmitter for the Omega navigation system: in the Lake Sumner and Lake Pearson areas and in the Omarama district of North Otago. The purpose of the new system was to provide aircraft, ships or submarines equipped with an Omega radio receiver with data on their exact geographical position anywhere in the world, to within about one or two nautical miles; being able to pinpoint locations is something we take for granted now with global positioning satellites but this was not possible then. *The Press* reported that the Omega system would operate on VLF meaning the signals could travel very long distances, with the system working with only eight stations

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[98] From Roth's answers to a questionnaire sent by the Engineering Institute of the University of Michigan, HI, 26758, 108/11, 1957-58, *ANZ*.
[99] Special Committee on Nuclear Propulsion, *The Safety of Nuclear Powered Ships*, Department of the Prime Minister and Cabinet, Wellington, 1992, p4.
[100] McCahon to External Affairs, 6 February 1967, CABI, CH56, 23/20/1, 1967-68, *ANZ CHCH*.
[101] Kevin Clements, *Back From the Brink: The Creation of a Nuclear-Free New Zealand*, Allen & Unwin/Port Nicholson Press, Wellington, 1988, p84.

worldwide.[102] The University of Canterbury student newspaper, *Canta*, responded with three full pages on the story, with headlines like "Omega Radio Will Invite Nuclear Attack" and "Christchurch Airport Would be Prime Target". *Canta* reported:

> Until now, New Zealanders have drawn some comfort from the knowledge that in the event of nuclear war, there is no apparent reason why any hostile nation might select so small, relatively sparsely populated, and unimportant a land for destruction. At one stroke, the New Zealand Government plans to place us among one of the eight most important targets in the world. … As a hostile nation would be unable to locate U.S. polaris submarines, the only effective way to reduce American firepower would be to eradicate as rapidly as possible the known 8 stations by which they navigate. … From the moment such a station reached completion, Intercontinental missiles with atomic warheads will be aimed to home on New Zealand, since this would be the only way to remove the threat from the world roving polaris fleet. … If it is the will of New Zealanders to be the target during the first few hours of atomic attack, then there will be no opposition to this plan. If enough of you believe that it should be opposed, then let your strongest voice be heard over this land, before this thing is done.[103]

Canta also reported that Christchurch airport would not be spared if the alpine site was bombed, "so we could expect saturation bombing over Canterbury. Missiles could attack New Zealand at the same time as similar targets in Australia were eradicated. The sparsely populated hinterland of Canterbury would be reduced to an arid desert. Those not killed by the initial blast heat or radiation would die from fallout spreading from the explosions in the alps and at Christchurch Airport. Christchurch itself would be completely destroyed."[104]

People responded to *Canta*'s call for action and Omega became a national issue. Suddenly the idea that New Zealand might become a nuclear target seemed very real. Students demonstrated against the proposed station, people marched in protest and the Labour Opposition leader, Norman Kirk, came out against Omega. Meanwhile, debate raged about whether the system was intended for military or commercial shipping. Either the protestors' voices were heard or New Zealand's terrain proved too challenging – the proposed station was not built in New Zealand; it was eventually built in Victoria, Australia.[105]

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[102] *The Press*, 14 June 1968, reproduced in *Canta* 25 June 1968, University of Canterbury Archives 16578, MB 1281, Box 2, Item 1/12, Newspaper cuttings 1944-67.
[103] *Canta* 25 June 1968, pp1-2, University of Canterbury Archives 16578, MB 1281, Box 2, Item 1/12, Newspaper cuttings 1944-67.
[104] *Canta* 25 June 1968, p3, University of Canterbury Archives 16578, MB 1281, Box 2, Item 1/12, Newspaper cuttings 1944-67
[105] Elsie Locke, *Peace People: A History of Peace Activities in New Zealand*, Hazard Press, Christchurch, 1992, p262-266.

Conclusion

In the 1950s, New Zealanders became aware of the health risks posed by radioactive fallout from bomb testing, and the public began to be wary of dangers posed, for example, by strontium contamination of milk. But this fear of radiation dangers from fallout was associated with the testing of nuclear bombs and did not usually extend to a fear or suspicion of nuclear power or nuclear science and medicine. Despite growing evidence of the dangers of all exposure to radiation, workers were happy to line up for a free X-ray to screen for tuberculosis, parents let their children's feet be irradiated by pedascopes in shoe shops, radon-irradiated water continued to be offered for sale and watchmakers hid their supplies of radioactive paint from authorities. Towards the end of the 1960s, however, public awareness had grown and demand for these potentially dangerous novelties waned.

Concerns about fallout led to public action, which prompted the Government to be more open about fallout information. The Dominion X-ray and Radium Laboratory – the public's trusted source of advice and information on radiation issues – began publishing quarterly fallout statistics in the 1960s. But in other application of nuclear science and medicine, it was not public demand, but government officials responding to the latest scientific evidence or to international law that led to the implementation of more stringent regulations. The Department of Health took the lead in advising the medical profession and the public on safety measures and had to take measures to control over-enthusiastic users of radioactive materials who chose to continue using them – radon paint and radon-infused water – against medical advice.

Chapter 8

Atoms for Peace:

Nuclear science in New Zealand in the atomic age

"A country backward in nuclear science can only stumble blindly in the atomic age, ignorant of opportunities, deficient in technique and the pawn of countries more advanced."
J. Williams, Report on Development of Nuclear Sciences in New Zealand, 19 July 1956[1]

"A new source of power to light the homes of the people and turn the wheels of industry; an order to build a ship that will cross the seas without coal or oil fuel. This atomic age is indeed beginning to show signs of an assured future."
The Dominion, 17 October 1956[2]

In the 1950s, nuclear technology, which had until that time been primarily focused on weaponry, came to encompass electricity generation and other so-called "peaceful" uses of the atom: by 1957, nuclear power for electricity was being produced in the Soviet Union, the United States and the United Kingdom, and the United States had launched the world's first nuclear-powered submarine.

In this new atomic age, the United States vied with the United Kingdom to supply New Zealand with a nuclear reactor and nuclear science laboratory equipment. Woods and other historians have written about the "ANZAC dilemma" in which New Zealand was "tied inextricably to two great and powerful friends, whose policies occasionally diverged and whose interests were coming to differ from those of New Zealand".[3] Although the United Kingdom was used to New Zealand following its lead, and the United States expected a small country like New Zealand to accept their offers of assistance and guidance, New Zealand asserted independence in continually keeping national interest to the fore when it came to decisions about its nuclear future.

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[1] J. Williams, 'Report on Development of Nuclear Sciences in New Zealand', 19 July 1956. Quoted in Rachel Barrowman, *Victoria University of Wellington 1899-1999,* Victoria University Press, Wellington, 1999, p166.
[2] *The Dominion*, 17 October 1956, ED1, W2673, 2/0/65/5, *ANZ.*
[3] F. L. W. Wood, 'New Zealand Foreign Policy 1945-1951'. In *New Zealand in World Affairs, volume 1*, Price Milburn/New Zealand Institute of International Affairs, Wellington, 1977, p112; Philippa Mein Smith, *A Concise History of New Zealand*, Cambridge University Press, Cambridge, 2005, pp177-79.

That didn't dampen excitement about the atomic age: while opposition to Pacific nuclear bomb tests was growing, New Zealanders were enthusiastic about peaceful uses of nuclear technology. In 1960, thousands of people flocked to the ports to welcome the United States' nuclear submarine USS *Halibut*, a positive symbol of an atomic future. This unchallenged positivity about a nuclear future, however, would not last.

Nuclear science in New Zealand

By the mid-1950s, many of the young DSIR scientists who had worked on the Manhattan and Montreal projects had moved into other areas of research. While the DSIR had taken pride in the work these scientists had done in the United Kingdom, there were now limited opportunities for them to be involved in nuclear projects in New Zealand, and with an agriculturalist, Bill Hamilton, leading the DSIR – which was operating under a budget slashed by Sidney Holland's National Government – there was no one with Marsden's enthusiasm and leadership to champion nuclear projects.[4]

Charles Watson-Munro, who had led the New Zealand teams working on ZEEP and GLEEP, left the DSIR in 1951 to take the position of professor of physics at Wellington's Victoria University College. He did not stay long. There were limited opportunities for an experienced nuclear reactor specialist in New Zealand and in 1955 Watson-Munro left New Zealand to become chief scientist with the Australian Atomic Energy Commission. Australia's atomic energy projects were now well in advance of New Zealand's: a uranium mining industry was exporting to the UKAEA and a £5.5 million atomic energy programme had begun with the construction of a heavy-water moderated, enriched-uranium research reactor (HIFAR) at Lucas Heights near Sydney.[5] George Page and Gordon Fergusson, both part of Watson-Munro's team that had worked on the British nuclear reactor project (GLEEP), continued working on nuclear sciences in the DSIR's Dominion Physical Laboratory, though Page soon left New Zealand to join Watson-Munro and fellow New Zealander Cliff Dalton at Lucas Heights.[6]

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[4] Ian L. Baumgart, 'Hamilton, William Maxwell 1909–1992', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz downloaded 8 April 2010; Ross Galbreath, *DSIR: Making Science Work for New Zealand*, Victoria University Press, Wellington, 1998, p247.
[5] Alice Cawte, *Atomic Australia, 1944-1990,* New South Wales University Press, Sydney, 1992, pp72-3, 100; AAS biography of Watson-Munro at www.science.org.au/academy/memoirs/watson-munro.htm, downloaded 10 December 2009; ANSTO history site at www.ansto.gov.au/discovering_ansto/history_of_ansto/hifar, downloaded 20 April 2010.
[6] Galbreath 1998, p156.

Figure 8.1: When the Australian nuclear science research establishment officially opened at Lucas Heights on 18 April 1958, New Zealanders held the two top roles. On the left is Cliff Dalton, deputy chief scientist. In the centre, six from the left, is Charles Watson-Munro, chief scientist. Courtesy Australian Nuclear Science and Technology Organisation.

After Marsden left his role as head of the DSIR, another New Zealand scientist took a leading role in developing the field of nuclear science, taking it in a whole new direction. By becoming a world expert in the nascent field of radiocarbon dating, Athol Rafter established an international reputation for the DSIR's nuclear sciences team, and set the direction for the future research of what became the Institute of Nuclear Sciences. In 1948, Rafter, a DSIR chemist, had been sent on a trip to the United States and the United Kingdom, with Fergusson, to learn about radiochemistry. Back in New Zealand, Rafter later recalled, "no one really knew what to do with us. Nuclear science was a very young baby clothed in mysticism and nuclear annihilation. Any expenditure on nuclear science was of necessity a major expenditure, and any work involved hazards that the people of New Zealand little understood." Rafter and his colleagues, however, managed to assemble sufficient equipment to provide nuclear science services to medicine, agriculture and industry. Working in a shed "that looked like an outhouse" Rafter prepared radioactive isotopes for use around New Zealand. Page, working in the attic of the Dominion Physical Laboratory, built a mass spectrometer and Fergusson assembled equipment to measure natural background radioactivity.[7]

The team used isotope techniques on many projects, including determining nitrogen metabolism of apple trees; finding the origin of sulphur in New Zealand coals; measuring radioactivity levels in waters, gases and soil samples; and surveying the heavy water content of New Zealand waters.[8] Rafter also began experimenting with the new technique of radiocarbon dating, which calculates the age of organic material by comparing the ratio of radiocarbon atoms (carbon-14) to regular carbon atoms (carbon-12) in a sample with known radiocarbon:carbon ratios from

[7] Athol Rafter, extract from 'Problems in the Establishment of a Carbon-14 and Tritium Laboratory', paper presented at the Sixth International Conference on Radiocarbon and Tritium Dating, Washington State University, 1965. In Rebecca Priestley (ed), *The Awa Book of New Zealand Science*, Awa Press, Wellington, pp251.
[8] DSIR memo on Peaceful Uses of Atomic Energy, 5 April 1955, ED1, W2673, 2/0/22/5, part 1, *ANZ.*

different time periods. Rafter was prompted to investigate the new technique by the DSIR head Frank Callaghan, who requested that Rafter attempt to date the age of New Zealand's volcanic ash showers to "stop the geologists arguing".[9] Rafter used radiocarbon dating first to date pieces of organic matter from ash deposits in the North Island and to date moa bones. After difficulties with the process used by Willard Libby, the American pioneer of radiocarbon dating, Rafter worked with Fergusson and a DSIR team to perfect a more reliable method of radiocarbon dating using carbon dioxide gas rather than solid carbon.[10] The new technique was very successful: the carbon dioxide method soon became the standard procedure and Rafter and his team established an international reputation for radiocarbon dating.[11]

An *Evening Post* article in 1952 described New Zealand's nuclear scientists as using radioactive isotopes from Harwell, and working "quietly, often in inadequate laboratories and with makeshift equipment which astonishes visiting scientists", where they were "doing very valuable work in the fields of industry, agriculture, medicine and historical research".[12] Outside of the DSIR, other New Zealand research laboratories were making use of radioactive and stable isotope tracers: the Department of Agriculture's Animal Research Laboratory to determine the effect of cobalt on animal metabolism; the New Zealand Fertiliser Manufacturers' Research Association to study fertiliser uptake in plants; and the Otago University Medical School to study thyroid function.[13] Radioactive isotopes were also being used in industry, for example to trace welding faults at the Maraetai power station on the Waikato River.[14]

In academia, Auckland University College had constructed and was using a low energy linear accelerator – a machine that can accelerate subatomic particles and ions to significant speeds – for research, and Otago University was constructing a Van de Graaff accelerator. Victoria University College and Auckland University College were studying cosmic rays and radioactive contamination of the atmosphere and there was work on low-energy X-rays at Canterbury University College.[15]

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[9] Athol Rafter, extract from 'Problems in the Establishment of a Carbon-14 and Tritium Laboratory', paper presented at the Sixth International Conference on Radiocarbon and Tritium Dating, Washington State University, 1965. In Rebecca Priestley (ed), *The Awa Book of New Zealand Science,* Awa Press, Wellington, p251.
[10] Veronika Meduna and Rebecca Priestley, *Atoms, Dinosaurs & DNA: 68 Great New Zealand Scientists*, Random House, Auckland, p74.
[11] Galbreath 1998, pp160-169.
[12] *Evening Post*, 6 October 1952, EA1, W2619, 121/2/1, part 1, *ANZ*.
[13] Memo on Peaceful Uses of Atomic Energy, 5 April 1955, ED1, W2673, 2/0/22/5, part 1, *ANZ.*
[14] *Evening Post*, 6 October 1952, EA1, W2619, 121/2/1, part 1, *ANZ.*
[15] Paper on Peaceful Uses of Atomic Energy in New Zealand, prepared by the Permanent Heads Committee on Atomic Energy, 15 March 1956, ED1, W2675, 2/0/22/5, part 1, *ANZ*; Hamilton, Atomic Energy (report on 1955 overseas visit), c. 1955 (undated), ED1, W2673, 2/0/22/5 part 1, *ANZ.*

Nuclear science techniques practised by New Zealand scientists were now established in many areas of New Zealand industry and agriculture. But the most extensive use of radioactive isotopes was in medicine. In radiation therapy an isotope of cobalt, cobalt-60, had begun to be used in preference to radium as it was a cheaper source of radioactivity for treatment. Other radioactive isotopes for diagnosis and therapy were prepared for hospital use by DSIR scientists from bulk shipments received from overseas.[16] With no local source of the radioisotopes needed for research and industrial, agricultural and medical applications – from cobalt-60 and radium-228 used in cancer treatment to caesium-137 and phosphorus-32 used in industry and agriculture – New Zealand had to import them initially from the United Kingdom, the United States and Canada, and, from the 1960s, from the HIFAR nuclear reactor in Australia. Because of the limited useful life of most isotopes, they had to be brought to New Zealand by air, and in most cases with protective shielding. But some particularly short-lived isotopes, such as fluorine-18, used overseas in dental examinations and with a half-life of just 109 minutes, could not be used in New Zealand as the time involved in transporting them would render them useless.[17]

Eisenhower's Atoms for Peace speech

The United States began promoting peaceful uses of nuclear technology in the 1950s. On 8 December 1953, the United States President, Dwight D. Eisenhower, addressed the United Nations General Assembly with a speech promoting the establishment of an international atomic energy agency which could stockpile fissionable materials for use by non-nuclear powers for peaceful purposes. He called for atomic energy to be applied "to the needs of agriculture, medicine and other peaceful activities" and specifically "to provide abundant electrical energy in the power-starved areas of the world".[18]

While the nuclear powers discussed the establishment of an international atomic energy agency, the United States started to fulfil the promises made in Eisenhower's Atoms for Peace speech by offering assistance to other countries to construct small-scale nuclear reactors, sponsoring international scientific conferences on nuclear science, and providing technical information and training programmes.[19] Kevin Clements has described the United States as being "concerned to

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[16] *External Affairs Review*, 5, 5 (May 1955), p42.
[17] NZ Imports of Radioactive Isotopes, 16 March 1956, ED1, W2673, 20/0/22/5, part 1, *ANZ;* ANSTO website www.ansto.gov.au/discovering_ansto/history_of_ansto/hifar, downloaded 20 April 2010.
[18] Address by Mr. Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly, www.iaea.org/About/history_speech.html, downloaded 15 September 2009.
[19] Richard G. Hewlett and Jack M. Holl, *Atoms for Peace and War, 1953-1961: Eisenhower and the Atomic Energy Commission*, University of California Press, Berkeley, 1989, p227.

overcome its reputation as a nuclear bully and consolidate its reputation as a peace-loving nation".[20] Focusing on the peaceful potential of the atom, at the same time as continuing to test new and mightier nuclear weapons, played into what Matthew O'Meagher has called "the utopian hopes and genuine scientific excitement" of the new technology.[21] While planning proceeded for a United Nations conference on peaceful uses of the atom, the United States began to sign bilateral agreements to provide non-nuclear countries with information on the design, construction and operation of research reactors. While the United States promoted its Atoms for Peace programme as being motivated by a desire for world peace and prosperity, the United States National Security Council was clear that any bilateral agreements the United States entered into regarding provision of atomic energy or nuclear technology should seek to promote the United States' own atomic energy interests, and any nuclear materials provided by them to another country must be returned for reprocessing in the United States.[22] By promoting bilateral agreements ahead of the multilateralism soon to be introduced in an international atomic energy agency, the United States was able to maximise its own influence and control over the Western world's nuclear industries, and reap any benefits from research advances made in its partner countries.

The biggest advances in nuclear technology were now taking place in the United States where, following on from the science of the Manhattan Project, Willard Libby had developed radiocarbon dating and Robert van de Graaff had developed a powerful new type of particle accelerator.[23] New Zealand was a long way away from these advances, but still liked to acknowledge the role of Ernest Rutherford in the scientific cooperation that lead to the birth of nuclear physics. While the United Nations was working on the United States' Atoms for Peace conference proposal, New Zealand had a representative on the United Nations Security Council, Leslie Munro. In November 1954, Munro made a speech to the First Committee of the General Assembly in which he pointed out Ernest Rutherford's role in the development of knowledge that would later lead to the peaceful uses of atomic energy, and to the international cooperation in atomic research that had persisted up until the Second World War. "Dare I express the hope", Munro said:

> … that it may now be possible, slowly but surely, to revert to the basis of international cooperation on which our atomic science was

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[20] Kevin Clements, *Back From the Brink: The Creation of a Nuclear-Free New Zealand*, Allen & Unwin/Port Nicholson Press, Wellington, 1988, p30.
[21] Matthew O'Meagher, 'Prospects for Enrichment: New Zealand Responses to the Peaceful Atom in the 1950s', *Journal & Proceedings of the Royal Society of New South Wales* 139 (2006), p 52.
[22] Hewlett and Holl, pp227, 236.
[23] Galbreath 1998, p169.

> constructed. Is it too much to hope that before long the Rutherfords and Kapitzas[24] of present-day atomic physics may again join in seeking solutions to the many mysteries which still remain? No matter how great its resources, no matter how advanced its technology, no matter how numerous or well trained its scientists, no one nation could hope by itself to match the pooled efforts of a group of nations in this field. On the other hand, scientists from even the smallest countries, which may have little to offer by way of raw materials or industrial capacity, can make vital contributions.[25]

As well as calling for the resumption of international cooperation among atomic scientists, Munro expressed New Zealand’s support for the establishment of an international atomic energy agency and a proposed scientific conference on the peaceful uses of the atom.

The United States was active in seeking a bilateral agreement with New Zealand. In 1954, New Zealand was one of several countries visited by an American team offering Government level cooperation with atomic energy projects.[26] But while the Department of External Affairs was enthusiastic at the prospect of cementing New Zealand/United States relations through signing a bilateral agreement under the Atoms for Peace programme, how did the government agencies that would be most involved in a nuclear reactor for research or power generation – the DSIR and the State Hydro-electric Department – react? In contrast to the External Affairs officials, focused on strengthening New Zealand’s relationship with the United States, representatives of the Government’s scientific and engineering agencies were cautious and pragmatic. Arthur Davenport, secretary of the State Hydro-electric Department, in May 1955 told the Secretary for External Affairs, Alister McIntosh, that, “the construction of a research reactor in New Zealand would not assist in the practical application of nuclear energy in the generation of nuclear power. If the construction of such a research reactor is an essential part of the bilateral agreement with USA, this Department is not prepared to recommend the signing of the agreement.”[27] Bill Hamilton, secretary of the DSIR, also had concerns about the proposed bilateral agreement, suggesting to McIntosh that any exchange of information between the United States and New Zealand be restricted to unclassified data as “the receiving of even a small amount of classified information might limit freedom of publication of original work done in New Zealand, or work based on information obtained in an unclassified form from other sources, such as the United Kingdom”.[28]

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[24] Peter Kapitza was a Nobel Prize-winning Russian physicist who spent 10 years working with Ernest Rutherford at the Cavendish Laboratory.
[25] Speech by Munro to UN General Assembly, *External Affairs Review* 4, 11 (1954), p9.
[26] Malcolm Templeton, *Standing Upright Here: New Zealand in the Nuclear Age 1945-1990,* Victoria University Press, Wellington, 2006, pp30-31.
[27] A. E. Davenport to Secretary for External Affairs, 30 May 1955, ED1, W2673, 2/0/22/5, *ANZ.*
[28] Secretary of External Affairs to Secretary of DSIR, 17 March 1955, ED1, W2673, 2/0/22/5, *ANZ.*

The United States' standard bilateral agreement became more worthy of New Zealand's consideration in 1955 when it was revised to include funding for half the price of a nuclear reactor (with a ceiling of £125,000, or US$350,000).[29] The DSIR, however, was still coping with a reduced budget, and advised the External Affairs Department that the DSIR was "of the opinion that New Zealand is not yet at a stage where it could contemplate entering into such an agreement", noting that the "high capital cost involved and the cost of maintenance would be out of all proportion to the benefits which would accrue, particularly as we are able to secure for our present limited needs all the radioactive isotopes which New Zealand requires for research purposes in agriculture, medicine, biology, etc". While the United States had surpassed the United Kingdom in taking the scientific lead in nuclear technology, there were still many personal and professional links between New Zealand and British scientists; the DSIR also said that were New Zealand in the future to make a decision to construct a research reactor, it would be preferable to do so through existing links with the United Kingdom.[30]

As well as wanting to maintain existing links with British science and scientists, there seems to have been a degree of mistrust of the United States amongst New Zealand science administrators. It was later revealed that the United Kingdom was concerned about the possibility of New Zealand buying an American reactor, saying that they did not want New Zealand to buy an inferior or outdated reactor (they believed their technology was superior) and offering their help.[31] The DSIR was happy, however, to accept a technical library from the United States Atomic Energy Commission. When the American Ambassador handed over the library to Holland on 20 October 1955, Holland made a connection between Ernest Rutherford and the latest nuclear technology, proudly noting that "in a sense all the scientific advances surveyed in this assembly of material had their beginnings in this country of ours."[32] Rutherford, of course, did no work on nuclear science in New Zealand, but, once again, the New Zealand Government was happy to claim national links with this exciting new field of science.

Atoms for Peace conference 1955

The first United Nations International Conference on the Peaceful Uses of Atomic Energy, commonly known as the Atoms for Peace conference, was held in Geneva from 8 to 20 August

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[29] External Affairs paper on Implications of the Development of Peaceful Uses of Atomic Energy for New Zealand, 1 December 1955, EA1, W2619, 121/2/1, part 1, *ANZ*; Draft Cabinet Paper on Nuclear Research Programme, 1 March 1957, EA1, W2619, 121/2/1, part 1, *ANZ.*

[30] Secretary of DSIR to Secretary of External Affairs, 14 June 1955, ED1, W2673, 2/0/22/5, part 1, *ANZ.*

[31] Memo to Mr Laking, 3 May 1957, ABHS 950, W4627/3534, 12/2/4, *ANZ.*

[32] *External Affairs Review* 6, 6 (1956), pp8-9.

1955, 10 years after the bombing of Hiroshima and Nagasaki. The conference was the first large-scale meeting of scientists from the West and from Communist-bloc nations since the Second World War, and was marked by the release of much previously secret or highly-classified information.[33] The main scientific concerns of the conference – which presented nuclear energy as the only long-term solution to society's energy needs – were the generation of electricity through nuclear reactors, and the use of radioisotopes in medicine, biology, agriculture and industry.[34]

At the conference, the United States restated its offers of half-price nuclear reactors and supplies of fissile materials to countries which would undertake research in nuclear physics and so add to the sum of world knowledge about peaceful uses of the atom; and offered opportunities for advanced training for scientific and engineering graduates from countries planning to construct atomic power stations.[35] The New Zealand delegation was also approached informally by members of the Australian delegation with a scheme for Australian-New Zealand partnership in an atomic research project. [36]

It is important to note that while it was done with more fanfare, the United States was not the only country offering assistance in the field of nuclear technology. The Soviet Union had given technical assistance to help China, Poland, Czechoslovakia, Rumania and East Germany to set up experimental bases for research in nuclear physics. The United Kingdom, whose atomic energy programme was initially more advanced than the United States' and had been unencumbered by any secrecy clauses such as in the United States 1945 Atomic Energy Act, had already been offering informal technical assistance to other European countries and hosting visitors from New Zealand and other Commonwealth countries.[37] This Commonwealth scientific cooperation dated back to the Second World War, when a system of formal scientific liaison officers was set up, one of the aims of which was to share information and pool research results, particularly as related to defence science – a prospect that the United States found threatening

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[33] Latta, Report on visit overseas, June – October 1955, ED1, W2675, 2/0/22/5, part 1, *ANZ;* 'Atomic Energy in Harness: Britain's Opportunity', *The Economist*, 23 July 1955, pp1-17; G. D. L. White, Memo on International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1955, ED1, W2673, 2/0/22/5, part 1, *ANZ.*

[34] *Evening Post*, 23 August 1955, ED1, W2673, 2/0/65/3, *ANZ;* Latta, Report on visit overseas, June – October 1955, ED1, W2673, 2/0/22/5, part 1, *ANZ;* D. Walker, 'Power, Thermo-Nuclear Research, Nuclear Physics', *Symposium on Nuclear Science*, DSIR Information Series No. 23, 25 February 1959.

[35] Secretary of External Affairs to Secretary of DSIR, 17 March 1955, ED1, W2673, 2/0/22/5, part 1, ANZ; New Zealand Ambassador, Washington to Minister of External Affairs, Wellington, 16 June 1955, ED1, W2673, 2/0/22/5, part 1, *ANZ.*

[36] External Affairs paper on Implications of the Development of Peaceful Uses of Atomic Energy for New Zealand, 1 December 1955, EA1, W2619, 121/2/1, part 1, *ANZ.*

[37] 'Atomic Energy in Harness', *The Economist*, 23 July 1955, pp1-17; Clements, p32.

and had opposed. In June 1946, alongside a Prime Ministers' Conference held in London, was a Commonwealth Conference on Defence Science, the stated objective of which was to distribute research and development in defence science. The Dominions could assist Britain by providing scientists and engineers, who were in short supply in the United Kingdom, in return for post-graduate training. Arrangements such as the New Zealand scientists seconded to the Atomic Energy Research Establishment at Harwell were therefore at least as beneficial to the United Kingdom as to New Zealand.[38] This system of what was near-competition between the United Kingdom and the United States for the loyalty and expertise of Antipodean scientists can therefore be seen as being established during the Second World War.

Hamilton led the New Zealand delegation to the 1955 Atoms for Peace conference. The delegates, who also included representatives from the State Hydro-electric Department, the Ministry of Works, the Department of External Affairs and two university physics departments, reported on the conference on their return. While they all accepted the need for New Zealand to have nuclear power in the future, and agreed that people would have to be trained in preparation, they disagreed over whether or not New Zealand should establish a nuclear energy research programme.[39]

Again, it is interesting to note the difference in stance between External Affairs officials, who were clearly seeking to strengthen relations with the United States, by now the Western superpower and New Zealand's partner in the ANZUS treaty, and the more insular responses from New Zealand's scientific and engineering communities, who focused on what they saw as New Zealand's immediate needs. In his report on the conference, Lloyd White, from New Zealand's High Commission in London, noted that "a country's political weight will henceforth be judged, at least in part, by its participation in the atomic field. If we want to maintain an influential position among nations ... we must take part in this progress." He went on to argue in favour of an atomic research programme in New Zealand, noting that while it was too early to place an order for a nuclear reactor for atomic energy production, it was not too early "to be thinking about training atomic technicians and accumulating a body of knowledge on the sort of atomic reactors which would be best suited to New Zealand conditions".[40]

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[38] Wayne Reynolds, *Australia's Bid for the Atomic Bomb*, Melbourne University Press, Melbourne, 2000, pp40-47.
[39] *Evening Post*, 23 August 1955, ED1, W2673, 2/0/65/3, *ANZ; New Zealand External Affairs Review* 5, 8 (1955), p33.
[40] White, Memo on International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1955, ED1, W2673, 2/0/22/5, *ANZ.*

Templeton has described White's boss, External Affairs head Alister McIntosh, as "ever-cautious" and "no great lover of scientists" [41] but he did recognise the potential value to New Zealand of cooperation with the United States in nuclear science. Before the 1955 conference McIntosh had written to Hamilton saying that the high level attention being given by the United States to the Atoms for Peace conference was a political fact that New Zealand must take into account.[42] Whether or not Hamilton took any notice of this is unclear; he seems to have consistently recognised the need for nuclear power at some time in the future, but not for any advancements in the field of nuclear science research. In his report on the conference, Hamilton dismissed White's argument as sounding "like a variant of 'keeping up with the Joneses'," adding that "surely the influence of a nation depends on the standard of living of her people, in the broadest sense, and the contribution of <u>ideas</u> she can make in world affairs, not on whether she is doing atomic research irrespective of whether or not it is germane to her problems."[43]. In his report on the conference, Hamilton advised that New Zealand should not undertake research in nuclear physics and technology, but rather should begin training "a few bright young engineers-cum-physicists in general reactor design and operation in order to keep abreast of developments … and to assist in deciding what type of nuclear plant New Zealand should buy and when would be the appropriate moment to enter the market."[44] Hamilton's antipathy towards White's attitude was reciprocated: Templeton has uncovered a personal letter sent in addition to his formal report in which White described Hamilton as "hopeless as a delegation leader" and observed that he had clearly "made up his mind in advance that New Zealand should not interest itself in atomic research".[45]

Latta, from the State Hydro-electric Department, who was perhaps best placed to judge New Zealand's need for a nuclear reactor for electricity generation, agreed there was "no pressing necessity to construct atomic power stations in the immediate future" and stated his belief that it would be better to allow experimental nuclear power stations overseas to advance further before New Zealand committed to "expending a great deal of capital on plant which might be obsolete before it went into service."[46]

These New Zealand scientists and engineers were not going to be pushed into accepting a reactor – which, while a gift in part, would have cost a great deal of investment in terms of money and

[41] Templeton 2006, p100.
[42] McIntosh to Hamilton, 28 June 1955, ABHS 950, W4627, 3405, 121/7/2, part 1, *ANZ*. In Templeton 2006, p31.
[43] Hamilton., Atomic Energy (report on 1955 overseas visit), c. 1955 (undated), ED1, W2673, 2/0/22/5, *ANZ.*
[44] Hamilton., Atomic Energy (report on 1955 overseas visit), c. 1955 (undated), ED1, W2673, 2/0/22/5, *ANZ.*
[45] Templeton 2006, pp24-25.
[46] Latta, Report on visit overseas, June – October 1955, ED1, W2675, 2/0/22/5, part 1, *ANZ.*

people power – just because a global superpower wanted them to. As well as refusing to be swayed by the United States offers, New Zealand was also reluctant to enter into any sort of cooperation with Australia. While Philip Baxter, head of the Australian Atomic Energy Commission, and chief scientist Charles Watson-Munro, were keen for New Zealand and Australia to pool their efforts in nuclear science, the DSIR, under Hamilton, was not convinced. Baxter subsequently attributed New Zealand's failure to advance in the field of nuclear sciences to Hamilton's agricultural bias and failure to recognise the possibilities of the new field.[47]

Cabinet Committee on Atomic Energy

Meanwhile, in the Department of External Affairs, Paul Cotton, a young graduate working in the Specialised Agencies Division, proposed that a Cabinet Committee be set up to respond to questions regarding the American offers of assistance and Australian offers of cooperation, and to study the general implications for New Zealand of the increasing development of peaceful uses of atomic energy.[48] Acting on Cotton's recommendation, Cabinet set up a Cabinet Committee on Atomic Energy to study the reports of the delegation to the Atoms for Peace Conference.[49] At its first meeting, on 13 February 1956, the Cabinet Committee established a committee of the permanent heads of the departments with an interest in the development of the peaceful uses of atomic energy.[50] The Permanent Heads Committee on Atomic Energy was asked to report and make recommendations on the question of a bilateral agreement with the United States of America; the American "half-price" reactor offer; and participation in the Australian Atomic Energy Commission's research programme.[51] They were also asked to prepare a draft statement of New Zealand's policy on the development of the peaceful uses of atomic energy. [52]

Hamilton, who chaired the Permanent Heads Committee on Atomic Energy, drafted a policy statement, stating that New Zealand had no intention of setting up a research reactor in the near future and, provided the proposed Cook Strait submarine cable project – a plan to transport electricity from the South Island to the North island – was feasible, would have no need for

[47] Frank Corner to Alister MacIntosh, 11 October 1957. In Ian McGibbon (ed), *Undiplomatic Dialogue: Letters Between Carl Berendsen and Alister McIntosh, 1943-52*, Auckland University Press, Auckland, 1993, pp233-234.
[48] Paul Cotton, personal email of 3 July 2002; External Affairs paper on Implications of the Development of Peaceful Uses of Atomic Energy for New Zealand, 1 December 1955, EA1, W2619, 121/2/1, part 1, *ANZ.*
[49] Report of Cabinet Committee on Atomic Energy (CP (56) 85), 17 February 1956, EA1, W2619, 121/2/1, part 1, *ANZ.*
[50] W. M. Hamilton, 'The Development of Nuclear Science in New Zealand', *Symposium on Nuclear Science*, DSIR Information Series No. 23, 25 February 1959.
[51] Report and recommendations of the Permanent Heads Committee (not dated) ED1, W2675, 2/0/22/5, part 1, *ANZ.*

nuclear power for 30-40 years. Hamilton's draft was at odds with the Cabinet Committee's enthusiasm for the United States offer of a bilateral agreement and a half-price reactor; Cotton found the draft "most unsatisfactory", and subsequently prepared a new draft of the report, that moderated Hamilton's views, for presentation at the first meeting of the Permanent Heads Committee on Atomic Energy.[53]

The Permanent Heads Committee subsequently recommended to Cabinet that the bilateral agreement with the United States be concluded as soon as possible. They also advised against accepting an offer of cooperation with Australia, believing that an atomic research partnership with the Australian Atomic Energy Authority would be costly, with no apparent benefit to New Zealand.[54] In regard to the United States' offer of a half-price reactor, the Committee recommended that the immediate priority was to purchase an accelerator, but also recommended approval for the installation of a research reactor to be in operation in "approximately three years time".[55] More significantly, the Committee noted that "New Zealand cannot keep abreast of developments in nuclear science by merely seconding officers to work in overseas organisations such as Harwell in the United Kingdom or Chalk River in Canada. Officers seconded to these establishments will not return if there are no facilities in New Zealand in this field to enable them to pursue the advanced work for which they have been trained" and recommended the immediate establishment of an institute of nuclear sciences. It advised that the new institute should incorporate the Isotopes Division of the Dominion Physical Laboratory, and be established as a branch of the DSIR, with an advisory committee representing the University of New Zealand, DSIR and other interested parties.[56]

At about the same time, the Council of Scientific and Industrial Research (CSIR) set up a small technical sub-committee to report on the future part New Zealand might play in atomic energy research and application.[57] The CSIR sub-committee, which comprised George Currie, Vice-Chancellor of the University of New Zealand, Ernest Marsden, Professor Darcy Walker of Victoria University College and Bill Hamilton, made recommendations to the CSIR which adopted their report with minor modifications and conveyed it to the Minister in a memo in June

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[52] Report of Cabinet Committee on Atomic Energy (CP (56) 85), 17 February 1956, EA1, W2619, 121/2/1, part 1, *ANZ.*
[53] Cotton to McIntosh on Committee on Atomic Energy, 5 March 1956, EA1, W2619, 121/2/1, *ANZ.*
[54] Cotton, Minutes of first meeting of Permanent Heads Committee on Atomic Energy, 16 March 1956, ED1, W2673, 2/0/22/5, *ANZ*; Cabinet Paper on Peaceful Uses of Atomic Energy – Report of Cabinet Committee (CP (56) 343), 11 May 1956, EA1, W2619, 121/2/1, part 1, *ANZ.*
[55] Report and recommendations of the Permanent Heads Committee (not dated) ED1, W2675, 2/0/22/5, part 1, *ANZ.*
[56] Report and recommendations of the Permanent Heads Committee (not dated) ED1, W2675, 2/0/22/5, part 1, *ANZ.*
[57] Hamilton's report on Nuclear Science to CSIR, 26 April 1957, EA1, W2619, 121/2/1, part 1, *ANZ.*

1956.[58] The CSIR paper recommended the establishment of an institute of nuclear sciences as a branch of the DSIR, with the immediate purchase of an accelerator, and a research reactor planned for two-to-three year's time. While similar to the Permanent Heads Committee's report, the CSIR report differed on two key points – it gave the need to purchase a research reactor much less emphasis and omitted the proposal to take advantage of the American offer of a half-price reactor.[59]

Arguments that a bilateral agreement with the United States might hinder New Zealand's relationship with the United Kingdom had now dissipated: after New Zealand's original rejection of the United States' offer, the United Kingdom had told New Zealand they would welcome an agreement between New Zealand and the United States, partly because it would make the exchange of information between New Zealand and the United Kingdom easier.[60] By this time the United Kingdom may have been recognising the American superiority in nuclear technology and could see advantages to New Zealand having access to this technology. So following the recommendations of the Permanent Heads Committee and the CSIR sub-committee, Cabinet decided to sign the bilateral agreement with the United States, while deferring consideration of the remaining proposals.[61]

The bilateral agreement between New Zealand and the United States was signed on 13 June 1956. The agreement allowed for the exchange of information regarding the design, construction and operation of research reactors and allowed for the lease of up to 6 kg of enriched uranium (uranium with a higher proportion of the fissionable uranium-235 than occurs naturally) for use as reactor fuel.[62] Of interest in today's global situation is the fact that the United States signed a similar agreement with Iran in March 1957, which also included leasing Iran enriched uranium.[63]

The bilateral agreement with the United States represented a significant strengthening of the relationship between New Zealand and the United States on nuclear matters, though the

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[58] Hamilton's report on The Development of Nuclear Science in New Zealand, 23 February 1959, EA1, W2619, 121/2/1, part 1, *ANZ.*
[59] External Affairs paper on Nuclear Research, 15 August 1956, EA1, W2619, 121/2/1, part 1, *ANZ.*
[60] External Affairs paper on Implications of the Development of Peaceful Uses of Atomic Energy for New Zealand, 1 December 1955, EA1, W2619, 121/2/1, part 1, *ANZ.*
[61] Minister of External Affairs to Secretary DSIR, 22 May 1956, SIR1, W1414, 74/33, *ANZ.*
[62] Agreement for Cooperation Between The Government of the United States of America and The Government of New Zealand Concerning Civil Uses of Atomic Energy, 3 July 1956, SIR1, W1414, 74/33, *ANZ.*
[63] File note in SIR1, W1414, 74/33, *ANZ.* It is ironic to learn that it was the United States who encouraged Iran's move towards nuclear technology: in 2002 United States President George W. Bush named Iran as one of three countries in an "axis of evil" responsible for harbouring terrorists and seeking to create weapons of mass destruction, including nuclear weapons. CNN transcript of Bush's 2002 State of the Union address at http://archives.cnn.com/2002/ALLPOLITICS/01/29/bush.speech.txt/.

relationship with the United Kingdom was still strong. New Zealand had an agreement to send up to three men a year to the United Kingdom Atomic Energy Research Establishment at Harwell, but it was to be another three years before a formal agreement was signed between the UKAEA and the New Zealand Government regarding New Zealand's uranium resources.

While Cabinet was considering the full reports on the future of nuclear science in New Zealand, opposition to their recommendations was growing. The universities were concerned that the proposed institute of nuclear sciences might not be sited on a campus and that full opportunities for DSIR/university cooperation might not develop.[64]

Discussions on the subject of nuclear research revealed clear differences of opinion as to the value and urgency for New Zealand of an expanded nuclear research programme. In an August 1956 paper outlining the issues to his Minister, the Secretary of External Affairs noted that their Department's major concern in the matter was New Zealand's relationship with the United States, adding that New Zealand's failure to take advantage of the United States' offer of $350,000 towards the cost of a reactor "may be difficult for the United States authorities to understand" and that the matter was "causing some embarrassment in our relations with the Americans".[65] Within the DSIR, the enthusiasm of individual scientists in the Dominion Physical Laboratory (according to External Affairs) was not matched in the senior administration where the development of research and training in nuclear sciences was seen only as a financial burden.[66]

Despite the DSIR's seeming ambivalence on the issue, Cabinet decided to accept the United States' offer as part of a suite of decisions regarding New Zealand's nuclear future. The 11 March 1957 Cabinet decision stated that New Zealand's policy in regard to research into and development of atomic energy should include:

(i) opportunity for New Zealand scientists to keep reasonably abreast of developments in the uses of atomic energy overseas

(ii) secondment of a small number of departmental officers for study at important nuclear stations in other countries

(iii) purchase of an accelerator as a first step in the implementation of this policy

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[64] Hamilton's report on The Development of Nuclear Science in New Zealand, 23 February 1959, EA1, W2619, 121/2/1, part 1, *ANZ.*

[65] External Affairs paper on Nuclear Research, 15 August 1956, EA1, W2619, 121/2/1, part 1, *ANZ.*

[66] Cotton to R. B. Atkins, N.Z. Permanent Mission to the UN in New York, 7 September 1956, EA1, W2619, 121/2/1, part 1, *ANZ.*

(iv) the setting up of a suitable committee or institute to deal with the question of location, etc. when the purchase of an accelerator is authorised

(v) an approach to the United States Government with a view to accepting their offer to pay a portion of the cost of a suitable reactor.[67]

With regard to the issue of an institute of nuclear sciences, representatives of the University of New Zealand also put forward their views that any such institute should be autonomous, rather than associated with a government department like the DSIR, and called for an overseas expert to be brought to New Zealand to advise on the development of nuclear science in New Zealand. After a report on nuclear science in New Zealand by Philip Baxter, chairman of the Australian Atomic Energy Commission, and physicist Leslie Martin, and a visit from a USAEC mission, the CSIR submitted proposals to Government, which Cabinet approved. The university's argument was overruled and the decision was made to establish an institute of nuclear sciences as a branch of the DSIR.[68] The plan was slow to be implemented, however, and the Government was criticised for the delays in getting the institute set up and ordering equipment. In January 1958 the *Otago Daily Times* editorialised that "the atomic age is getting into its stride and New Zealand is already lagging several years behind".[69]

Institute of Nuclear Sciences

The establishment of the Institute of Nuclear Sciences helped to give status to the nuclear scientists already working within the DSIR, and gave New Zealand a second organisation – alongside the Department of Health's Dominion X-ray and Radium Laboratory – focused on nuclear and radiation science. In 1958, as a step towards the establishment of the Institute of Nuclear Sciences, the DSIR's nuclear scientists were given the status of working under a separate DSIR Division of Nuclear Sciences with Rafter as director. As part of the June 1958 Cabinet decision that established the Institute, Cabinet also approved the entering of negotiations with manufacturers of accelerators with a view to ordering a 3 million volt Van de Graaff accelerator; and expenditure on the first stage of development of the programme involving the purchase of land, purchase and housing of an accelerator, and building of an administration and laboratory block. In answer to the universities' requests, the Institute of Nuclear Sciences was required to make provision for the use of facilities and allocation of laboratories for use by the

[67] Cabinet paper on Peaceful Uses of Atomic Energy, 11 May 1956, EA1, W2619, 121/2/1, part 1, *ANZ*; R. L. Hutchens to Minister in Charge of DSIR, 12 March 1957, ED1, W2675, 2/0/22/5, *ANZ.*
[68] W. M. Hamilton, 'The Development of Nuclear Science in New Zealand'. In *Symposium on Nuclear Science,* DSIR Information Series No. 23, 25 February 1959.
[69] *The Otago Daily Times*, 9 January 1958.

universities and other government departments.[70] The original plan for the Institute of Nuclear Sciences was that it would first require a multi-curie cobalt-60 source, then a Van de Graaff accelerator, and then a research reactor.[71]

While Philip Holloway, the Labour Minister in charge of the DSIR, talked about the "miraculous possibilities" of the application of nuclear science to New Zealand's future, Hamilton was less enthusiastic. The most positive thing that Hamilton said about the DSIR's latest research unit was that the new Institute of Nuclear Sciences would help existing work in nuclear science by "providing better equipment and facilities".[72]

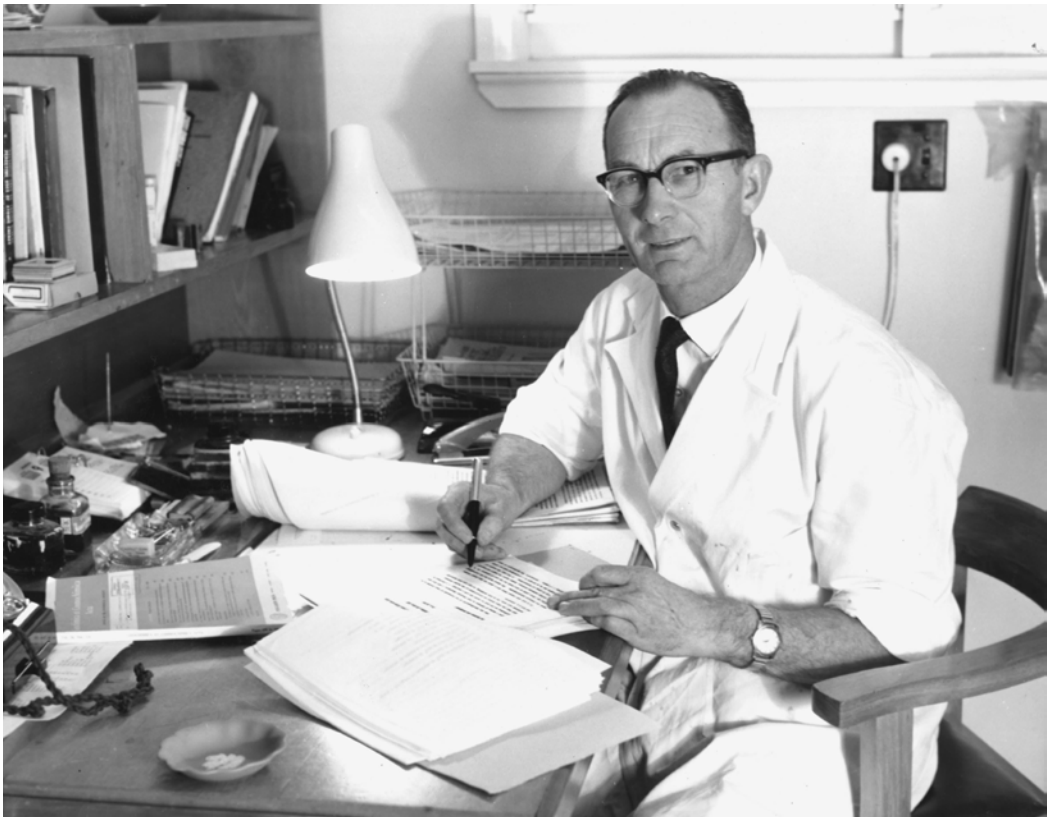

Figure 8.2: The DSIR's Athol Rafter pioneered radiocarbon dating in New Zealand and, with Gordon Fergusson, perfected a more reliable method of radiocarbon dating using carbon dioxide gas rather than solid carbon. Rafter went on to lead the DSIR's Institute of Nuclear Sciences from 1959 until his retirement in 1978. Source: Courtesy of GNS Science.

[70] Hamilton to Minister of SIR, 2 May 1960, SIR1, W1414, 74/8, volume 3, *ANZ.*
[71] File note in SIR1, W1414, 74/8, volume 2, *ANZ.*
[72] *New Zealand Herald*, 5 June 1958, p12.

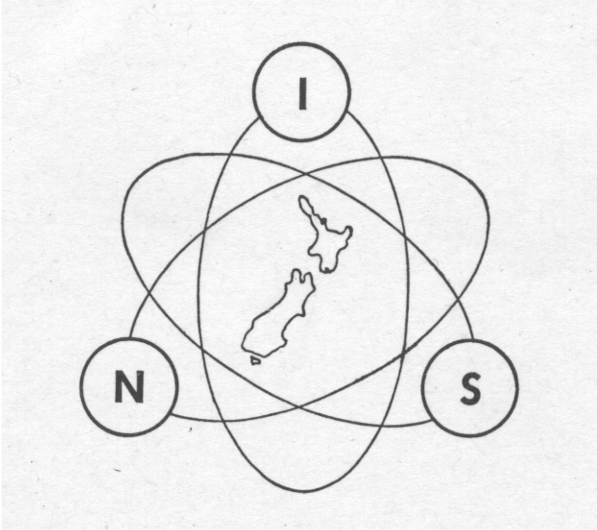

Figure 8.3: The DSIR's Institute of Nuclear Sciences was formed in 1959 and continued under this name until the disbandment of the DSIR in 1992, after which the organisation became part of the Institute of Geological and Nuclear Sciences Ltd, now known as GNS Science.

While the work of the new Institute would focus on radiocarbon dating and use of isotopes for environment and industrial monitoring, there was some public apprehension about New Zealand's foray into nuclear sciences. While rhetoric about atomic energy being the promise of the future was high in the 1950s, the reality in New Zealand was that the greatest public awareness of things nuclear was the American and British bomb testing in the Pacific that had ceased only when a temporary moratorium had been reached the previous year. In a 1959 address to a Nuclear Sciences Symposium in Wellington, Holloway, the Minister in charge of the DSIR, said that the new Institute must:

> enable our young men and women to become so used to the word "nuclear" science, and so used to its practical application that they themselves will have confidence, and inspire confidence into the community. We must persuade the people that nuclear science is not necessarily a fearful thing; that reactors, accelerators, and all other machines used in its development, need not cause apprehension. The Press of the country must present the peaceful development of nuclear science clearly so that the public will accept it as a natural development and not something to be dreaded.[73]

At the same time as approving the Institute of Nuclear Sciences, Cabinet established the New Zealand Atomic Energy Committee (NZAEC), initially as an advisory committee for formulating the policy of the new Institute of Nuclear Sciences.[74] One of the Committee members was Sir Ernest Marsden.[75] Marsden's knighthood was another example of New Zealand acknowledging its role in the birth of nuclear physics – while Marsden had made an important contribution to New Zealand science by leading the DSIR for two decades, it was after

[73] P. N. Holloway, 'Address by Minister'. In *Symposium on Nuclear Science*, DSIR Information Series No. 23, 25 February 1959.
[74] Cabinet Secretary to Minister in charge of the DSIR, 3 June 1958, ABLP, W4215, 1/1, part 1, *ANZ*.

the Minister of Health spoke in Parliament about Marsden's role in the birth of nuclear physics that he was recommended for a knighthood for his services to science.[76] The responsibilities of the NZAEC were to advise on the organisation and administration of the Institute of Nuclear Sciences; make recommendations regarding the programme of research work at the Institute and the funds required; advise on the coordination of New Zealand's activities in atomic affairs; encourage the publication and dissemination of the results of nuclear research; and advise on other matters relating to nuclear sciences.[77]

The first challenge was to find a site for the new Institute. It was required that the site be in the Wellington area, close to existing DSIR services, have adequate rock foundations for heavy equipment, and be at a safe enough distance from the public for the operation of a nuclear reactor. In March 1959, the DSIR recommended a hillside site at Gracefield, opposite the existing DSIR campus.[78] In 1959, Rafter was appointed inaugural director of the DSIR's Institute of Nuclear Sciences, which was finally established after protracted negotiations with the universities. Meanwhile, in November 1959, the 3 million volt Van de Graaff accelerator was ordered at a cost of £84,000. The Health Department finally approved the site in July 1960, and by September, the Ministry of Works had presented new cost estimates for the project. Immediately after the extra expenditure had been approved, the DSIR requested that the Ministry of Works purchase the land, develop the site, prepare plans and call tenders for the building.[79] With regards to the planned nuclear reactor, Cabinet finally, in 1960, approved in principle the purchase of a reactor from the United States. But when they learned that it was no longer United States policy to give the half-price reactor subsidy to developed countries like New Zealand, the plans for acquiring a nuclear reactor were once again deferred.[80]

Progress on construction of the building was slow, and when the Van de Graaff accelerator arrived in New Zealand in July 1961 it had to go into storage. When, by December 1961, there had been little further progress, the NZAEC considered the situation so serious that they approached the Prime Minister and members of Cabinet to outline the delays in the programme

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[75] Press Statement on New Zealand Atomic Energy Committee, 9 July 1958, ABLP, W4215, 1/1, part 1, *ANZ*.
[76] *New Zealand Parliamentary Debates* 311 (1957), pp684-86; J. R. Hanan in Sir Ernest Marsden's 80th Birthday Book, p129.
[77] Press Statement on New Zealand Atomic Energy Committee, 9 July 1958, ABLP, W4215, 1/1, part 1, *ANZ*.
[78] Memo for NZAEC meeting with the Prime Minister and Members of Cabinet, 5 December 1961, ABLP, W4215, 1/1, part 1, *ANZ*.
[79] Memo for NZAEC meeting with the Prime Minister and Members of Cabinet, 5 December 1961, ABLP, W4215, 1/1, part 1, *ANZ*.
[80] Templeton 2006, p48.

and seek continued assurance of support.[81] The NZAEC addressed Cabinet on 5 March 1962, arguing the ways in which nuclear science was supporting New Zealand agriculture, forestry and environmental science and making specific mention of attempts to irradiate apple seeds to prevent germination during cold storage; giving Forestry Research Institute quick methods for determining variations in timber density; accurate and easy methods of gauging river flows; radiocarbon dating; and checking fallout from bomb tests.[82]

The Institute of Nuclear Sciences building was finally completed and the accelerator assembled by 1966. Unfortunately, the magnet on the Van de Graaff accelerator was found to be damaged but the warranty had expired while it was in storage.[83] Nonetheless, the accelerator soon became an important tool in the Institute's work and was used for radiocarbon dating as well as other research projects until a more powerful tandem accelerator replaced it in 1986.[84]

Atoms for Peace Conference 1958

The Second International Scientific Conference on the Peaceful Uses of Atomic Energy was held under the auspices of the new United Nations International Atomic Energy Agency (IAEA) in Geneva from 1 to 13 September 1958. With more than 6000 participants, it was the largest international conference ever held.[85] The IAEA had been set up in 1957 as the "Atoms for Peace" organisation proposed in Eisenhower's 1953 speech. In the words of its statute, its purpose was "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".[86] While its initial focus was on the peaceful use of atomic energy, the IAEA's work that came to be most relevant to New Zealand scientists was in the setting of international standards and regulatory procedures with regard to health and safety, which could be applied to the use of radioisotopes in industry, medicine and agriculture as well as atomic energy.[87]

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[81] Memo for NZAEC meeting with the Prime Minister and Members of Cabinet, 5 December 1961, ABLP, W4215, 1/1, part 1, *ANZ.*
[82] Address to Prime Minister and Cabinet by NZAEC, 5 March 1962, ABLP, W4215, 1/1, part 1, *ANZ.*
[83] *Dunedin Evening Star*, 20 June 1966; file notes in SIR1, W1414, 74/8, volume 4, *ANZ.*
[84] Galbreath 1998, pp167-8.
[85] John Cockcroft, A Summary of the Geneva Conference, ED1, W2673, 2/0/22/5, *ANZ.*
[86] David Fischer, *History of the IAEA: The First Forty Years*, Vienna, The Agency, 1997, pp471-474. Downloaded from www-pub.iaea.org/MTCD/publications/PDF/Pub1032_web.pdf on 21 October 2009.
[87] Minutes of NZAEC meeting, 10 November 1964, SSC2, 8/3/4/2, *ANZ.*

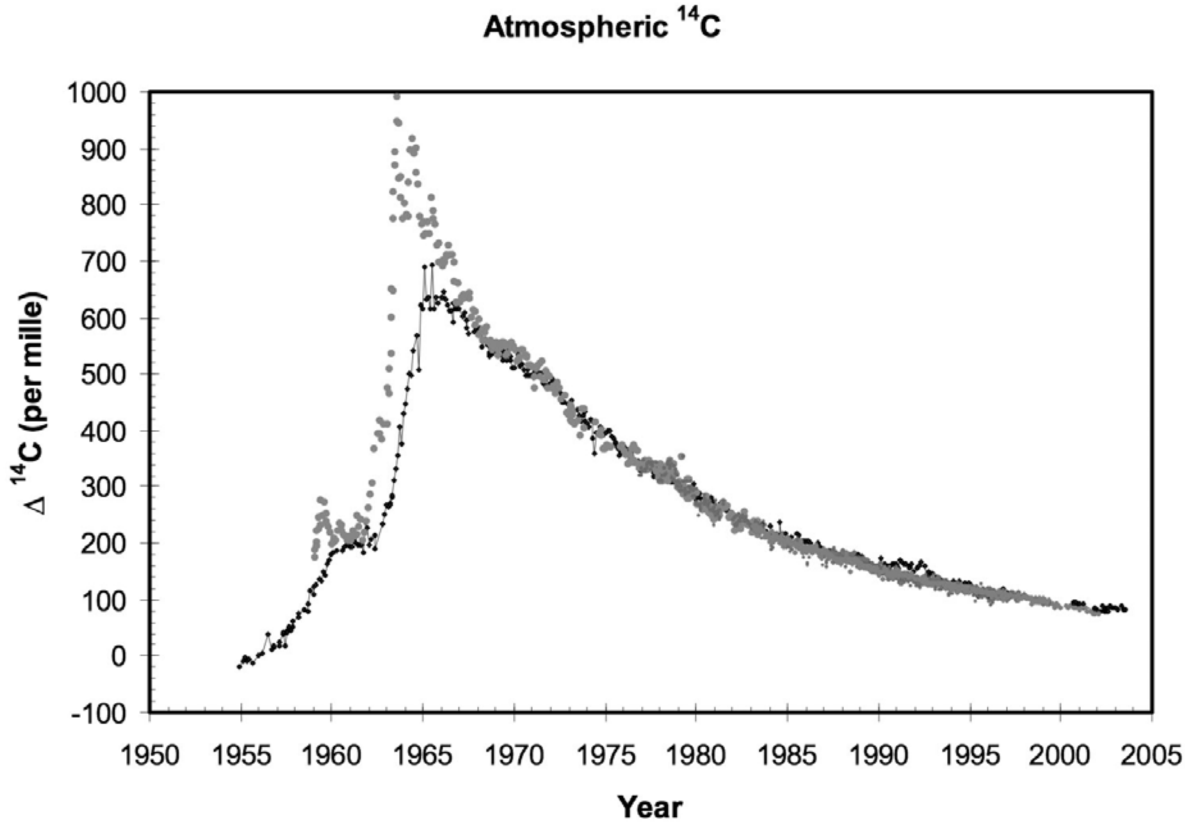

Figure 8.4: Atmospheric carbon-14 levels measured by Rafter and Fergusson from 1955 showed an increase in levels of carbon-14 that they attributed to atmospheric nuclear bomb testing. This graph, which shows carbon-14 levels from 1955 to 2005 depicts a clear spike in carbon-14 levels in the 1960s, when atmospheric testing was at its peak. The continuous line is Wellington data, the unconnected points are Northern Hemisphere data, with carbon-14 levels expressed as parts per million above normal levels. Source: Courtesy Rodger Sparks.[88]

New Zealand was represented at the 1958 Atoms for Peace conference by Bill Hamilton and Athol Rafter from the DSIR, Darcy Walker, professor of physics at Victoria University, H. N. Parton, professor of chemistry of the University of Otago, Ernest Marsden, representing the NZAEC, and John Scott, of the New Zealand High Commission in London.[89] At the conference, Rafter presented the discovery of a link between atmospheric nuclear testing and raised level of radiocarbon in the atmosphere, which he and Fergusson had first published in *The New Zealand Journal of Science & Technology* under the title “The Atom Bomb Effect”. He and Fergusson had determined that the nuclear weapons tests of the 1950s had doubled the normal amount of atmospheric carbon-14 in the northern hemisphere, and increased southern hemisphere levels by 60 per cent. Since radiocarbon dating relies on comparing radiocarbon:carbon ratios in a sample with known ratios from specific time periods, this finding was highly significant, with the sudden spike of “bomb” carbon allowing samples from the 1960s to be dated to within a year or

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[88] Rodger Sparks, ‘Radiocarbon Dating – New Zealand Beginnings’, *New Zealand Science Review* 61, 2 (2004), pp39-41.
[89] Hamilton, report on Second United Nations International Conference on the Peaceful Uses of Atomic Energy, 10 February 1959, ED1, W2673, 2/0/22/5, part 2, *ANZ*.

two.[90] Impressed by their paper, Libby, the American pioneer of radiocarbon dating, contacted Rafter to ask if his team would participate in Project Sunshine, a USAEC project to measure environmental radioactivity resulting from nuclear bomb tests. As covered in chapter seven, a network of monitoring stations was established in New Zealand with USAEC funding, with rainwater samples tested monthly for levels of strontium and other radioactive isotopes. In 1959, however, the network was passed onto the Department of Health's Dominion X-Ray and Radium Laboratory that was now responsible for monitoring fallout levels in New Zealand.[91]

The trip was also an opportunity for New Zealand scientists to learn more about the northern hemisphere nuclear programmes and to cement relationships with scientists in the United States and United Kingdom nuclear industries. After the conference, Hamilton and the other New Zealand delegates were guests of the UKAEA and visited the Atomic Energy Research Establishment at Harwell, the Calder Hall nuclear power station in Cumbria, and Dounreay in the north of Scotland where a team led by the New Zealander R. W. Hurst was experimenting with the first fast breeder reactor. In these early years of nuclear technology, before the problems of disposal of a reactor's radioactive waste were acknowledged, a nuclear reactor that could produce more fissile material than it burned was considered a good thing. Hamilton then travelled to the United States, where he visited the USAEC's headquarters in Washington, Brookhaven National Laboratory at Long Island, and the nuclear laboratory at Los Alamos, which continued to be involved in the development of nuclear weapons.[92]

First-hand exposure to the British and American nuclear industries did not sway Hamilton's resolve that a nuclear reactor was not a priority for New Zealand science. In the *Dictionary of New Zealand Biography* profile of Hamilton, this agricultural scientist is described as being "convinced that the country's economic future depended on scientific research that was focused on its resources and potentials".[93] A nuclear reactor did not fit into this scheme. In reporting on the 1958 conference, Hamilton repeated his conclusion from the end of the 1955 conference that New Zealand should not undertake research in nuclear physics or technology. He did recommend, however, that there was scope to extend the use of radioisotopes in industry in New Zealand, recommending the appointment of a full-time staff member to advise industry on how

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[90] T.A. Rafter and G.J. Fergusson, 'The Atom Bomb Effect: Recent Increase in the 14C Content of the Atmosphere, Biosphere, and Surface Waters of the Oceans'. *New Zealand Journal of Science and Technology* 38, 8 (1957B): 872–883.
[91] Galbreath 1998, p162
[92] *The Evening Post*, 11 November 1958, ED1, W2673, 2/0/22/5, part 2, *ANZ*.
[93] Ian L. Baumgart, 'Hamilton, William Maxwell 1909–1992', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded on 8 April 2010.

isotopes could be profitably employed. Illustrating the DSIR's agricultural focus, he also advised on an expansion of the use of radiation-induced mutations in the DSIR's plant breeding programme. "The cobalt source now at the Division of Nuclear Sciences is well suited for irradiation of plant material and no further additional facilities are required" he wrote, though he did concede that "the installation of an accelerator and, at a later date, a reactor, will permit a wider choice of ionising radiation".[94] The possibilities of fusion as a power source were a feature of the 1958 conference but Hamilton rightly told *The Evening Post* that it was "unlikely that electric power obtained by harnessing the hydrogen bomb – the fusion of deuterium and tritium – will be making a great contribution to the world's supply in the present century".[95]

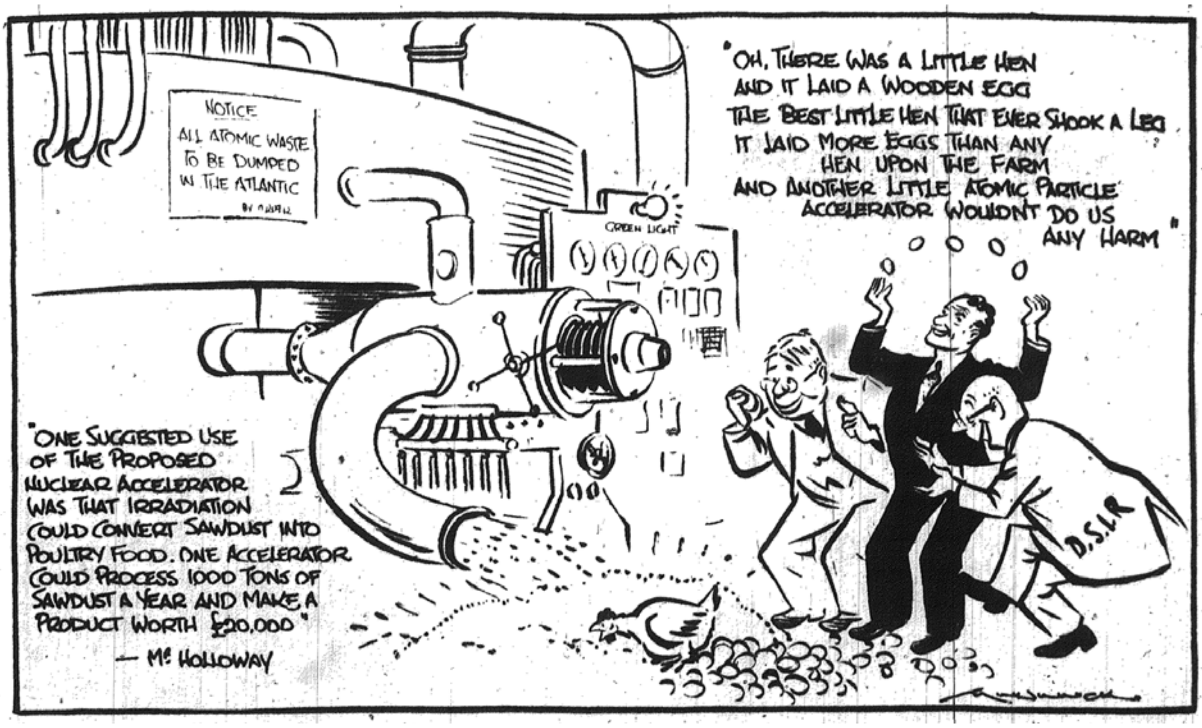

Figure 8.5: In June 1958, Holloway, the Minister in charge of the DSIR, suggested the new Institute of Nuclear Science's accelerator could be used to convert sawdust into poultry food. *New Zealand Herald*, 5 June 1958, p12.

John Scott of the New Zealand High Commission in London also reported on the 1958 conference. Consistent with the support that the Ministry of External Affairs had been giving American approaches to assist New Zealand with pursuing atomic energy for the future, Scott concluded his report by saying, "Every country, including New Zealand, which aspires to high living standards, enlightened policies and practices for social betterment, and the maintenance of its position in the forefront of the progressive and developing countries of the world, must accept

[94] Hamilton, report on Second United Nations International Conference on the Peaceful Uses of Atomic Energy, 10 February 1959, ED1, W2673, 2/0/22/5, part 2, *ANZ*.
[95] *The Evening Post*, 11 November 1958, ED1, W2673, 2/0/22/5, part 2, *ANZ*.

the challenge which atomic energy presents. It is a tool which will benefit greatly those who put use to it quickly.” While saying that the 1958 conference focused on developments in relation to fusion, Scott also reported on some of the latest predictions on the future use of isotopes, including, “the production of books using specially prepared paper that would last 20,000 years, the preservation of food, disinfestation of grain, and the treatment of inoperable cancer”.[96] In New Zealand there were other unusual predictions about the possibilities of nuclear technology for the future. In announcing the decision to set up an institute of nuclear sciences and purchase an accelerator, Holloway talked about the “miraculous possibilities” in the peaceful use of nuclear energy. As well as outlining applications of nuclear science to medicine, industry and agriculture, he said one possibility was that the new accelerator could process 1000 tons of sawdust a year into poultry food worth £20,000.[97] How irradiation could turn sawdust into food was not explained.

US Nuclear Equipment Grant and New Zealand’s first nuclear reactor

New Zealand science was as under-funded in the 1950s as it is today – particularly after Holland’s National Government slashed the DSIR’s budget. Offers of gifts of laboratory equipment to the DSIR and the universities were always going to be well received, so when the USAEC offered gifts to support research in nuclear science, they were accepted with no apparent suspicions of ulterior motives on the part of the Americans.

The first proposal for a nuclear reactor in New Zealand had come from Ernest Marsden and Charles Watson-Munro in 1947. Their proposal was for an Australasian low-energy pile, which they believed would have defence significance. This proposal never came to fruition, and later plans for a research reactor at the Institute of Nuclear Sciences were continually deferred to the point of never being realised. In 1961, however, New Zealand did get a nuclear reactor, though rather than being associated with the DSIR it was installed in Canterbury University’s Engineering School.[98]

At the request of the New Zealand Government, a six-man American nuclear advisory mission made a 10-day tour of New Zealand in March 1958, visiting and lecturing at various places. The team, led by the USAEC’s Richard Kirk, visited with the intent to advise on the establishment of

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[96] J. V. Scott, Report on the Second United Nations Conference on the Peaceful Uses of Atomic Energy, p27, ED1, W2673, 2/0/22/5, part 2, *ANZ.*
[97] *New Zealand Herald,* 5 June 1958, p12.
[98] W. M. Hamilton, ‘The Development of Nuclear Science in New Zealand’. In *Symposium on Nuclear Science,* DSIR Information Series No. 23, 25 February 1959.

an atomic energy programme in New Zealand, specifically on the running of a nuclear institute, the siting and operation of a research reactor, the health and radiation problems involved in running a nuclear research institute, and the use of isotopes in agriculture, medicine and industry.[99]

After the visit, the American Ambassador suggested to Holloway that certain items of equipment which the atomic energy mission considered would be of immediate use in New Zealand institutions for research and training might be made available by the United States authorities under arrangements allowed for in the 1956 bilateral agreement. In March 1959, the Labour Prime Minister Walter Nash formally replied to the American Ambassador to express New Zealand's interest in the proposal, attaching a list of equipment requested by the Auckland and Canterbury universities and the DSIR Division of Nuclear Sciences.[100] The physics and chemistry departments of the University of Auckland requested various equipment for their lab to the value of US$65,672; the nuclear engineering laboratory of the Department of Electrical Engineering of the University of Canterbury requested funding for a sub-critical research reactor and ancillary equipment to the value of US$130,000; and the DSIR's Division of Nuclear Sciences requested a mass spectrometer and other equipment to the value of US$102,280 – a total grant of US$297,952[101] (worth more than US$2 million in 2009 terms).[102]

So while the Institute of Nuclear Sciences was still expecting to gain a nuclear reactor at some stage in the future, the University of Canterbury was the site of New Zealand's first – and only – nuclear reactor. Nuclear power was seen as inevitable for future power generation and this was a valuable opportunity to train nuclear engineers in New Zealand. The sub-critical reactor at University of Canterbury arrived in the electrical engineering department in 1961, under the care of professor of electrical engineering N. M. MacElwee who only four years earlier was reported as saying that "it does not appear that nuclear power would have any advantages over hydro-electric power in the near future".[103] The sub-critical reactor by definition had no critical mass of fuel to produce a chain reaction; its operation depended on neutrons being continuously added from an outside source. The reactor used 2.5 tons of natural uranium as a fuel, a solid mixture of

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[99] Richard Kirk, Report of the visit to New Zealand, SIR1, 74/8, volume 2, *ANZ*; Series of Addresses by Members of the USAEC During Visit to New Zealand, 13 March 1958, ED1, W2673, 2/0/22/5, part 2, *ANZ.*
[100] Memo to Prime Minister, 2 March 1959, SIR1, 74/8, volume 2, *ANZ*; Paper on Purchase of Nuclear Equipment with Financial Assistance from the US, 19 August 1959, SIR1, 74/8, volume 3, *ANZ.*
[101] List of equipment in SIR1, 74/8, volume 3, *ANZ.*
[102] Calculated at www.measuringworth.com on 19 October 2009.
[103] Newspaper clipping, nd or identified, but probably *The Press*, on page with clippings from April and May 1957, MB1281, Box 1, 1/1, *University of Canterbury Archives.*

plutonium and beryllium as a neutron source, and tap water as a moderator.[104] A reading of the Dominion X-Ray and Radium Laboratory files, however, suggests that the engineering department accepted the gift without knowing much about what it entailed. In order to approve the importation of radioactive material, required under the Radioactive Substances Act 1949, the Dominion X-Ray and Radium Laboratory needed specific details of the reactor's fuel and source. The Laboratory had to write to the USAEC, the donator of the gift, for details, confessing that "no-one in New Zealand has any information on the physical properties of the uranium – in fact we are not even sure if it is uranium metal or uranium oxide, or whether U^{235} has been extracted".[105]

The secretary of the NZAEC, Jim O'Leary, described in a letter to the Dominion X-ray and Radium Laboratory "a great deal of loose talk and emotion regarding the danger involved in such material" that could be dispelled if managed correctly.[106] As predicted, the October 1961 delivery of the plutonium/beryllium neutron sources, which arrived by ship to Lyttelton, was considered newsworthy – though in today's light it is remarkable what little excitement a shipment of plutonium aroused. *The Press* reported that the "plutonium" label in the ship's manifest caused "a stir" amongst the crew when the cargo came on board, but they were reassured by shipping authorities, who in turn had been assured by the Dominion X-ray and Radium Laboratory, that the cargo was safe. This shipment, the first shipment of plutonium and the most powerful neutron source ever to arrive in New Zealand, consisted of three small cylinders, each about 2.5 cm in diameter and 4 cm long, sealed inside a large drum filled with paraffin wax.[107]

The University of Canterbury's sub-critical nuclear reactor was soon operational. From 1964 onwards, the School of Engineering prospectuses advised that all third professional year electrical engineering students would attend a short lecture course on the electrical aspects of nuclear engineering. A later elective course, Advanced Electrical Engineering, focused almost entirely on nuclear engineering and used the reactor for laboratory demonstrations and experiments, though for some reason this was not made explicit in the name of the course.[108] It is also surprising that neither the Engineering School annual prospectus, or *Student Engineer*, an

[104] SIR1, 74/8, W1414, volume 3, ANZ; Yeabsley to NZ Shipping Co, 21 September 1961, CABI CH91, 15/768, 1956-61, *ANZ CHCH*.
[105] A. D. Eppstein to USAEC, 4 September 1961, CABI, CH91, 15/768, 1959-61, *ANZ CHCH.*
[106] O'Leary to Yeabsley, 18 September 1961, CABI, CH91, 15/768, 1959-61, *ANZ CHCH.*
[107] *The Press*, 23 October 1961; *Evening Post*, 23 October 1961; 'Peaceful Plutonium', in *Radiation Protection News & Notes* 34, April 1996, pp7-8.

annual booklet published by the Engineering Society of the School of Engineering, mentioned the sub-critical reactor, which as the only nuclear reactor ever to operate in New Zealand would surely have been a drawcard for the School.[109] There was nothing secret about the reactor, however. Richard Duke, an electrical engineering student who took the nuclear engineering course in 1973, recalls the reactor being installed in a room with internal windows, through which the general student population and visitors could observe its daily use. The reactor seemed to draw no opposition and at the School of Engineering's annual open days "there were always long queues of people waiting to climb the steps to peer into the reactor tank and see the rods", recalls Duke.[110] In 1981, by which time it was clear that New Zealand had no need for nuclear power, at least until after the end of the century, the University of Canterbury ceased offering the nuclear engineering course, closed down the nuclear engineering laboratory and dismantled the reactor. The uranium in it went to the Institute of Nuclear Sciences and the neutron sources containing the plutonium went to the university's physics department where it was used in research before being recalled after reaching its 30 year lifespan.[111]

While the American gifts under the Atoms for Peace programme were of benefit to the New Zealand scientists and institutions whose laboratories they went to, it was not altruism on the part of the United States. The terms of the USAEC's gifts of research equipment to the University of Auckland's physics and radiochemistry laboratories were that the results of any research deriving from the use of equipment and materials would be shared with the United States.[112] The equipment arrived in November 1960, and Ted Collins of the physics department wrote of the "fever of excitement in the Chemistry Department as they open up their Xmas Box from Uncle Sam".[113] When American Ambassador Anthony Akers visited the new laboratories in October 1961, he expressed his view "that your countrymen share the American dream of a world at peace, and it is with great pleasure that I participate here today in this programme reflective of the peaceful use of the atom".[114]

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[108] University of Canterbury, *School of Engineering Prospectuses* for 1963-70, 77-82; Email from Richard Duke, 21 April 2010.
[109] *Student Engineer* 1961-69.
[110] Email from Richard Duke, 21 April 2010; Email from John Campbell, 20 April 2010.
[111] 'Peaceful Plutonium', in *Radiation Protection News & Notes*, No 34, April 1996, pp7-8; Diana Neutze and Eric Beardsley, *Design for a Century,* University of Canterbury Publication No. 37, Christchurch, 1987; John Campbell, personal email of 16 April 2010.
[112] H. G. Lawrence, DSIR to the Registrar, University of Auckland, 27 October 1960, SIR1, 74/8, volume 4, *ANZ.*
[113] E. R. Collins to J. T. O'Leary, NZAEC, 25 November 1960, SIR1, 74/8, volume 4, *ANZ.*
[114] *New Zealand Herald*, 11 October 1961.

Atoms for Peace

While New Zealand scientists did not embrace the nuclear age to the extent that its American friends might have hoped, it was still part of New Zealand's vision of the future. At a 1960 visit of the United States's nuclear submarine *Halibut*, thousands of Aucklanders and Wellingtonians flocked to the ports to welcome the vessel. The National Film Unit included the visit in their regular Pictorial Parade, describing the "sleek dark shape" entering Wellington Harbour in the early morning and marvelling that "somewhere inside her long grey hull a small atomic reactor provides enough power to take her around and around the world".[115] The *New Zealand Herald* described the "silent, slate-grey" submarine that arrived at Devonport as an "impressive sight", marvelling that she had travelled most of the 3,900 miles (6,200 km) from Pearl Harbour under water. "Ferry passengers gaped and New Zealand sailors slipped away from their jobs to peer at her" the paper continued.[116] As Matthew O'Meagher described the *Halibut*, "it was a symbol of progress and its capacity to travel the oceans was a vivid and attractive manifestation of the possibilities, not the fears, that New Zealanders again hoped the atom could foster".[117]

The Institute of Nuclear Sciences was well established by the mid 1960s and was conducting original research as well as providing services to agriculture, industry and medicine. Director Athol Rafter continued to hope for the long promised nuclear reactor, telling a visiting group from the National Research Advisory Council in 1965 that a nuclear reactor would be "of immense value to the nation and its scientists, and of particular value to industry".[118] With the Institute of Nuclear Sciences now fully operational and its accelerator installed, the NZAEC was, in 1966, reconstituted to act as an advisory committee on any aspects of research, development or application of nuclear science in New Zealand.[119]

By now, New Zealand was making annual contributions to the IAEA's budget, which covered most of the regular functions of the Agency such as staff, conferences and some technical assistance.[120] New Zealand representatives attended the third IAEA Atoms for Peace conferences in 1964.

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[115] USS *Halibut* Nuclear Submarine, www.nzhistory.net.nz/media/video/uss-halibut-nuclear-submarine, downloaded 20 April 2010.
[116] *New Zealand Herald*, 20 April 1960, p13.
[117] O'Meagher 2006, p59.
[118] *Evening Post,* 28 May 1965.
[119] Cabinet Minute on Atomic Energy Committee Reorganization, CM 66/16/17, ABLP W4215, 1/1, part 1, *ANZ.*
[120] Minutes of NZAEC meeting, 10 November 1964, SSC2, 8/3/4/2, *ANZ.*

Table 8.1: New Zealand contributions to International Atomic Energy Agency (IAEA).

Year	Fixed contribution (US$)	Nuclear Security Fund (US$)
1957		
1958	16,356	
1959	20,378	
1960	22,788	
1961	24,055	
1962	25,816	
1963	27,066	
1964	27,436	
1965	29,309	
1966	29,465	
1967	31,191	
1968	34,556	
1969	35,929	
1970	39,115	
1971	44,061	
1972	44,914	
1973	56,305	
1974	72,723	
1975	78,138	
1976	100,411	
1977	108,775	
1978	149,102	
1979	177,409	
1980	216,869	
1981	227,078	
1982	215,632	
1983	226,796	
1984	238,682	
1985	235,137	
1986	289,098	
1987	332,720	
1988	353,020	
1989	357,457	
1990	408,172	
1991	480,699	
1992	459,209	
1993	506,895	
1994	524,409	
1995	579,195	
1996	643,499	
1997	606,890	
1998	541,328	
1999	506,745	
2000	458,040	
2001	411,114	
2002	474,958	25,000
2003/04	560,735	25,000
2004/05	670,126	25,000
2005/06	704,182	20,000
2006/07	699,922	30,000
2007/08	748,611	25,000
2008/09	995,446	30,000
2009/10	945,618	75,000

The size of New Zealand's significant contributions to the IAEA budget can be seen as an example of how successful the nuclear industry has been in promoting a multilateral approach that has spread the costs over all countries, even New Zealand, which has never had a nuclear industry. Source: Figures for 1958-2002 assessed by the IAEA October 2002 and provided by MFAT, Vienna, 14 October 2002 by email. Figures for 2002/03 to 2009/10 calculated from data provided by MFAT, Vienna, 24 March 2010 by email.

When the United States, United Kingdom and the Soviet Union signed the Limited Test Ban Treaty in 1963, there was new hope that the world might be moving away from the endless development of new and more powerful nuclear weapons and that nuclear technology would start being used more for peaceful purposes than for weaponry.[121]

Conclusion

The 1950s and 60s saw the United States and United Kingdom looking to establish in New Zealand a nuclear partner whose dependencies on the bigger nation would be to that nation's advantage. New Zealand officials, however, cooperated only in a self-interested way, moving forward in the field of nuclear science only to the extent that it would benefit the advancement of the nation and its own scientific endeavours.

While New Zealand had concerns about nuclear bomb testing, it was generally enthusiastic about the so-called peaceful uses of the atom, and lined up, along with other smaller countries, to accept gifts from the USAEC – including a technical library, a nuclear reactor for the University of Canterbury and laboratory equipment for the DSIR – and training opportunities from the United Kingdom. Despite repeated offers of a subsidised nuclear reactor, however, the DSIR and the State Hydro-electricity Department were adamant that a research reactor was not a priority for New Zealand science or industry; rather than it being a welcome gift it would be an unnecessary source of expenditure. The scientists and engineers making these decisions showed independence in this regard – weighing up the offers made and making pragmatic decisions about what would be useful to New Zealand's future – often to the chagrin of the Department of External Affairs, who saw the DSIR's agricultural focus as blinding them to the potential benefits of nuclear science and were concerned about the impact on New Zealand's relationship with the United States.

New Zealand did not participate in the global nuclear industry to the degree that some other politically small countries did – Australia, for example, was exporting uranium from its mines and creating radioisotopes for medical and industrial use at its Lucas Heights reactor – but did play its part on the global stage, sending delegates to United Nations conferences on the peaceful uses of the atom and making financial contributions to the IAEA.

[121] Lawrence Badash, *Scientists and the Development of Nuclear Weapons: From Fission to the Limited Test Ban Treaty 1939-1963*, Humanity Books, New York, pp109-10.

The establishment of a DSIR Institute of Nuclear Sciences in 1959 cemented the work of a group of nuclear sciences working within the DSIR and, under the leadership of Athol Rafter, established an international reputation in the field of radiocarbon dating, becoming the southern hemisphere’s top radiocarbon dating laboratory. Even in 1959, however, when the Institute was established, there was a degree of nuclear fear and misconceptions about what nuclear science might involve, that the Government felt the need to reassure the public about.

New Zealand was now about to face a new decision with regard to a nuclear future. In 1964 the New Zealand Electricity Department flagged that a nuclear power station would be needed to meet New Zealand’s electricity demands by about 1977 and began the search for a suitable power station site and started training engineers for the task.

Chapter 9

Nuclear decision:

Plans for nuclear power

"It is safe to say that within about half a century electricity from nuclear sources will be supplied to houses and small industries under much the same conditions as the present water supply."

Ernest Marsden, June 1955[1]

"... nations may in the future be rated as advanced or backward, developed or under-developed, according to their success in applying atomic energy to the solution of their problems."

External Affairs, 14 June 1957[2]

By the late 1970s, nuclear technology was an integral part of New Zealand's medical system and nuclear science was thriving: the Institute of Nuclear Sciences was supporting environment studies and industrial and agricultural industries and had established a reputation as the southern hemisphere's leading radiocarbon dating laboratory. New Zealand's attempts to establish a uranium mining industry, however, had come to nothing; despite extensive investigations the West Coast uranium deposits were not economic. A heavy water plant planned for Wairakei had not gone ahead and the plans had not been revisited. But ever since the 1950s, there was one other aspect of nuclear technology that had been a hope for New Zealand's future – nuclear power for electricity generation.

Early plans for nuclear power

Consideration of nuclear power as an energy source for New Zealand homes and industry began in the 1950s, when nuclear power seemed poised to offer the world a safe, cheap, clean and almost limitless supply of electricity. In 1954 the world's first nuclear power plant began operating in Obninsk, near Moscow, and two years later a British nuclear plant at Calder Hall began feeding power into the national grid. The young Queen Elizabeth, who opened the plant,

[1] *Te Puke Times*, 17 June 1955, ED1, W2673, 2/0/65/3, *ANZ.*
[2] External Affairs briefing paper on Peaceful Uses of Atomic Energy for 1957 Prime Ministers' Conference, EA1, W2619, 121/2/1 (part 1), *ANZ.*

announced that nuclear energy would be "harnessed for the first time for the common good of our community".[3]

Internationally, the rhetoric for atomic energy was high. In his address to the 1955 Atoms for Peace Conference, Indian nuclear physicist and president of the United Nations Conference on the Peaceful Use of Atomic Energy, Homi Bhabha said "for the full industrialization of the under-developed areas, for the continuation of our civilisation and its further development, atomic energy is not merely an aid: it is an absolute necessity. The acquisition by man of the knowledge of how to release and use atomic energy must be recognized as the third great epoch in human history".[4] In the United States, the chairman of the United States Atomic Energy Commission spoke of an atomic future where electricity would be "too cheap to meter".[5] Australia's plans for nuclear power were already well in advance of New Zealand's when, in 1955, Charles Watson-Munro left New Zealand to lead Australia's atomic energy programme and described atomic power as "a coming force that would be comparable with the first onslaught of electricity on civilisation". [6]

But New Zealand's interest in nuclear power was about more than just keeping up with the rest of the world. By the mid 1950s, electricity demand in New Zealand was rapidly outstripping supply – particularly in the North Island – despite the regular commissioning of new hydro-electric power stations. In a 1955 paper on the economics of nuclear power in New Zealand, Tony McWilliams described New Zealand as "probably the only country in the world with a relatively high standard of living which has a continuing and serious power shortage".[7]

In 1955, in response to the need for a more systematic planning process, Cabinet set up a Combined Committee on the North Island Power Supply, initiating a system of annual planning reports.[8] That same year, Geothermal Developments Ltd was formed to produce electricity and heavy water at Wairakei (as covered in chapter 5), uranium was found in the Buller Gorge (as

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[3] Alexander Hellemans and Bryan Bunch, *The Timetables of Science*, Simon and Schuster, New York, 1988, p519; Tony Hall, *Nuclear Politics: The History of Nuclear Power in Britain*, Penguin, Harmondsworth, 1986, p32.
[4] W. M. Hamilton, Atomic Energy (report on 1955 overseas visit), c. 1955 (undated) ED1, W2673, 2/0/22/5, *ANZ.*
[5] *New York Times*, 7 August 1955, quoted in Canadian Nuclear Society website www.cns-snc.ca/media/toocheap/toocheap.html downloaded 24 November 2009.
[6] Alice Cawte, *Atomic Australia, 1944-1990,* New South Wales University Press, Sydney, 1992, p100; *The Daily News*, 14 January 1955.
[7] J. A. McWilliams, *The Economics of Nuclear Power in New Zealand*, 25 September 1957, ED1, W2673, 2/0/22/5, Part 2, *ANZ.*
[8] John E. Martin (ed), *People, Politics and Power Stations: Electric Power Generation in New Zealand 1880-1998,* 2nd ed, Electricity Corporation of New Zealand and Historical Branch, Department of Internal Affairs, Wellington, 1998, pp133-35.

covered in chapter 6) and the New Zealand delegation returned from the first United Nations Atoms for Peace conference (as covered in chapter 8).

In his report on the Atoms for Peace conference, DSIR secretary Bill Hamilton wrote that there were three main possibilities to solve the North Island's looming electricity problem: bringing hydro-power from the South Island by submarine cable; conventional thermal plants burning coal or oil; or nuclear power. Hamilton's characteristic pragmatic approach stated that the choice between the three must rest on their respective economic advantages but he did point out the benefits of the submarine cable. Not only was hydro-electric power a renewable resource that should be fully developed before we turned to non-renewable sources like coal and uranium, he wrote, it was independent from overseas supply and would not be threatened in the event of war. Hamilton also saw delaying the introduction of nuclear power as advantageous, as we would then have the benefit of technological advances and a likely cheapening of the power source.[9] Bill Latta, of the State Hydro-electric Department, was in broad agreement with Hamilton – the idea of a Cook Strait cable had come from Latta in 1950 – concluding in his report on the conference that "there is no pressing necessity to construct atomic power stations in the immediate future".[10]

Not everyone agreed. Before leaving for Australia, Watson-Munro advised that unless geothermal steam was found to provide a plentiful and cost efficient energy source, the North Island would be forced to rely on atomic power within the next 10 years. He considered the country's hydro-electric potential close to exhaustion, and advised that the use of a submarine cable to bring power from the South Island to the North Island was too problematic.[11]

By early 1956, the media was presenting the solving of New Zealand's ever-increasing demand for electricity as a choice between nuclear power and a Cook Strait submarine cable. While the DSIR and the State Hydro-electric Department favoured the Cook Strait cable, many individual scientists preferred the nuclear option, and roused popular support for it too. Not only was nuclear power seen as being more reliable than hydro-electricity, because it was not dependent on the weather, it was also able to be sited close to where the power was needed and costs were expected to come down by the time New Zealand was ready to commission a nuclear power station.

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[9] W. M. Hamilton, Atomic Energy (report on 1955 overseas visit), c. 1955 (undated) ED1, W2673, 2/0/22/5, *ANZ.*
[10] M. G. Latta, Report on Visit Overseas June-October 1955, 17 November 1955, ED1, W2673, 2/0/22/5, *ANZ.*
[11] *Southland News*, 15 January 1955.

Figure 9.1: In this *Auckland Star* cartoon, Prime Minister Sidney Holland, who was criticised for going slowly on nuclear power, is seen driving the 1911 hydro-electric model vehicle. Source: Lonsdale, *Auckland Star*, 27 April 1956.

Francis Farley, senior lecturer in physics at Auckland University College and, along with Hamilton and Latta, one of New Zealand's delegates to the 1955 Atoms for Peace Conference, was reported as saying that "the real obstacle to nuclear power in New Zealand is the over-cautious play-safe attitude that is adopted in Wellington", predicting that if the "present increase in power demand continues, we might expect to have 10 nuclear power stations by 1975 to 1980".[12] Farley's colleague Professor Percy Burbidge agreed, arguing that "the system of generating power in one island and transmitting it largely to the other is to be deplored".[13] In an article in the *Auckland Star*, Farley criticised the Minister of Works, Stan Goosman, and the head of the State Hydro-electric Department, A. E. Davenport, and put forward his view that atomic power would be cheaper than a Cook Strait cable.[14] Ernest Marsden, always keen to have his voice heard on nuclear issues, supported the argument for nuclear power, and was reported as saying that those who were holding New Zealand back from nuclear science were "lazy-minded conservative diehards who are afraid of change" and frightened that nuclear science had become "a malevolent, uncultured arbiter of our destiny instead of the traditional servant of the industrial revolution".[15] Darcy Walker, Watson-Munro's successor as professor of physics at Victoria

12 *Auckland Star*, 26 April 1956, p1.
13 *The Rotorua Post*, 26 April 1956
14 *Auckland Star*, 24 April 1956, p3.
15 *The Dominion*, 18 February 1956, EA1, W2619, 121/2/1, *ANZ.*

University, and another New Zealand delegate to the 1955 Atoms for Peace conference, wrote an impassioned letter to the Department of External Affairs in which he referred to nuclear science as “the crowning achievement of man’s research in the physical sciences” and criticised New Zealand’s “lack of decision about atomic energy”. Walker called for “a bold and enterprising attitude towards atomic energy” to help New Zealand retain its best brains and stimulate a new outlook on the nation’s industrial future. “If nuclear science and engineering is largely ignored”, Walker added, “we forego the benefits of one of the most powerful stimulating forces of modern science. If we have faith in the future of New Zealand we cannot afford to do this.”[16]

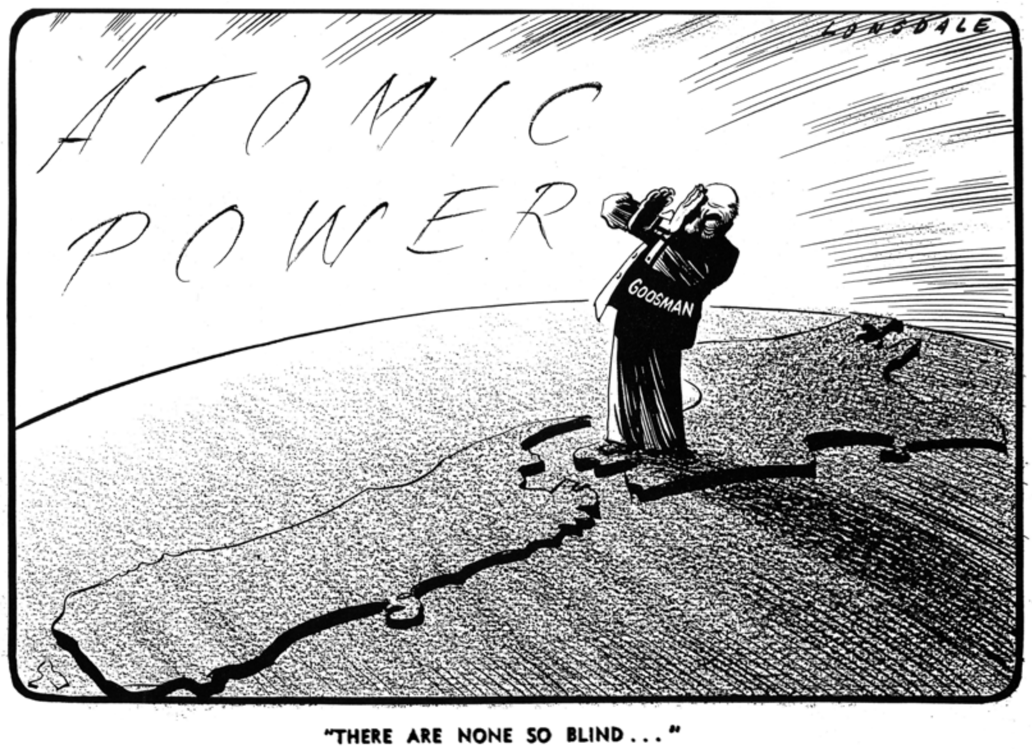

Figure 9.2: Stan Goosman, Holland’s Minister in charge of Works and the State Hydro-electric Department, is seen being blinded by the light of atomic power: an editorial the previous week had described those who said atomic power stations were years away were “blind to the fact that Britain is proceeding with a full-scale nuclear power programme”.[17] Goosman was seen as blind to the idea that that nuclear power was the right option for New Zealand’s future. Source: Lonsdale, *Auckland Star*, 4 May 1956, p2.

The editor of the *Auckland Star* took the side of physicists like Farley and Burbidge. Under editorials headlined “These scientists must not be ignored”, and “Only the best advice will do” the stance of government officials like Hamilton and Latta was criticised, with the comment that “at a time of electricity crisis, when the whole country is paying for the mistakes of the past, the Government remains stubbornly deaf to the advice of men in a position to give the best possible advice on the practical economics of a nuclear power station”. The May 1956 editorial added

[16] Darcy Walker to J. V. Wilson, Dept of External Affairs, 3 January 1956, EA1, W2619, 121/2/1 (part 1), *ANZ*.
[17] Editorial, *The Auckland Star*, 27 April 1956, p4.

that the "people are in no mood to tolerate further short-sightedness over power planning. They see atomic energy as a probable, and perhaps the only effective, alternative to a future darkened by power shortages", and called for an investigation into the possibility of nuclear power.[18] The *Otago Daily Times* added to the argument against the submarine cable, describing Cook Strait as "a region notoriously disturbed by strong currents and seismic shocks in which the seabed contains fissures of considerable width".[19] It was not just the mainstream newspapers advocating nuclear power. The left wing newspaper *The People's Voice* concluded a piece reporting Farley and Burbidge's arguments by saying "It is in the interests of workers, housewives, farmers and industrialists of New Zealand to have available a source of reliable power, and it is the responsibility of the government to provide it".[20]

As the argument between the university physicists and the government officials continued, other newspaper headlines warned of looming power cuts if Auckland consumers failed to meet voluntary savings targets: there was high public awareness of the need for a new power source.[21] But the Government line about nuclear power remained cautious. Stan Goosman, the Minister in charge of Works and the State Hydro-electric Department in the National Government, warned New Zealanders not to harbour premature hopes that nuclear power would soon be brought into New Zealand, saying that nuclear power would not be economically feasible for many years.[22] Goosman responded to Burbidge's claims by challenging the argument that atomic power would be cheaper than hydro power and asking "on what ground, or by what authority, Professor Burbidge sets himself up as an authority on practical power supply economics".[23] Hamilton remained circumspect, with newspapers reporting his views that nuclear power held no promise of cheap electricity and it would probably be 20 years before New Zealand had need for trained operatives capable of supervising the running of nuclear power stations.[24] The Ministry of Works agreed, with senior engineer J. W. Ridley stating that while atomic power would be one of New Zealand's major sources of energy in the future, it would not be an economic proposition for New Zealand within the next 20 years.[25] The voices of overseas experts always carried weight in a domestic argument, and in May 1957, when Leonard Cronkhite, director of the United States Atomic Industrial Forum, visited New Zealand his opinion was widely reported.

[18] *Auckland Star*, 27 April 1956, 2 May 1956, ED1, W2673, 2/0/65/3, *ANZ.*
[19] *Otago Daily Times*, 14 June 1956, ED1, W2673, 2/0/65/3, *ANZ.*
[20] *The People's Voice*, 9 May 1956, ED1, W2673, 2/0/65/3, *ANZ.*
[21] 'Save Power or Take Cut on Monday' was the front page headline in the *Auckland Star*, 27 April 1956, p1.
[22] *The Auckland Star*, 27 April 1956, p4.
[23] *The Auckland Star*, 28 April 1956, p3.
[24] *Christchurch Star Sun*, 7 June 1956; *The New Zealand Herald*, 11 September 1956, ED1, W2673, 2/0/65/3, *ANZ.*
[25] *The Timaru Herald*, 29 September 1956, ED1, W2673, 2/0/65/3, *ANZ.*

Cronkhite voiced his support for the Government stance, saying that New Zealand appeared to be the least in need of atomic power of any of the 12 countries he had visited on his world tour. Cronkhite pointed out that New Zealand was "fortunately situated with natural power resources, such as rainfall, fast-flowing rivers, and geothermal power resources. The country could probably use the money required by an atomic reactor to much better advantage by producing power by these means."[26]

Opinions remained divided, with individual scientists tending to be the ones voicing their endorsement of nuclear power. As with the current climate change "debate", these vocal dissenters got more than their share of media coverage. A DSIR physicist, Tony McWilliams, after returning to New Zealand from Harwell (where he had been working on the fractional distillation of heavy water in preparation for the planned Wairakei heavy water plant), pushed for the early use of nuclear power plants in New Zealand. In a 1957 address to the Wellington branch of the New Zealand Institute of Engineers, which was widely reported in newspapers, McWilliams said that "nuclear power shows promise of satisfying completely the incremental power demand with considerably less strain on the economic resources of the country. It frees the power supply from the vagaries of the weather which will always plague hydro-electric power. Great advantage should stem from the use of nuclear power and its early introduction should be seriously considered." He added that nuclear power stations could be introduced to New Zealand as early as 1962-63.[27] There were also some warning voices from within the universities, however, and as early as 1955, Professor Rastrick, of Canterbury University College's mechanical engineering department, warned that the problem of disposal of radioactive waste would have to be overcome before atomic power could be generated in New Zealand.[28]

Today, the Labour Party is closely associated with New Zealand's nuclear-free policy and for enacting nuclear-free legislation in 1987, but when it came to decisions about nuclear power in the 1950s, they were more pro-nuclear than National. At the end of 1957, after a Labour Government led by Walter Nash had been elected, the new Minister of Works and Electricity, Hugh Watt, responded to public calls with an announcement that the Government would launch an investigation into the possibility of nuclear power stations in New Zealand. While in opposition, the Labour Government had opposed the Cook Strait cable project, and Watt now

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[26] *The Evening Post*, 29 May 1957; *The Press*, 1 June 1957.
[27] *The Dominion*, 26 September 1957, ED1, W2673, 2/0/65/3, *ANZ;* J. A. McWilliams, 'The Economics of Nuclear Power in New Zealand', September 1957, ED1, W2673, 2/0/22/5, part 2, *ANZ.*
[28] *The Dominion*, 31 August 1955, EA1, W2619, 121/2/1, part 1, *ANZ.*

said that the investigations into nuclear power would be more intense than under the previous Government and would be conducted with the view that electricity produced by nuclear means was a distinct possibility for the future.[29]

The State Hydro-electric Department reported in 1958 that the Government had made enquiries regarding the provision of power from atomic energy, which it described as a "promising source of power". It continued, however, that New Zealand had "natural sources which, at the moment and for some few years ahead, seem likely to provide power more economically and with less drain on overseas funds". It recommended that atomic energy be reconsidered in five years. The report continued by approving the construction of a new hydro-electric station at Benmore on the Waitaki River, initially to supply power to the South Island, and deferred a decision on linking the islands with a Cook Strait cable.[30]

By 1961, after numerous technical issues had been resolved, the Government approved the scheme to link the North and South Island power systems and a contract for manufacturing and laying the cables was placed. In 1965 a submarine high-voltage DC cable – only the third of its kind in the world – finally linked the North and South Islands. The Benmore station, on the Waitaki River, became operational in May 1965, with most of its power going north to provide the growing population of the North Island with, at last, a plentiful and reliable source of electricity. But while the Cook Strait cable had won the toss up between nuclear power and a link between the North and South Islands, it now seemed that both solutions would eventually be required.[31]

Meanwhile, the annual reports of the New Zealand Electricity Department (NZED)'s Planning Committee on Electric Power Development in New Zealand continued to project future electricity demand and detail plans for future power sources for New Zealand. (The State Hydro-electric Department had became the New Zealand Electricity Department in 1958, reflecting the country's diversifying sources of electricity.) The 1964 report of the Planning Committee on Electric Power Development in New Zealand contained the first mention of nuclear power as a possible source of electricity for New Zealand. In this report hydro, geothermal, natural gas, oil, coal and nuclear were all considered to meet New Zealand's future and rapidly escalating demand for power. In considering nuclear power as an option, the Committee noted that "there is

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[29] Martin 1998, p137; *The Evening Post*, 20 December 1957, ED1, W2673, 2/0/65/3, *ANZ.*
[30] Electric Power Development: Statement by the Hon. H. Watt, 20 August 1958, *AJHR* 1958, volume 2, D4a.
[31] Martin 1998, pp174-82; A. H. McLintoch (ed), *An Encyclopedia of New Zealand*, 1966 at www.teara.govt.nz/en/1966/power-resources/10, downloaded 23 November 2009.

no doubt that this means of power generation must be introduced in New Zealand by about 1977". It also had the foresight to note that the cost of setting up such a plant could be in the order of at least £100 million, and recommended that a possible site for a nuclear reactor be selected, and a meteorological observing and recording station be set up to provide details on local atmospheric conditions.[32]

Training nuclear engineers

While there had been many arguments about the timing of the introduction of nuclear power to New Zealand, and the relative benefits of different energy sources, it was widely accepted, even amongst the cautious DSIR hierarchy, that nuclear power would be introduced at some stage in the future, and scientists and engineers should be trained for this eventuality. As covered in chapter 8, in 1961 the University of Canterbury set up a nuclear engineering course, complete with a sub-critical nuclear reactor in the laboratory, to train engineers for the New Zealand industry.

The responsibilities of the New Zealand Atomic Energy Committee (NZAEC) included liaison between organisations and departments concerned in planning for the introduction of nuclear power, and in 1964 the committee set up siting and manpower subcommittees to study suitable sites for a nuclear power station and manpower requirements for the operation of a power station.[33] The NZAEC Manpower Subcommittee was chaired by Robin Williams (one of the young New Zealand scientists who worked on the Manhattan Project during the Second World War) and included representatives from the NZED, the Ministry of Works, DSIR, and Institute of Nuclear Sciences.[34]

The Manpower Subcommittee first reported in 1966, outlining recommendations for a training programme to enable the NZED and the Ministry of Works to train staff to work with consultants engaged in siting, design, construction and start up of a nuclear power station that was anticipated to be needed by 1977. A first stage, sending two senior engineers for a four-month nuclear engineering course at Lucas Heights in Australia, had already taken place.[35] Henry Hitchcock of the NZED described the 1966 course, which he attended as a 54-year-old research engineer, as both interesting and traumatic. He recalled arriving at the course "equipped

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[32] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1964.
[33] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1965.
[34] Report of Sub-committee on Manpower Requirements for Nuclear Power Development, 25 November 1966, ABLP, W4215, 3/5, part 1, *ANZ.*

with stage one physics and stage one chemistry which I'd passed in 1930, which is two years before the neutron was discovered. Nuclear physics was a big jump ... I was dragged from the beginning of the twentieth century to the second half of the twentieth century by the scruff of my neck."[36]

A programme sending more engineers – nuclear, electrical, mechanical and civil – as well as a reactor physicist and a health physicist was to follow, with the Australian School of Nuclear Technology at Lucas Heights and the University of New South Wales in Sydney recommended as the closest places for intensive nuclear engineering education. The Committee noted that offers for overseas training had also come in from the UKAEA and Atomic Energy of Canada Ltd.[37] The Committee rejected the idea of expanding training facilities in New Zealand, but was operating under the expectation that training would eventually be available at the proposed Institute of Nuclear Sciences research reactor at Gracefield.[38] After purchasing a sub-critical nuclear reactor with funds provided by the American Atoms for Peace programme in 1961, the University of Canterbury's Electrical Engineering Department began offering a nuclear power engineering course to train students for the eventual introduction of nuclear power stations to New Zealand. More advanced training was offered overseas: throughout 1967 and 1968 a further seven NZED officers attended the training course at Lucas Heights and another two NZED staff attended a nuclear course at Imperial College in London.[39]

A larger team spent two years training in the United Kingdom. In May and August 1967, a team of six New Zealanders – five engineers and a radiation physicist – travelled to the UKAEA Reactor Design headquarters at Risley, Lancashire where they worked on a joint British and Australian project to adapt the enriched fuel Steam Generating Heavy Water Reactor into a reactor that could be fuelled by natural – rather than enriched – uranium. The New Zealand group was led by Hector Jones of the NZED and included men from the Ministry of Works, the NZED and the Department of Health's National Radiation Laboratory. The New Zealanders' main objective in this project was to become competent in the technology associated with a

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[35] Report of Sub-committee on Manpower Requirements for Nuclear Power Development, 25 November 1966, ABLP, W4215, 3/5, *ANZ.*
[36] Henry Coleridge Hitchcock, interview by Judith Fyfe, 19 and 23 February 1987, NZOHA Electricity Centenary Oral History Project, Alexander Turnbull Library OHInt-0003/04.
[37] Report of Sub-committee on Manpower Requirements for Nuclear Power Development, 25 November 1966, ABLP, W4215, 3/5, part 1, *ANZ.*
[38] Third report of Sub-committee on Manpower Requirements for Nuclear Power Development, February 1969, ABLP, W4215, 3/5, part 2, *ANZ.*
[39] Third report of Sub-committee on Manpower Requirements for Nuclear Power Development, February 1969, ABLP, W4215, 3/5, part 2, *ANZ.*

water-moderated nuclear reactor, so as to form a team of engineers capable of working with overseas consultants when it came time for New Zealand to commission a nuclear reactor.[40]

Figure 9.3: The ANZAC team, at the end of their two-year stint, at the UKAEA Reactor Design Office at Risley. The New Zealand team includes Rob Aspden (in back row, smiling, third from left), Hector Jones (in front and to the right of Aspden) and Neil Fyfe (back row, obscured). Three other members of the New Zealand team are absent from the photograph. Courtesy Rob Aspden.

The project was completed in 1969 – coincidentally, the same year the Maui gas field was discovered in offshore Taranaki by a group of international petroleum companies. After the course, three members of the New Zealand team stayed on in London to study the functions of a licensing authority, and the procedures followed in reactor safety assessment and nuclear power station safety inspection, with the Ministry of Power's Inspectorate of Nuclear Installations. They also visited Germany and Canada's heavy water reactors. In their report to the NZED they concluded that even if the discovery of natural gas deferred the planned New Zealand nuclear programme, then global advances in operating nuclear power stations of the type suitable for New Zealand conditions would have built up to the point where reasonably developed and proven systems will be available. "Such a delay should not mean any let-up in our efforts to prepare for the introduction of nuclear power stations into New Zealand" they added. "On the

[40] D. H. Jones, New Zealand Nuclear Group general report on attachment to UKAEA and other related assignments, October 1969 (Rob Aspden collection); Second report of Sub-committee on Manpower Requirements

contrary, the ‘breathing space’ should be utilised to continue to build a pool of engineers and scientists trained in the various technologies and know-how involved, and who will be capable of forming a solid foundation on which successful nuclear power generation in New Zealand must ultimately rest.”[41]

Despite increased uncertainty about the future of nuclear power for New Zealand caused by the Maui gas discovery, which had the potential to solve New Zealand’s electricity needs for the medium term, officers from the NZED, Ministry of Works, Department of Health and Commission for the Environment continued to be trained at Lucas Heights and other international nuclear technology courses. By the beginning of 1976, 26 New Zealanders had undergone some form of overseas training in nuclear technology.[42]

Finding a suitable site

Auckland’s population was rapidly expanding and creating the biggest increase in electricity demand. In his 1964 report on nuclear power generation, Eric Mackenzie, general manager of the NZED, had recommended that serious consideration be given to locating a nuclear power station north of Auckland city, given “the very difficult transmission problems concerned with delivering power to the Auckland area” and the lack of an indigenous fuel resource.[43] In December 1964 the Siting Subcommittee of the NZAEC met for the first time, and, responding to recommendations tabled by the NZED, selected a peninsula in the south-east area of the Kaipara Harbour as the primary site for New Zealand’s first nuclear power station, with a nearby site, at South Head, identified as a second option.[44]

The Siting Subcommittee was led by Philip Blakeley of the NZED and included representatives from the Ministry of Works, the Meteorological Office, the Department of Health (Jim McCahon of the National Radiation Laboratory) and the Institute of Nuclear Sciences. The Committee’s brief was to select a site that took into account health and safety issues and engineering and transport requirements, and had a suitable supply of cooling water, and to begin observations of climate, hydrology and background radioactivity. While sites at Kawau Creek and Oyster Point on the Kaipara Harbour were the focus of investigations, the Committee also

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for Nuclear Power Development, February 1968, ABLP, W4215, 3/5, part 2, *ANZ.*
[41] D. H. Jones, New Zealand Nuclear Group general report on attachment to UKAEA and other related assignments, October 1969 (Rob Aspden collection), p8-9.
[42] R. G. Norman to Members of NZAEC, February 1976, ABLP, W4215, 3/5, part 4, *ANZ.*
[43] E. B.Mackenzie, Nuclear Fuel Power Generation, Appendix 4 to Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1964.
[44] Minutes of sub-committee meeting, 21 December 1964, ABLP, W4215, 3/2, part 1, *ANZ.*

considered a further 18 sites between the Manukau and Kaipara Harbour entrances on the west coast – including a site at Bethells Beach and one between Piha and Karekare – and between the Whangaparaoa Peninsula and Pakiri on the east coast. Water for the proposed power station would come from streams in the Waitakere ranges and in the hills north of Puhoi or by drilling to the water table. In 1965 the Meteorological Office installed anemometers to measure wind speed at the two favoured sites on the Kaipara Harbour, and the NZED began measuring sea-water temperatures. The New Zealand Navy conducted a hydrographic survey near the two sites and the New Zealand Geological Survey conducted seismic surveys to investigate the underlying geology.[45] Further investigations studying foundation materials and availability of cooling water confirmed by 1968 that the South Head site was suitable, and investigations began to focus on the Oyster Point site, which had the advantage of being closer to Auckland.[46]

In considering the best site for a power station, priority was given to safety of the human population in the event of an accident. One of the issues faced was the risk of earthquakes, and in 1971 the New Zealand Atomic Energy Committee set up a Working Group for Seismic Effects on Nuclear Installations to "examine and report on problems relating to design requirements and the construction of nuclear reactor installations in New Zealand, resistant to seismic effects".[47] The impact of the day-to-day running of a nuclear power station on the land and marine environment was given less consideration. A report was received, however, from the New Zealand Oceanographic Institute, who advised that the discharge of warm water effluent from a power station into an enclosed shallow harbour like Kaipara, the largest harbour in Northland, would significantly raise the water temperature which, as well as encouraging the breeding and growth of species already present, could encourage the establishment of exotic warm water species arriving on ships. It also said that algal blooms and various destructive marine boring organisms could be more likely in the warmer waters. In summing up, the Oceanographic Institute said that altering the temperature regime in the harbour could "affect a large number of people and cause considerable public inconvenience and anger … because it would affect the facilities for recreation … and commercial fisheries."[48]

Given that Auckland was the city most in need of a new power source it is perhaps not surprising that academics from Auckland University led the call for nuclear power. In the

[45] Notes from Siting Sub-committee meeting of 13 December 1965, ABLP, W4215, 3/2, part 1, *ANZ*; Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1966.
[46] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1968.
[47] J. T. O'Leary to Chairman and Members, NZAEC, 23 September 1971, AAOQ, W3872, 72/184/6, part 1, *ANZ*.
[48] New Zealand Oceanographic Institute to NZED, 3 October 1966, ABLP W4215, 3/2, part 1, *ANZ*.

tradition of Watson-Munro, Farley and Burbidge before him, Auckland University's chemistry professor, A. L. Odell (who was involved in many nuclear science projects), in 1965 said that New Zealand would benefit greatly through cooperation with Australia on the introduction of nuclear power.[49] *The Dominion* called his suggestion "eminently sound", pointing out that Australia had already amassed a fund of scientific and engineering knowledge about nuclear power that could help save New Zealand time and money.[50] By now Australia's research reactor at Lucas Heights had been operating for five years, and in another four years, in 1969, plans would be announced for a nuclear power station to be built in Jervis Bay in New South Wales. Tenders for the reactor, which would have to be supplied from overseas, would be called for and $1.25 million spent on building access roads, houses for future employees, and water and power services.[51]

Commission date set

While earlier reports identified the likely need for nuclear power by about 1977, 1968 was the first year that plans for a nuclear power station came within the NZED's 10-year planning period. The 1968 annual report recommended a 250 MW reactor turbine generator unit to start operation in 1977, with three similar units following at yearly intervals, to build the station up to 1000 MW generating capacity. As well as observations made at the favoured Kaipara Harbour sites, consideration had also been given to possible additional nuclear power station sites in the Firth of Thames, south of Auckland City, and at Baring Head, near Wellington. The 1968 report concluded, however, that the programme for the introduction of nuclear power could be significantly affected in the event of early large-scale discoveries of natural gas, which would have the advantage of being an entirely indigenous resource.[52]

The 1969 report pushed the commissioning date for the first 250 MW nuclear power station back one year, to 1978. [53] Also in 1969, the British company of Preece, Cardew, and Rider were engaged to prepare a report studying the economics of nuclear generation in relation to hydro-electric and thermal power generation. If nuclear power was found to be economically viable, they would then proceed to make a specific proposal suitable for New Zealand conditions.[54] In

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[49] *Evening Post*, 1 November 1965; 'Recent Research', from A. H. McLintock (ed), *An Encyclopaedia of New Zealand*, originally published in 1966. *Te Ara - the Encyclopedia of New Zealand*, www.TeAra.govt.nz/en/1966/nuclear-science-in-new-zealand/4, downloaded 15 March 2010.
[50] *The Dominion*, 2 November 1965.
[51] Cawte 1992, pp128-131. Plans for The Jervis Bay nuclear power station were cancelled in 1971.
[52] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1968.
[53] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1969.
[54] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1969.

May 1969 *The Evening Post* touted natural uranium, heavy water for the first electricity-generating nuclear reactor in New Zealand, giving its advantages as being a low-cost fuel, with fuel fabrication procedures simple enough to be carried out in New Zealand. The article also added that such a reactor "produces a considerable quantity of plutonium", adding that "because it is unlikely New Zealand would require plutonium until some years after the first nuclear station is established, the spent fuel would be stored away in underground tanks on the station site". [55] Plutonium was useful as a reactor fuel and for bomb production, but if it was being produced but not used it would become a highly radioactive waste that required enormous care to be either held or transported. Plutonium is also inflammable and can be very dangerous when dispersed by fire. It was not until the mid 1970s that plutonium produced by reactors was seen as a potential problem rather than an advantage, though even then environmentalists' main concerns were the possibility of some plutonium escaping into the atmosphere, or the threat of terrorism – rather than disposal of the highly radioactive waste.[56]

Preece, Cardew and Rider's final report on the Economics of Nuclear and Alternative Forms of Generation was received by the NZED in late 1970. While the initial brief of the company was to confirm that nuclear power was the most economic way to meet growing demand in the North Island, and to recommend the most suitable type of reactor, the Maui gas discovery switched the focus of their investigations to economic comparisons between gas-fired, oil-fired, and nuclear-fuelled stations. Preece, Cardew & Rider's report showed that the "relative economic merits of the various types of generation considered depended on the price payable for fossil fuels, and the weighting given to overseas funds". The consultants recommended that if, after taking into account the above factors, nuclear-fuelled generation appeared to be the most attractive proposition, tenders should be called for a 1000 MW nuclear-fuelled station. Should the tenders confirm its economic advantage, construction of such a nuclear power station could proceed.[57]

Indigenous fuel sources, however, were now proving more abundant than previously realised. By 1972, testing of the oil wells off the Taranaki coast had revealed large quantities of natural gas; more than enough to fire the 600 MW power station under construction at New Plymouth. At the same time, a reassessment of Waikato's coal reserves revealed enough coal in the Huntly

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[55] *Evening Post*, 15 May 1969, AATJ 6090, W4897/102, 5/22, part 5, *ANZ.*
[56] *The Post*, 5 August 1974, AATJ 6090, W4897/102, 5/22, part 5, *ANZ.*
[57] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1971.

area to support a 1000 MW thermal power station.[58] In 1973, the New Zealand Government entered into a joint venture with an oil consortium to develop the Maui off-shore gas field, a move the NZED saw as meaning that New Zealand could now defer the introduction of nuclear power stations until the late 1980s, or even later, should more indigenous energy resources be found. Even so, they made it clear that consideration should continue to be given to the resources required for a future nuclear power programme.[59]

The early months of 1973 were very dry and New Zealand's reliance on hydro-electricity meant more electricity restrictions and even occasional power cuts and blackouts. Later in the year came the oil crisis, in which Arab nations set up an embargo on oil exports, leading to huge increases in oil prices which limited the possibility for thermal generation using oil but also highlighted the difficulties of reliance on imported fuel supplies. Another dry summer followed. In response, the NZED's construction programme was advanced, the Power Planning Committee pushed for sufficient capacity to meet dry season demand, and the 1973 Huntly coal-fired station was approved.[60]

The 1974 report noted that "other countries without the indigenous resources of New Zealand are embarking on a vigorous nuclear programme to meet their energy requirements" and as far as New Zealand was concerned, "plans for introducing nuclear power must be made".[61] This was the first plan that adopted a 15-year planning period (as opposed to the 10 years used previously), meaning that a nuclear power station was back on the power plan. A North Island nuclear power station of 2 x 600 MW was scheduled for commissioning in October 1988, with the rider that the introduction of the station should be deferred if suitable alternative indigenous energy sources became available. The report noted that "in the planning of nuclear power stations, safety will be a major consideration, and any proposals will have to comply with the exacting standards which would undoubtedly be laid down by whatever independent authority is responsible for the licensing and supervision of such instalments."[62] Appendix II contained information about radioactive waste disposal. It described how spent fuel from a New Zealand nuclear power station would be stored at the power station for up to three months, to allow the decay of short-lived fission products. It would then be loaded into specially constructed containers "designed to remain intact in severe accident conditions" and transported to the

[58] Letter from E. B. Mackenzie, NZED, to A. G. Robb, NZAEC, 22 August 1972, ABLP, W4215, 1/1 (part 2), *ANZ;* Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1972.
[59] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1973.
[60] Martin, pp141-43.
[61] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1974.
[62] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1974.

reprocessing plant where the unburnt fuel would be recovered. It concluded that "should a decision be made to install a nuclear station it will be necessary to conclude an agreement with an overseas reprocessing plant to treat the used fuel. The spent fuel would be transported to the plant, and the wastes treated and stored in that country along with the other wastes produced at the plant."[63]

The same year, the *New Zealand Science Review* carried an editorial about safety aspects of disposing of waste from a nuclear power station in New Zealand. The editor, J. G. Gregory, commented on Prime Minister Norman Kirk's assurance that no decision on a nuclear power station for New Zealand would be considered "until or unless there is an absolute assurance that it is possible to dispose of the poisonous and dangerous wastes of that power plant in complete safety".[64] Gregory noted that "even the United States Atomic Energy Commission did not claim to be absolutely sure of the safety of disposal and postulated the consequences of release of plutonium-239", and continued:

> More of our children would abort or be stillborn, more would be born with genetic defects, more would die in infancy, we ourselves might not live to see our grandchildren. All this would occur in an atmosphere of mental tension and ill health, social stress, and heightened civil unrest … It is *not* an option to dump these wastes anywhere – in the sea, in salt mines, in space, in the Antarctic, anywhere.[65]

The following year, 1975, the Labour Government established a Fact Finding Group on Nuclear Power to report on the possible environmental consequences of a nuclear power production programme in New Zealand. The Group set up four expert working parties to study electricity supply and demand; nuclear power generation and reactor safety; health risks; and the siting of power stations. [66]

Public opinion had changed by 1975. Internationally, nuclear power plants had been generating electricity for domestic and industrial consumption for nearly 20 years, and were now in use in nearly 20 countries, including the United Kingdom, the United States, the Soviet Union, Canada, France and India. By waiting so long to seriously consider nuclear power – primarily for cost reasons, as even without taking into account the hidden costs of nuclear power, such as management of radioactive wastes, indigenous power sources continued to be assessed as being cheaper than nuclear – New Zealand had deferred its nuclear decision until the arguments for

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[63] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1974.
[64] *Evening Post*, 27 June 1974; J. G. Gregory, 'Run Out, Fallout, All Fall Down", *New Zealand Science Review* 31, 4 (1974), p75.
[65] Gregory 1974, p75.
[66] Report to the New Zealand Government of the Fact Finding Group on Nuclear Power, 1977.

and against nuclear power were more sophisticated. Nuclear energy produced by fission had initially been promoted as a cheap, pollution-free, self-perpetuating source of energy. However, because of unexpectedly high costs, the unresolved problem of what to do with the radioactive waste it generated, and increased public opposition to nuclear energy, many plans for nuclear power plants had been shelved. Public opposition had grown in part because of the industry's connections with weapons manufacturing (the British nuclear power plant at Calder Hall, for example, produced plutonium for weapons as well as generating electricity) and a series of nuclear accidents. A 1957 fire at Britain's first nuclear reactor at Windscale, for example, caused radioactive contamination of the surrounding countryside and a reactor meltdown on a Soviet icebreaker in 1966 made international headlines. The images nuclear power conjured up were no longer so rosy. The *Listener's* Boyce Richardson described nuclear reactors as now symbolising "an impersonal future world of computers, robots, explosive violence and uncontrollable technology, rather than the cornucopia overflowing with goods and pleasure that they once promised".[67]

Safety was an increasingly important concern. The nuclear power programmes of Europe, begun in the 1960s and boosted by the oil shock of 1973, were in a new phase that *Listener* writer Geoff Chapple described as one of "public challenge, planning delays and outright rejection".[68] Anti-nuclear protestors had occupied nuclear reactor sites in Germany, France and the United States, staged street demonstrations in the United Kingdom and Australia, and caused informal moratoriums on the building of new reactors in West Germany and Japan. Australian scientist F. P. Robotham described those fighting against the "atomic juggernaut" as a "strange and somewhat unique coalition of church groups, scientists, trade unionists, political parties and plain ordinary people".[69]

Elsie Locke's claim that "a profound distrust of nuclear energy in any form was widespread" was true of a portion of the New Zealand population. The Campaign for Nuclear Disarmament had led a campaign opposing visits from nuclear-powered ships. Nuclear power was seen as potentially dangerous, and, since 1971, American nuclear powered ships were not allowed into New Zealand harbours unless the United States guaranteed liability for any damage to people or places in the event of a nuclear accident (as covered in chapter seven).[70] Environmental

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[67] Boyce Richardson, 'The Nuclear Decision: A Debate About New Zealand's Future: Part 1', *New Zealand Listener*, 22 November 1975, pp14-16.
[68] Geoff Chapple, 'Nuclear Power Slows Down', *New Zealand Listener*, 24 February 1979, p22-23.
[69] E. W. Titterton and F. P. Robotham, *Uranium: Energy Source of the Future*, Abacus, Melbourne, 1979, p191.
[70] Elsie Locke, *Peace People: A History of Peace Activities in New Zealand*, Hazard Press, Christchurch, 1992, p307-9.

movements had also emerged around the world, and in New Zealand the fight against the raising of Lake Manapouri to boost hydro-electric power generation had, in Boyce Richardson's words, "moved forever the foundation on which official and public thinking about the environment of this country is based".[71] In 1974, the British Royal Commission on Environmental Pollution examined the impact of nuclear power on the environment at a time when the United Kingdom seemed on the threshold of a major commitment to nuclear power, in particular to the fast-breeder reactor. In its report published in 1976, the Commission found that inadequate means for disposal of radioactive waste, as well as the risks of using and producing large quantities of plutonium, made the large scale introduction of nuclear power "irresponsible and morally wrong" adding that "we should not rely for our energy supply on a process that produces such a hazardous substance as plutonium unless there is no reasonable alternative".[72] In March 1976, a coalition of environmental and anti-nuclear groups formed the Campaign for Non-Nuclear Futures to oppose the introduction of nuclear power to New Zealand, promoting instead renewable alternative energy options like solar, wind and geothermal power. The main goal of the campaign was to collect half a million signatures in a petition against nuclear power.[73] It was against this background that New Zealand considered whether or not to proceed with nuclear power.

Royal Commission of Inquiry into Nuclear Power Generation

The 1975 report of the Planning Committee on Electric Power Development, which had retained proposals for two 600 MW nuclear power stations, noted that "if there is to be any chance of meeting a 1988 commissioning date it will be necessary for a decision to be made by 1977 on whether or not to introduce nuclear power".[74] It was with this in mind, then, that Robert Muldoon's National Government, that had come to power in 1975, set up a Royal Commission of Inquiry into Nuclear Power Generation: it had been part of the National Party's election manifesto that nuclear power would not be introduced to New Zealand "until a public inquiry into all aspects of this source of energy has taken place".[75] The commissioners were announced in August 1976: the Commission was to be led by Sir Thaddeus McCarthy, a retired judge and President of the Court of Appeal. The other commissioners were Ian Blair, a plant pathologist with community involvement in protection against water pollution; Vivienne Boyd, Vice-

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[71] Richardson 1975, p14.
[72] Hall 1986, pp144-45.
[73] Michael Szabo, *Making Waves: The Greenpeace New Zealand Story*, Reed Books, Auckland, 1991, p75.
[74] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1975.
[75] Royal Commission of Inquiry into Nuclear Power Generation in New Zealand, *Nuclear Power Generation in New Zealand: Report of the Royal Commission of Inquiry*, Government Printer, Wellington, 1978, p20.

President of both the National Council of Women and the Wellington Association of Baptist Churches; Bruce Liley, professor of physics at Waikato University; and Lindsay Randerson, a businessman.[76] There was some opposition to the appointment of Liley, the only scientist appointed to the Commission. Liley's research into the application of plasma physics to nuclear fusion reactors was cited by Campaign Half Million and some environmental groups, including Friends of the Earth, as evidence of his advocacy for nuclear power for electricity generation and they called for his resignation.[77] The Minister of Electricity, Eric Holland (son of the late Sidney Holland) defended Liley's appointment, arguing that they had appointed a truly impartial commission that would present credible and dispassionate recommendations.[78] Just a few days after the commissioners were announced, the Planning Committee on Electric Power Development in New Zealand tabled its 1976 report, in which the two planned nuclear power stations were now scheduled for 1990, with a decision on whether or not to proceed with them required by 1977.[79]

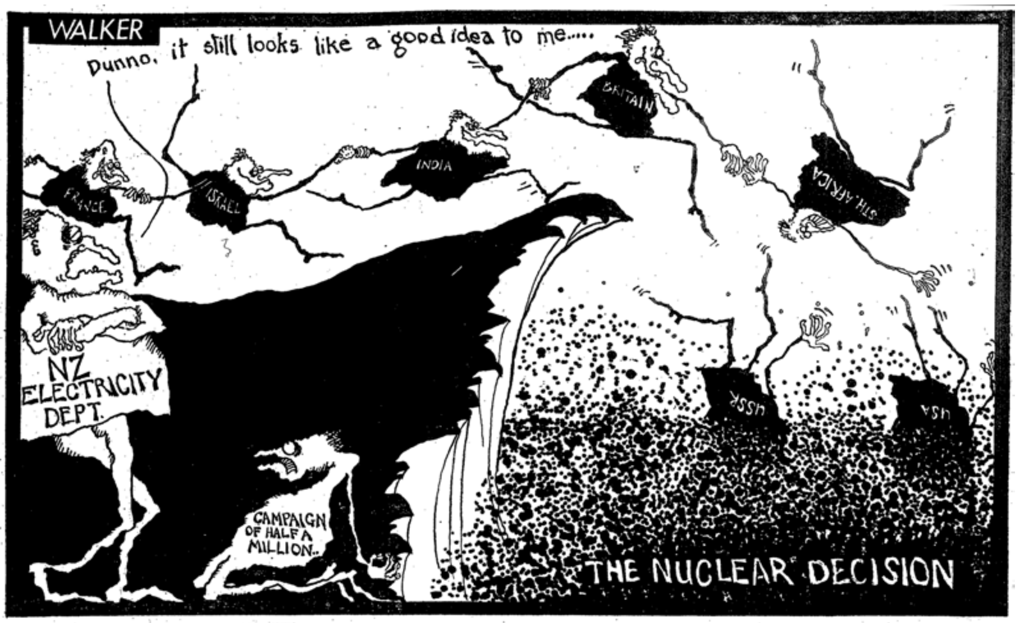

Figure 9.4: The Campaign for Non-Nuclear Futures launched its Campaign Half Million to collect signatures opposing the introduction of nuclear power to New Zealand – something the New Zealand Electricity Department saw as inevitable. Meanwhile, many countries with nuclear power had moratoriums on new nuclear power stations and the global industry was in decline. Source: Malcolm Walker, *Sunday News*, 4 July 1976, p17.

Before the 1970s, the focus of anti-nuclear protests was opposition to nuclear weapons testing, but the anti-nuclear movement was increasingly encompassing opposition to nuclear power and nuclear warships, and nuclear issues were coming to a wider public awareness. It is revealing to

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[76] Royal Commission of Inquiry into Nuclear Power Generation in New Zealand 1978, p13; *The Dominion*, 24 August 1976, p3.
[77] *The Dominion*, 25 August 1976, p3; *The Dominion*, 18 September 1976, p2.
[78] *The Dominion*, 23 September 1976, p3.
[79] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1976; *The Dominion*, 27 August 1976, p1.

look at a single issue of *The Dominion*, from 27 August 1976. Page one carried two nuclear stories, one on the Planning Committee on Electric Power Development in New Zealand's plans for two nuclear power stations by 1990, which began "New Zealanders will probably have to accept nuclear power by 1990", and one on the Civil Defence preparations for an upcoming visit by the nuclear-powered USS *Truxtun*. Under the Government's safety code for the entry of nuclear-powered ships to New Zealand ports, the national civil defence nerve centre under the Beehive was activated, and radiation monitoring devices were installed at 20 sites around Wellington Harbour.[80] Page 3 of the newspaper carried a story about MPs debating and defeating a Bill calling for a South Pacific nuclear weapon free zone and the prohibition of nuclear weapons and reactors from New Zealand (this issue will be covered more fully in chapter 10).[81] At about this time the links between nuclear power and nuclear weapons were also being made, and not just by people in the peace movement. *The Dominion* editorial of 17 August 1976 had described international stability as being disturbed by countries acquiring nuclear weapon capability through projects meant for peace, describing the Einsenhower's Atoms for Peace project, in which the United States provided many countries with nuclear reactors, fissile material, and training for their scientists, as being "founded out of bad conscience". The editorial continued to point out that "the fuel from reactors … can produce a crude bomb" and "the technology is freely available not only to governments anxious to develop a nuclear muscle but also to terrorist organisations".[82]

Over the course of the Royal Commission of Inquiry into Nuclear Power Generation in New Zealand, the Commission heard 141 submissions from organisations potentially involved in the establishment of nuclear power stations in New Zealand, such as the NZED, the DSIR, and the Ministry of Works and Development, from environmental, church and women's organisations, as well as from a number of interested individuals. The Commission members also travelled overseas to conduct interviews and visit energy installations in the United States, Canada, Europe and South Africa.[83]

Most submissions were against the introduction of nuclear power, generally because of cost – other options were still assessed as being cheaper than nuclear – or for reasons of environmental safety and public health. Others criticised New Zealand's total energy consumption, urging a

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[80] *The Dominion*, 27 August 1976, p1; *The Dominion*, 25 August 1976, p1.
[81] *The Dominion*, 27 August 1976, p3.
[82] *The Dominion*, 17 August 1976, p6.
[83] Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1976; *The Dominion*, 27 August 1976, p24.

move towards a sustainable society promoting energy conservation and development of renewable resources. The Inquiry report noted that submissions were, numerically, opposed to nuclear power, which respondents found "an expensive, dangerous, imported technology".[84] Many of the individual and group submissions came from scientists, and here it is interesting to note the change of attitude towards nuclear technology from the 1950s to the 1970s, especially as it is possible to track the changing opinions of individual scientists. In the 1950s, when the DSIR and NZED were wary about the need for nuclear power, many individual scientists, including Percy Burbidge and Gordon Williams, were berating the Government's cautious attitude and talking enthusiastically to the media about the inevitability of nuclear power and the need to start training nuclear engineers immediately. By 1977, when he made a submission to the Royal Commission on Nuclear Power Generation, Burbidge was long retired from his position as professor of physics at the University of Auckland. In contrast to his 1950s calls favouring a nuclear power station over a Cook Strait cable, Burbidge now claimed that not only was there ample energy available from native sources of energy for the next 30 years, but "the danger to our population and the potential damage to our industrial production are too great to justify the introduction of reactors for electrical power", identifying dangers inherent in the operation of nuclear reactors arising from the possibility of radioactive contamination due to accidents relating to coolant leaks, waste disposal, mishandling or meltdown.[85] Gordon Williams, a past Dean of the University of Otago School of Mines and Metallurgy, had in the 1950s been excited about the prospects for uranium mining in New Zealand. But in his 1977 submission against the introduction of nuclear power to New Zealand he referred to nuclear power as "a partially developed technology that is not acceptably safe".[86] The Soil Association of New Zealand, the General Practitioners Society and the Geological Society of New Zealand were among other scientists and groups of scientists who made submissions against the introduction of nuclear power to New Zealand, with all groups mentioning public safety, or the hazards inherent in the operation of nuclear power stations, as a factor in their opposition. Only one scientist, the Institute of Nuclear Sciences' Neil Whitehead, made a submission speaking positively about nuclear power, in which he argued that under present safety standards, health risks from nuclear power stations were extremely low and public fears were "unjustified".[87]

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[84] Royal Commission of Inquiry into Nuclear Power Generation in New Zealand 1978, pp32, 36.
[85] P. W. Burbidge, submission 25, Royal Commission on Nuclear Power Generation in New Zealand, Submissions, volume 3, Government Printer, Wellington, 1978.
[86] G. J. Williams, submission 31, Royal Commission on Nuclear Power Generation in New Zealand, Submissions, volume 4, Government Printer, Wellington, 1978.
[87] N. Whitehead, submission 28, Royal Commission on Nuclear Power Generation in New Zealand, Submissions, volume 4, Government Printer, Wellington, 1978.

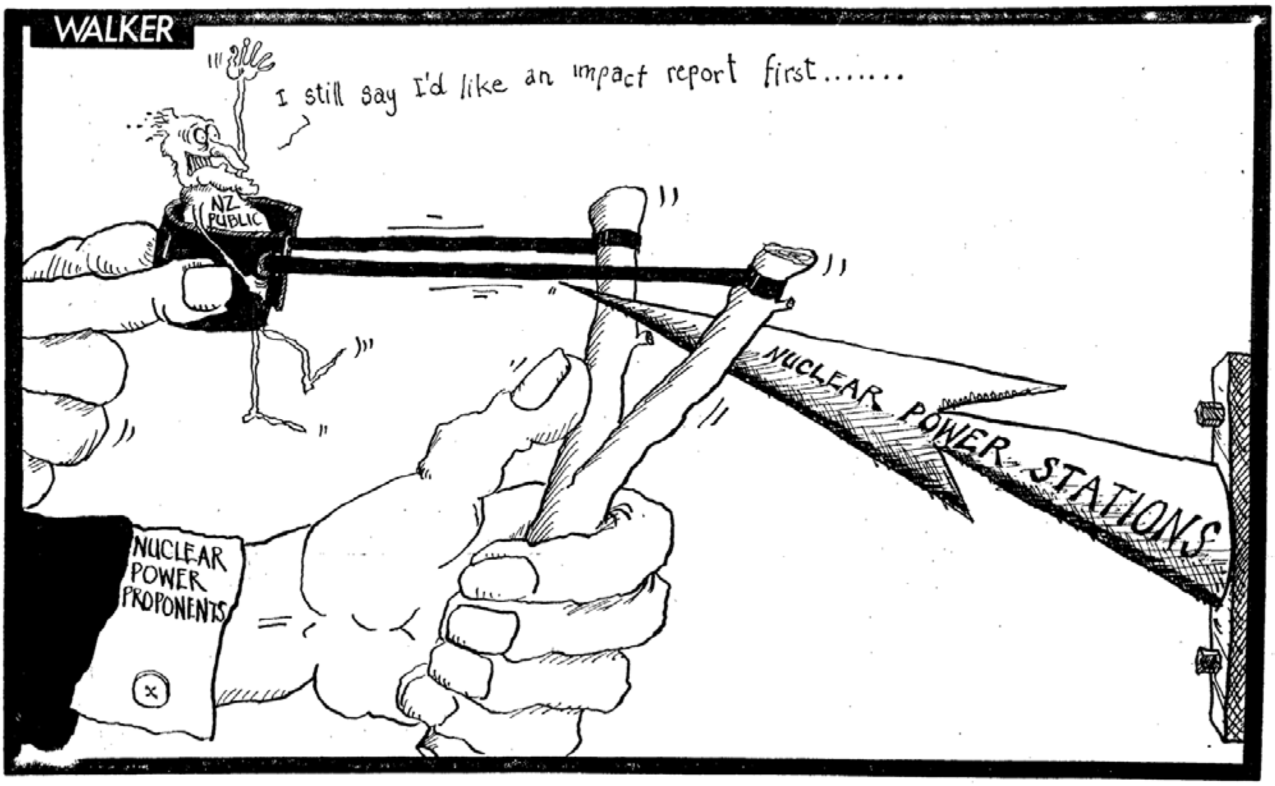

Figure 9.5: This Malcolm Walker cartoon, from the *Sunday News* of 25 April 1976, shows a small frightened man, representing the New Zealand public, about to be shot from a slingshot wielded by nuclear power proponents onto the point of a large dart protruding from a nuclear power station. Walker is referring to the strong-arm tactics of those supporting the introduction of nuclear power, and the relatively weak protests of those against the introduction. Malcolm Walker, *Sunday News*, 25 April 1976, p19.

At the same time as the Commission was calling for submissions, the public made clear their views on nuclear power in other ways: in November 1976 Campaign Half Million, organised by the Campaign for Non-Nuclear Futures, presented to Parliament a petition, with 333,088 signatures, calling for an entirely non-nuclear future – they opposed nuclear power as well as nuclear weapons – for New Zealand.[88] Edward Teller, the American scientist known as “father of the H bomb” (“Try not to call me the father of anything,” said Teller to the *Listener’s* Geoff Chapple, “My son resents the situation where the H bomb is considered to be his kid brother”) visited New Zealand in 1977 for a week-long study and lecture tour. He visited the Wairakei power station, had morning tea with the New Zealand Atomic Energy Committee, and enjoyed a great turnout at “sherry with members of the Royal Society”. While hundreds of scientists and government officials attended receptions for the acclaimed scientist, other New Zealanders picketed his talks, protesting his role in the development of nuclear weapons and his advocacy of nuclear power.[89]

[88] Royal Commission of Inquiry into Nuclear Power Generation in New Zealand 1978, p20.
[89] *Evening Post*, 4 May 1977; Geoff Chapple, ‘Energy Which Never Ceases’, *New Zealand Listener*, 28 May 1977, pp24-25.

The report of the Fact Finding Group on Nuclear Power, a scientific investigation that was separate from the Royal Commission, was presented to Government on 31 March 1977 and released to the public shortly thereafter. The Group's mandate was to report on the possible environmental consequences of nuclear power generation in New Zealand. In contrast to concerns voiced by environmental groups, they reported that under strict supervision and normal operations, a nuclear power plant may be "among the least environmentally objectionable of the alternatives".[90]

While the Royal Commission members were hearing submissions, conducting their own research and preparing their report, electricity demand projects were greatly reduced. In the 1977 Report of the Planning Committee on Electric Power Development, updated demand forecasts meant that a nuclear plant was dropped from the 15-year plan. By this time increased power use was no longer seen as a marker of a growing economy – the Government had begun to encourage energy conservation – and demand had not grown as fast as had been predicted. The reduction in demand deferred the requirement for the nuclear power station beyond the 15-year planning period. The initial purpose of the Commission of Inquiry was now, in one sense, obsolete. It was clear that New Zealand did not need to make an immediate decision on whether or not to adopt nuclear power. The Commission of Inquiry nonetheless completed its investigation and published its report, in the hope that the technical detail amassed and the information about the public debate would be useful when the nuclear option was considered in the future.[91]

The Royal Commission of Inquiry report, *Nuclear Power Generation in New Zealand,* was made public in May 1978. In line with the updated NZED electricity demand projects, the report concluded that, "nuclear power is not justified for New Zealand until about the turn of the century, or even perhaps later." While this recommendation was the result of reduced demand projections, the Commission noted public opposition to the plans for a nuclear power station, describing the history of nuclear power as one of "official enthusiasm, early public acceptance or apathy, and then of rising opposition". A survey of New Zealanders at the time showed that only 24-25 per cent favoured nuclear power. The report described nuclear power's early association with military objectives as being responsible for the "cloud of suspicion and mistrust" that enveloped the technology in the minds of the public and commented on New Zealanders'

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[90] Report to the New Zealand Government of the Fact Finding Group on Nuclear Power, Government Printer, Wellington, 1977, pp4-5.
[91] Royal Commission of Inquiry into Nuclear Power Generation in New Zealand 1978, pp28-30; Report of the Planning Committee on Electric Power Development in New Zealand, NZED, 1977.

general ignorance about nuclear power, something seen as "an emerging technology, novel and esoteric". In commenting on the opposition to nuclear power evident in the submissions, the commissioners noted that New Zealand had a strong environmental lobby, but no strong pro-nuclear lobby. The commissioners, however, who had visited many overseas nuclear installations as part of their inquiry, were impressed by the officials and engineers they met who were "almost unanimous that nuclear power was a necessary and irreplaceable source of the future energy for mankind".[92]

The report did not reject nuclear power outright, however, suggesting that the question of nuclear power should again be considered in depth by about 1985. It also advised that New Zealand must "maintain and update its knowledge of nuclear power generation as well as evaluating and proving alternative means, so that it is to that extent qualified to avail itself of the nuclear option should it prove desirable".[93]

Based on the demand forecasts, the Inquiry recommended that nuclear power be retained as an option for the future, once indigenous resources had been fully exploited, with an expected commissioning date of 2005-07. Interesting in today's climate is the Inquiry's observation that obstruction to the environmental impacts of enlarged hydro, geothermal and coal production could, in the future, lead the call for the adoption of nuclear power. "If New Zealand wants more electricity, and we are sure it will, some environmental impacts will have to be paid", it said. The Commission was far-sighted in recommending such energy saving measures as encouraging the use of heat pumps and ensuring that all houses have some form of ceiling insulation.[94] These recommendations have only recently become government policy in programmes initiated by the Green Party.

Conclusion

By the late 1970s, it was time for New Zealand to make a decision about whether or not to take the first steps towards commissioning a nuclear power station. What had seemed inevitable in the 1950s and 60s was, however, now being brought into question as an anti-nuclear movement grew, environmental protests gained force and other energy sources continued to look cheaper and more viable than nuclear power. But there was still the problem of how New Zealand was

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[92] Royal Commission of Inquiry into Nuclear Power Generation in New Zealand 1978, pp31-34.
[93] Royal Commission of Inquiry into Nuclear Power Generation in New Zealand 1978, p45.
[94] Royal Commission of Inquiry into Nuclear Power Generation in New Zealand 1978, pp40-44.

going to meet the growing demand for electricity. In 1975, the National Government established a Royal Commission on Nuclear Power Generation.

While the Commission of Inquiry was investigating, however, electricity demand projects were greatly reduced and nuclear power was reassessed as not being needed for at least another 15 years, beyond the planning time for the NZED. The decision not to proceed with nuclear power at this time was therefore wholly pragmatic, and did not need to be put to any ideological or economic test – there just was not an immediate need for another large power station as had been predicted just a few years earlier. The Commission reported all the same, noting that the majority of submissions were against the introduction of nuclear power to New Zealand.

This would, however, have felt like a victory for anti-nuclear campaigners. And while, in the end, there was no real call for a nuclear power station, the fact of the Commission of Inquiry's existence helped to focus attention on health, safety and environmental issues associated with nuclear technology and consolidate public opinion on the matter. Many of these same individuals and groups would become instrumental in the election of the 1984 Labour Government, with their staunch opposition to nuclear-powered warships, and the beginning of a "nuclear-free" New Zealand identity that soon came to embrace nuclear power as well as nuclear weapons.

Chapter 10

Nuclear-free New Zealand: The forging of a new national identity

"New Zealand is a nuclear-free country. We reject any strategy for our defence which relies on nuclear weapons. New Zealand will not in any way take part in the nuclear arms race or join in any confrontation between nuclear forces. New Zealand will take no action which suggests that its security depends on nuclear weapons."

Prime Minister David Lange, 1986[1]

"New Zealand gets nuked, too"

Chapter heading in Douglas Copeland's iconic book *Generation X*, 1991[2]

While New Zealand had embraced nuclear technology in industry, agriculture and medicine, had tried to establish a uranium mining industry, and had examined the possibility of nuclear power, there was, running alongside these ventures, a steadily growing movement against nuclear weapons and their testing in the South Pacific. Public and political anti-nuclear sentiment, which emerged in response to the British and American explosions of the first atomic bombs, was further fuelled by French nuclear testing in the Pacific and, later, by visits from American nuclear-powered and nuclear-armed warships.

French nuclear testing in the Pacific

As covered in chapter five, in The Partial Test Ban Treaty of 1963, the United States, United Kingdom and Soviet Union agreed to refrain from nuclear tests in the atmosphere, outer space and under water.[3] New Zealand signed the Treaty on 8 August 1963, the day it became open for signatures.[4]

That same year, President de Gaulle announced France's plan to move the French atmospheric testing programme from Algeria's Sahara Desert – where France had tested its first nuclear

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[1] Message from Prime Minister David Lange, in *Nuclear Free New Zealand*, New Zealand Government, Wellington, 1986, p3.
[2] Douglas Copeland, *Generation X*, Abacus, London, 1991, p67.
[3] The Treaty Banning Nuclear Weapon Tests in the Atmosphere, Outer Space and Under Water is reproduced in *New Zealand External Affairs Review* (*NZEAR)* 13, 7 (1963), pp28-29.
[4] *NZEAR* 13, 8 (1963), pp16, 26-27; *NZEAR* 13, 10 (1963), pp26-27.

bomb in 1960 – to the atolls of the South Pacific.[5] New Zealanders marched in protest at the French plans and signed a Campaign for Nuclear Disarmament (CND) petition calling for a complete halt to all nuclear testing in the southern hemisphere, a move initiated by the Australian Labor Party. With the slogan "No bombs south of the line", the 1963 petition called for a southern hemisphere nuclear-free zone and, with more than 80,000 signatories, was New Zealand's biggest petition since the women's franchise of 1893.[6] The following year, 1964, China became the world's fifth nuclear power, to condemnation by New Zealand's Prime Minister Keith Holyoake who described the test as "violating world opinion and greatly increasing the risks of dissemination of nuclear weapons".[7]

In contrast to New Zealand's logistical support for British nuclear tests in the Pacific, and, to a lesser extent, support for the American tests, New Zealand was very clearly and vocally opposed to French nuclear testing in the Pacific. Holyoake's Government communicated its opposition to the French plan to test nuclear weapons in the Pacific, and to the continuation of nuclear testing in general, directly to the French Government on several occasions. This opposition was expressed as being on the basis of public concerns about potential dangers to health from radioactive fallout, and because of New Zealand's goal of a comprehensive nuclear test ban.[8]

Despite the protests, France tested its first bomb at French Polynesia's Moruroa Atoll on 2 July 1966.[9] In response to concerns about an increase in radioactive fallout in the region, the National Radiation Laboratory intensified its radiation monitoring programme in the South Pacific. Levels of radioactive fallout were measured in New Zealand and at a chain of Pacific island stations – in Fiji, Rarotonga, Samoa, Tonga, Niue, and what were then known as the Gilbert and Ellice Islands (now the Republic of Kiribati) and at Raoul and Penrhyn Islands. Portable gamma ray monitors were read several times a day at island stations near the test zone. At other stations, daily air filter samples and weekly rainwater samples were measured for the total fallout content, and milk samples analysed for iodine-131. When the French atmospheric testing programme

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[5] Bengt Danielsson and Marie-Therese Danielsson, *Poisoned Reign: French Nuclear Colonialism in the Pacific*, Penguin Books, Ringwood, Vic, 1986, p58; *NZEAR* 13, 5 (1963), pp25-26.
[6] Elsie Locke, *Peace People: A History of Peace Activities in New Zealand*, Hazard Press, Christchurch, 1992, p180-1; Kevin Clements, *Back From the Brink: The Creation of a Nuclear-free New Zealand*, Allen & Unwin/Port Nicholson Press, Wellington, 1988, pp52-53; Malcolm Templeton, *Standing Upright Here: New Zealand in the Nuclear Age 1945-1990*, Victoria University Press, Wellington, 2006, p111.
[7] *NZEAR* 14, 10 (1964), p27.
[8] *NZEAR* 13, 5 (1963), pp25-26; Clements, p50-51; Templeton 2006, pp108-32.
[9] Kate Dewes and Robert Green, *Aotearoa/New Zealand at the World Court*, The Raven Press, Christchurch, 1999, p11; Ministry of Foreign Affairs, *New Zealand at the International Court of Justice: French Nuclear Testing in the Pacific*, New Zealand Ministry of Foreign Affairs, Wellington, 1996, p9.

ended, a modified environmental monitoring programme continued, to detect any venting to the atmosphere of debris from the underground nuclear tests.[10]

In their annual reports on fallout resulting from the French nuclear weapons tests, the National Radiation Laboratory commented that "there are no internationally accepted levels for the exposure of people to fallout from nuclear weapons testing" but compared measured values with annual dose limits set by the International Commission on Radiological Protection and with radiation exposure from background radiation.[11] Based on the data collected, and comparison with these levels, the National Radiation Laboratory regularly reported that the French tests "constituted no public health hazard".[12] Although the Laboratory was dealing with factual data, comparing one figure against another, their refusal to say the French tests were contributing dangerous levels of radioactive contamination to the Pacific islands had the effect of giving some people the impression they were condoning the French testing or even hiding information from the public. In 1972, media attention was given to a Fijian biologist's criticism of the National Radiation Laboratory's interpretation of the monitoring results, along with his comments that radioactive elements like strontium-90 were concentrated in the food chain, for example as small fish ate contaminated plankton and larger fish ate smaller fish, and that fish should be included in the monitoring programme.[13]

Table 10.1: French atmospheric nuclear tests in the Pacific

Year	Date	Location	Yield
1966	2 July 19 July 11 September 24 September 4 October	Moruroa Fangataufa Moruroa Fangataufa Moruroa	20-200 kt 20-200 kt 20-200 kt 20-200 kt 200 kt-1Mt
1967	5 June 27 June 2 July	Moruroa Moruroa Moruroa	<20 kt 20-200 kt 20-200 kt
1968	7 July 15 July 3 August 24 August 8 September	Moruroa Moruroa Moruroa Fangataufa Moruroa	20-200 kt 200kt-1Mt 20-200 kt >1Mt >1Mt
1970	15 May 22 May 30 May 24 June	Moruroa Moruroa Fangataufa Moruroa	<20 kt 200 kt-1Mt 200 kt-1Mt <20 kt

[10] L. P. Gregory, 'Radioactive Fallout', *Health and the Environment* 24, 4 (1972), pp14-15; K. M. Matthews, *Radioactive Fallout in the South Pacific: A History. Part 2: Radioactivity Measurements in the Pacific Islands,* National Radiation Laboratory, Christchurch, 1992, pp1-2, 16-17.
[11] See, for example, L. P. Gregory, *Fallout From Nuclear Weapons Tests Conducted by France in the South Pacific from June to August 1971*, National Radiation Laboratory, Christchurch, 1972, pp4-5.
[12] Matthews 1992, part 2, p70.
[13] *The Dominion*, 28 June 1972, p6.

	3 July	Moruroa	200kt-1Mt
	27 July	Moruroa	<20 kt
	2 August	Fangataufa	20-200 kt
	6 August	Moruroa	200kt-1Mt
1971	5 June	Moruroa	20-200 kt
	12 June	Moruroa	200 kt-1Mt
	4 July	Moruroa	<20 kt
	8 August	Moruroa	<20 kt
	14 August	Moruroa	200 kt-1Mt
1972	25 June	Moruroa	<20 kt
	30 June	Moruroa	<20 kt
	27 July	Moruroa	<20 kt
1973	21 July	Moruroa	<20 kt
	28 July	Moruroa	<20 kt
	18 August	Moruroa	<20 kt
	24 August	Moruroa	<20 kt
	28 August	Moruroa-aircraft	<20 kt
1974	16 June	Moruroa	<20 kt
	7 July	Moruroa	200kt-1Mt
	17 July	Moruroa	<20 kt
	25 July	Moruroa-aircraft	<20 kt
	15 August	Moruroa	20-200kt
	24 August	Moruroa	<20kt
	14 September	Moruroa	200kt-1Mt

Source: Adapted from *New Zealand at the International Court of Justice: French Nuclear Testing in the Pacific*, New Zealand Ministry of Foreign Affairs and Trade, Wellington, 1996, pp48-49.

New Zealand made diplomatic protests after each of France's tests, and continued to work internationally towards disarmament. In 1968, New Zealand signed the Treaty for the Non Proliferation of Nuclear Weapons, which was designed to limit the spread of nuclear weapons to other states. The United States, United Kingdom and Soviet Union also signed the Treaty in 1968, but China and France, the world's other nuclear powers, did not.[14]

At the United Nations Conference on the Human Environment at Stockholm in June 1972, Duncan McIntyre, the National Government's Minister of Maori and Island Affairs, secured eight co-sponsors for a statement calling for a halt to nuclear weapons tests that could contaminate the environment.[15] Following the tabling of this statement, a draft resolution sponsored by New Zealand and Peru was adopted. It resolved:

> 1. To condemn nuclear weapons tests, especially those carried out in the atmosphere.
>
> 2. To call upon those states intending to carry out nuclear weapons tests to abandon their plans to carry out such tests as they may lead to further contamination of the environment.[16]

[14] *NZEAR* 18, 7 (1968), p16; Templeton 2006, p147; Clements 1988, pp59-60.
[15] *New Zealand Foreign Affairs Review* (*NZFAR)* 22, 6 (1972), pp76-77; Locke 1992, p297

On 26 October 1972, New Zealand's Permanent Representative to the United Nations moved in the First Committee a resolution with 13 co-sponsors calling on all nuclear weapons states to suspend nuclear weapons tests in all environments. The resolution was passed by 106 votes to four, with eight abstentions.[17]

Figure 10.1: Marchers in Wellington City in 1972 protest against French nuclear testing in the Pacific. Source: 1/4-020364-F, Alexander Turnbull Library, Wellington, NZ.

While the Vietnam War dominated the efforts of many in the peace movement, the CND and other groups continued to campaign against French nuclear testing in the Pacific, with street marches in New Zealand and direct protests by boats sailing into the French test zone. In 1972 a 12-metre kauri ketch, the *Vega*, renamed *Greenpeace III* for the trip, sailed from Auckland to the

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[16] *NZFAR* 22, 6 (1972), p106-107.
[17] *NZFAR* 22, 10 (1972), pp92-95; *NZFAR* 22, 11 (1972), p57.

French test area to protest, with support from Greenpeace, the CND and many Auckland people. After a month in the area, during which time the French tested two nuclear bombs, the *Greenpeace III* was rammed by a French navy minesweeper, damaging the boat, which was towed into Moruroa for repairs. The news did not reach New Zealand for a week, after which it made front page headlines. Under the headline “Blast off! Crew held as bomb tests begin,” *The Dominion* reported that *Greenpeace III* had been seized as it entered the French test zone, and its crew were being held near Papeete.[18] As the damaged boat returned to New Zealand for more repairs, other boats sailed towards Moruroa to protest, and the Labour Party announced that if it were in power it would send a frigate to Moruroa, with Kirk stating in Parliament “we stand four-square on our policy of opposing nuclear tests, opposing the proliferation of nuclear weapons, bringing about nuclear disarmament”.[19] It was not only members of the peace movement who were protesting. The Federation of Labour imposed a ban on French shipping and aircraft with watersiders refusing to load or unload anything to or from France. Post Office workers in Wellington and Auckland placed a ban on telex and cable traffic to and from France and its territories.[20]

This was an election year, and the opposition Labour Party’s stated policy of taking a stronger stance against French nuclear testing may have helped Norman Kirk be elected Prime Minister of a new Labour Government in November 1972. In response to the new Kirk Government’s approach to France asking for a postponement of the French nuclear tests to allow time for discussions, France invited New Zealand to send a scientist to Moruroa to investigate potential health risks. George Roth, retired director of the National Radiation Laboratory, visited the French nuclear test sites from 23 February–5 March 1973. Roth reported that more atmospheric tests were likely at Moruroa, with underground testing also a possibility, but he also relayed assurances given to him that any official New Zealand protest vessels would come to no harm if they were in the test area.[21]

Growing public concern about the health and environmental effects of nuclear weapons testing led New Zealand and Australia, in 1973, to ask the International Court of Justice in The Hague

[18] *The Dominion*, 29 June 1972, p1.
[19] Locke 1992, pp286-296; Michael Szabo, *Making Waves: The Greenpeace New Zealand Story*, Greenpeace New Zealand, Auckland, 1991, pp6-19; *NZPD* 379 (1972), p1119.
[20] *The Dominion*, 22 June 1972, p1; *The Dominion*, 23 June 1972, p3; *The Dominion*, 26 June 1972, p3.
[21] Clements 1988, p71.

to challenge the legality of France's atmospheric tests at Moruroa.[22] Before the Court had made a ruling on the legality of French atmospheric testing, however, France announced that it would cease atmospheric testing and only test underground in the future. The Court decided, by nine votes to six, that since France had stopped atmospheric testing, there was no longer a case to answer.[23]

As covered in chapter five, in 1957, the New Zealand Navy frigates HMNZS *Pukaki* and *Rotoiti* had sailed to Christmas Island to act as weather ships in support of the British hydrogen bomb tests. In stark contrast, New Zealand navy frigates were now going to protest against nuclear testing in the Pacific. In June 1973, Prime Minister Norman Kirk sent the navy frigate HMNZS *Otago* to Moruroa, to join a small group of protest yachts that had already left from New Zealand, to "ensure that the eyes of the world are riveted [on] Moruroa".[24] Kirk, the Minister of Defence, and other dignitaries farewelled the frigate from Auckland on 28 June 1973. As well as the 243-strong navy crew, the frigate carried Immigration Minister Fraser Coleman, a group of journalists, and the National Radiation Laboratory's Jim McCahon, on board as radiation safety officer.[25] The Minister of Defence said the frigate, which the *Evening Post* dubbed the "ban-the-bomb frigate", would ignore any French attempts to make her leave the testing area: "she'll proceed on her merry way, exercising her right to peacefully sail the international high seas", he said.[26]

The HMNZS *Otago* arrived in the test zone in early July, once personal radiation monitors had been distributed to all people on board, and with McCahon taking daily air samples to test for radioactivity. On 21 July, a French nuclear bomb was detonated at Moruroa. The *Otago* crew listened to the French countdown, then were on deck a few minutes later, from where they saw the mushroom cloud, which McCahon described as "a tall spindly stem with a flattened blob on top, a reddish-brown colour against the surrounding white clouds". Following the explosion, McCahon increased the frequency of radiation measurements but was unable to detect any radioactivity from the small explosion. After the test, the HMNZS *Canterbury* relieved the *Otago* in the test zone and on 28 July, by which time McCahon had transferred to the *Canterbury,* a second French bomb was detonated. This time, because of the wind direction, the

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[22] Dewes and Green, 1999; Ministry of Foreign Affairs, *French Nuclear Testing in the Pacific: International Court of Justice Nuclear Tests Case, New Zealand v. France,* Ministry of Foreign Affairs publication no 446, Wellington, 1973.
[23] Dewes and Green 1999, pp11-15
[24] *The Evening Post*, 28 June 1973, p1.
[25] *The Evening Post*, 28 June 1973, p1; Jim McCahon, *Voyage to Mururoa – HMNZS Otago and Canterbury,* unpublished diary, 1973.

Canterbury did detect a small amount of radioactive fallout, equivalent to each person on board receiving a dose of less than 2 millirads.[27] *Canterbury* returned to Auckland on 12 August. The New Zealand frigates had achieved their goal of staging a protest to the French, and of focusing world media attention on French nuclear tests in the Pacific: twice-daily reports by the on-board journalists were published in New Zealand and disseminated around the world.[28]

Figure 10.2: Jim McCahon, second from the left in the back row, travelled on the HMNZS *Otago*, and then the HMNZS *Canterbury*, as radiation safety officer. An employee of the National Radiation Laboratory since the 1950s, McCahon was pleased to be able to “add my little bit of protest to the whole thing” but in his diary of his journey he said that amongst the naval officers on board he often felt he was the only person actually protesting against the French nuclear tests, rather than simply following Government orders. Next to McCahon, in the dark shirt, is Fraser Coleman. The other men, all civilians, are probably a medical officer and the three journalists. Source: Courtesy Jim McCahon.

Those were the last atmospheric nuclear bomb tests in the Pacific. On 24 September 1974 France announced they had completed their programme of atmospheric tests and would now be

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[26] *The Evening Post*, 9 July 1973, p1.
[27] McCahon 1973, pp18, 32, 49-53.
[28] Shaun Brown, ‘On Protest with Otago’, *New Zealand Listener*, 20 August 1973, p14; David Barber, ‘New Zealand Frigate Making Headlines in Europe as She Continues to Defy France’, *The Evening Post*, 11 July 1973, p1.

testing their nuclear weapons underground.[29] Once the underground testing programme began in 1975, New Zealand scientists found they could detect the explosions on the DSIR seismograph network designed to detect earthquakes. “It was back in 1975 that we saw something very strange on the seismogram recording in Rarotonga”, Warwick Smith, the DSIR’s chief seismologist, later recalled. “ ‘What on earth was that?’ we thought – because it didn’t look like an earthquake! We subsequently realised that what we had seen was a recording of the first French underground nuclear test in the Pacific.” Underground tests in French Polynesia set up something like a sound wave in the ocean that propagated extremely well to the station in Rarotonga. “We realised we had quite a sensitive detector of the French nuclear tests.” Smith would announce the test to the Prime Minister’s office which would contact other countries’ top officials and then release the information to the media. “It was all cloak and dagger stuff for a while”, says Smith. “Then, in the final stages of testing, the French used to make announcements that in less than an hour they would be doing another test.”[30]

Table 10.2: French underground nuclear tests in the Pacific, 1975-1990

Year	Date	Location	Yield
1975	5 June	Fangataufa	<20 kt
	26 November	Fangataufa	20-200 kt
1976	3 April	Moruroa	<20 kt
	11 July	Moruroa	20-200 kt
	30 October	Moruroa	<20 kt
	5 December	Moruroa	<20 kt
1977	19 February	Moruroa	20-200 kt
	19 March	Moruroa	200kt-1Mt
	2 April	Moruroa	<20 kt
	6 July	Moruroa	20-200 kt
	12 November	Moruroa	<20 kt
	24 November	Moruroa	200kt-1Mt
	17 December	Moruroa	<20 kt
1978	27 February	Moruroa	<20 kt
	22 March	Moruroa	<20 kt
	25 March	Moruroa	<20 kt
	1 July	Moruroa	<20 kt
	19 July	Moruroa	20-200 kt
	26 July	Moruroa	<20 kt
	2 November	Moruroa	<20 kt
	30 November	Moruroa	200kt-1Mt
	17 December	Moruroa	<20 kt
	19 December	Moruroa	20-200 kt
1979	1 March	Moruroa	20-200 kt
	9 March	Moruroa	20-200 kt
	24 March	Moruroa	20-200 kt
	4 April	Moruroa	20-200 kt
	18 June	Moruroa	20-200 kt
	29 June	Moruroa	200kt-1Mt
	25 July	Moruroa	200kt-1Mt

[29] Julie Miles and Elaine Shaw, *Chronology: The French Presence in the South Pacific, 1838-1990*, Greenpeace, Auckland, 1990, p17.
[30] Rebecca Priestley, ‘Seismic Stations Play Role in Policing Nuclear Bangs’, *Evening Post*, 22 June 1999, p5.

	28 July	Moruroa	<20 kt
	19 November	Moruroa	<20 kt
	22 November	Moruroa	<20 kt
1980	23 February	Moruroa	<20 kt
	3 March	Moruroa	<20 kt
	23 March	Moruroa	200kt-1Mt
	1 April	Moruroa	20-200 kt
	4 April	Moruroa	20-200 kt
	16 June	Moruroa	200kt-1Mt
	21 June	Moruroa	20-200 kt
	6 July	Moruroa	20-200 kt
	19 July	Moruroa	200kt-1Mt
	25 November	Moruroa	<20 kt
	3 December	Moruroa	200kt-1Mt
1981	27 February	Moruroa	<20 kt
	6 March	Moruroa	<20 kt
	28 March	Moruroa	20-200 kt
	10 April	Moruroa	20-200 kt
	8 July	Moruroa	20-200 kt
	11 July	Moruroa	<20 kt
	18 July	Moruroa	<20 kt
	3 August	Moruroa	200kt-1Mt
	6 November	Moruroa	<20 kt
	11 November	Moruroa	20-200 kt
	5 December	Moruroa	20-200 kt
	8 December	Moruroa	20-200 kt
1982	20 February	Moruroa	<20 kt
	24 February	Moruroa	<20 kt
	20 March	Moruroa	20-200 kt
	23 March	Moruroa	<20 kt
	27 June	Moruroa	<20 kt
	1 July	Moruroa	200kt-1Mt
	21 July	Moruroa	<20 kt
	25 July	Moruroa	200kt-1Mt
	27 November	Moruroa	<20 kt
1983	19 April	Moruroa	200kt-1Mt
	25 April	Moruroa	<20 kt
	25 May	Moruroa	200kt-1Mt
	18 June	Moruroa	<20 kt
	28 June	Moruroa	20-200 kt
	20 July	Moruroa	20-200 kt
	4 August	Moruroa	200kt-1Mt
	3 December	Moruroa	<20 kt
	7 December	Moruroa	20-200 kt
1984	8 May	Moruroa	<20 kt
	12 May	Moruroa	200kt-1Mt
	12 June	Moruroa	20-200 kt
	16 June	Moruroa	200kt-1Mt
	27 October	Moruroa	20-200 kt
	2 November	Moruroa	200kt-1Mt
	1 December	Moruroa	<20 kt
	6 December	Moruroa	200kt-1Mt
1985	30 April	Moruroa	20-200 kt
	8 May	Moruroa	200kt-1Mt
	3 June	Moruroa	20-200 kt
	7 June	Moruroa	20-200 kt
	24 October	Moruroa	<20 kt
	26 October	Moruroa	200kt-1Mt
	24 November	Moruroa	20-200 kt
	26 November	Moruroa	200kt-1Mt
1986	26 April	Moruroa	20-200 kt
	6 May	Moruroa	<20 kt
	27 May	Moruroa	20-200 kt
	30 May	Moruroa	200kt-1Mt
	10 November	Moruroa	<20 kt

	12 November 6 December 10 December	Moruroa Moruroa Moruroa	20-200 kt <20 kt 200kt-1Mt
1987	5 May 20 May 6 June 21 June 23 October 5 November	Moruroa Moruroa Moruroa Moruroa Moruroa Moruroa	20-200 kt 200kt-1Mt 20-200 kt 200kt-1Mt 200kt-1Mt 20-200 kt
1988	11 May 25 May 16 June 23 June 25 October 5 November 23 November 30 November	Moruroa Moruroa Moruroa Moruroa Moruroa Moruroa Moruroa Fangataufa	200kt-1Mt 200kt-1Mt <20 kt 20-200 kt <20 kt 200kt-1Mt 200kt-1Mt 200kt-1Mt
1989	11 May 20 May 3 June 10 June 24 October 31 October 20 November 27 November	Moruroa Moruroa Moruroa Moruroa Moruroa Moruroa Moruroa Moruroa	20-200 kt <20 kt 200kt-1Mt 200kt-1Mt 200kt-1Mt 20-200 kt 20-200 kt 200kt-1Mt
1990	2 June 7 June 26 June 4 July 14 November 22 November	Moruroa Moruroa Fangataufa Moruroa Fangataufa Moruroa	20-200 kt 20-200 kt 200kt-1Mt 20-200 kt 200kt-1Mt 200kt-1Mt
1991	7 May 18 May 29 May 16 June 5 July 15 July	Moruroa Moruroa Fangataufa Moruroa Moruroa Moruroa	<20 kt 200kt-1Mt 200kt-1Mt 200kt-1Mt <20 kt 200kt-1Mt
1995[31]	5 September 1 October 27 October 21 November 27 December	Moruroa Fangataufa ? Moruroa Moruroa	 <60 kt <40 kt <30 kt
1996	27 January	Fangataufa	<120 kt

Source: Adapted from *New Zealand at the International Court of Justice: French Nuclear Testing in the Pacific*, New Zealand Ministry of Foreign Affairs and Trade, Wellington, 1996, pp48-49.

Even after France took its nuclear testing programme underground, there remained a general public suspicion that the tests were harmful. New Zealand, along with Australia, and various small Pacific countries, continued to protest to France after each test and New Zealanders protested on street marches and boycotted French goods.[32] The National Radiation Laboratory continued to monitor the impact of the tests, issuing annual reports on environmental radioactivity in New Zealand and the Pacific. The degree to which the voice of the National

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[31] Dates and approximate yields for 1995-96 test series are from www.ratical.org/ratville/nukes/testChrono95-8.html, downloaded on 12 December 2004.

[32] Stuart McMillan, *Neither Confirm Nor Deny: The Nuclear Ships Dispute Between New Zealand and the United States*, Allen & Unwin/Port Nicholson Press, Wellington, 1987, p36.

Radiation Laboratory was trusted and believed, however, had waned since it first started issuing environmental monitoring reports in the 1960s. Greenpeace pointed out in 1990 that by 1977 the National Radiation Laboratory had been monitoring the atmosphere since 1957 and had issued 50 reports in which they regularly declared the French tests did not constitute a public health hazard.[33]

While making specific protests to France after each nuclear test, the Labour Government also worked towards wider disarmament issues, pushing for a South Pacific nuclear-weapons-free zone and a halt to weapons testing in general. On 31 October 1975, the New Zealand Ambassador Malcolm Templeton introduced to the United Nations a resolution, co-sponsored with Fiji and Papua New Guinea, calling for a South Pacific nuclear-weapons-free zone.[34] In November 1975, however, Labour lost the election to National. Robert Muldoon became Prime Minister, and the initiative was abandoned.[35] In February 1976 Muldoon said the National Party caucus was unanimous in agreeing with his policy of lifting the ban on visits to New Zealand by nuclear warships, and the first visit could be that very year.[36]

Visits from nuclear-powered ships

Nuclear ships had been visiting New Zealand since 1960 but in the 1980s, during the peak of France's Pacific nuclear testing programme, nuclear ship visits became another significant issue for the anti-nuclear movement. The first nuclear-powered vessel to visit New Zealand was the USS *Halibut*, a nuclear-powered submarine that visited Auckland and Wellington in April 1960. The next nuclear-ship visits were four years later, when the nuclear-powered cruisers the USS *Longbeach* and USS *Bainbridge* docked in Wellington in September 1964. (The nuclear-powered aircraft carrier USS *Enterprise*, which accompanied them, was too big to enter Wellington Harbour and had to stay in Cook Strait.) From 1965 to 1975, no nuclear-powered vessels were invited to New Zealand and it was made known to the United States authorities that they would not be welcome. The issue at this stage was not public opposition to nuclear ship visits (though there was growing opposition from environmental and peace groups), but rather the issue of liability in the case of an accident.[37]

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[33] Miles and Shaw 1990, p19.
[34] *NZFAR* 25, 10 (1975), pp6-14.
[35] Clements 1988, p83; Dewes and Green 1999, pp16.
[36] *The Dominion*, 27 February 1976, p3.
[37] Report of the Special Committee on Nuclear Propulsion, *The Safety of Nuclear-Powered Ships*, Department of the Prime Minister and Cabinet, Wellington, 1992, p183; Locke 1992, p220.

The New Zealand Atomic Energy Committee had set up a sub-committee in 1968 to look at the public safety aspects of visits to New Zealand of nuclear-powered ships. In 1971, Holyoake's Government advised the United States that a condition of future visits from nuclear-powered ships would be that the United States agree to accept liability in the event of a nuclear accident, and a New Zealand Code of Practice for Nuclear Powered Shipping was prepared. But by the time the United States agreed to accept liability, in 1974, a new Labour Government, under Bill Rowling, chose to continue the ban on nuclear-powered ships.[38]

Table 10.3: Nuclear powered ship visits to New Zealand

Dates	Vessel	Type	Port
19–22 April1960	USS *Halibut*	Submarine	Auckland
24–27 April 1960	USS *Halibut*	Submarine	Wellington
8–9 September 1964	USS *Longbeach*	Cruiser	Wellington
8–9 September 1964	USS *Bainbridge*	Cruiser	Wellington
8–9 September 1964	USS *Enterprise*	Aircraft carrier	Wellington
27 August–2 September 1976	USS *Truxtun*	Cruiser	Wellington
1–5 October 1976	USS *Longbeach*	Cruiser	Auckland
16–22 January 1978	USS *Pintado*	Submarine	Auckland
19–24 January 1979	USS *Haddo*	Submarine	Auckland
22–29 September 1980	USS *Truxtun*	Cruiser	Wellington
25–29 May 1982	USS *Truxtun*	Cruiser	Wellington
3–8 August 1983	USS *Texas*	Cruiser	Auckland
10–15 August 1983	USS *Texas*	Cruiser	Wellington
9–14 November 1983	USS *Phoenix*	Submarine	Auckland
23–30 March 1984	USS *Queenfish*	Submarine	Auckland

Source: Adapted from Report of the Special Committee on Nuclear Propulsion, 1992, p183.

Kevin Clements has described Labour supporters in the mid 1970s as being "fervently anti-nuclear for principled and political reasons" while the new National Government cast itself as "politically realistic in foreign and defence policies and not subject to the 'woolly minded' schemes of Labour in promoting unrealistic concepts such as a Pacific-wide nuclear-weapons free zone".[39] In 1976, therefore, National Prime Minister Robert Muldoon advised that nuclear powered ships could once again visit New Zealand as long as the owning nation accepted full responsibility for the ship, and the ship complied with the safety standards of the port it was

[38] Report of the Special Committee on Nuclear Propulsion 1992, p153; Clements 1988, p84; Andrew McEwan, *Nuclear New Zealand: Sorting Fact From Fiction*, Hazard Press, Christchurch, 2004, p81.
[39] Clements 1992, p86.

visiting, by now updated in the new Code of Practice for Nuclear Powered Shipping.[40] Muldoon saw any continuation of Labour's ban on nuclear ship visits as "nonsensical and a danger to the continuation of the ANZUS alliance".[41]

Visits of nuclear-powered ships to 1970s New Zealand would have a very different reception to those in the 1960s. In 1975 New Zealand's original "Peace Squadron" had been formed, when it had become clear the Labour Government was under pressure to admit nuclear-powered and nuclear-armed ships. The purpose of the Peace Squadron was to coordinate and inspire boat owners to use their craft to prevent nuclear ships from entering New Zealand ports and it subsequently met every nuclear ship to visit the country.[42]

In response to Muldoon's plans to resume nuclear ship visits, Labour MP Richard Prebble sought recognition of a South Pacific nuclear-free zone with the August 1976 introduction of his Nuclear Free Zone (New Zealand) Bill. Three weeks later, another Labour MP, Edward Isbey, introduced the United Nations Nuclear Free Zone Resolution Adoption Bill, which would adopt the United Nations resolution on a nuclear-free zone in the South Pacific that had been passed in December 1975. Both bills were rejected by the Government and not allowed a first reading.[43]

A further rejection of the proposed South Pacific nuclear-weapons-free zone was the Muldoon Government's invitation for the nuclear-powered cruiser USS *Truxtun* to visit Wellington. On 27 August 1976 the *Truxtun* entered Wellington harbour met by a small Peace Squadron, whose boats were outnumbered by security boats. In protest at the ship's visit, members of the Harbour Employees Union and the Watersiders' Union stopped work soon after the *Truxtun* entered the harbour. Ferry sailings were cancelled (even though it was school holidays!) and the *Truxtun* was forced to anchor in the stream for her six-day visit.[44] Muldoon and a group of Cabinet Ministers and MPs lunched with the captain on board the ship, after which Muldoon made fun of the protesters' objections by telling media "I didn't see anyone with four thumbs".[45]

By the time of the next nuclear ship visit, the Auckland Peace Squadron had some 50 craft registered, crewed and skippered by "members of Parliament, company directors and executives,

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[40] Clements 1992, p85; New Zealand Atomic Energy Committee, *New Zealand Code for Nuclear Powered Shipping (AEC 500)*, The Committee, Wellington, 1976.
[41] Barry Gustafson, *His Way: A Biography of Robert Muldoon*, Auckland University Press, Auckland, 2000, p230.
[42] Clements 1988, p109; Tom Newnham, *Peace Squadron: The Sharp End of Nuclear Protest in New Zealand*, Graphic Publications Ltd, Auckland, 1986, p10.
[43] *NZPD* 404 (1976), pp1313-28, 1400-1411; *NZPD* 405 (1979), pp2060-76.
[44] *The Evening Post*, 27 August 1976, p1; Newnham 1986, p11; Clements 1988, p109.
[45] *The Dominion*, 1 September 1976, p2.

radical activists and many ordinary members of the public who had never participated in protest before".[46] As the USS *Long Beach* approached Auckland early on the morning of 1 October 1976 she was met by members of the Peace Squadron, forcing her to slow down and stop while the protest boats were dealt with by the cruiser's naval and Police escort. The *Long Beach* eventually made its way into the harbour, through and past more than 150 protesting small craft – yachts, launches, dinghies and canoes. In Auckland, 3,000 people marched down Queen Street in protest at the visit of the nuclear cruiser, and in Parliament, politicians spent two hours debating the pros and cons of the visit following a motion by Labour MP Richard Prebble that the anchorage of the *Long Beach* in the harbour between Kings Wharf and the Devonport naval base was unsafe. While the Peace Squadron plan to stop the *Long Beach* berthing in Auckland failed, this first full-scale demonstration by the anti-nuclear movement attracted strong media attention and set the pattern for later protests.[47]

It was not only peace activists who sprang into action when a nuclear ship arrived in New Zealand waters. The New Zealand Code for Nuclear Powered Shipping was interpreted in a range of documents dealing with local responsibilities in regions where nuclear-powered ships might visit.[48] The Ministry of Civil Defence's 1976 Public Safety Plan for the Port of Wellington established that the day before the scheduled arrival of a nuclear-powered ship, the Minister of Civil Defence, in conjunction with the Police, Defence Department and local authorities, would establish a Public Safety Operational Headquarters in the basement of the Beehive, under the supervision and control of the Regional Commissioner of Civil Defence. As part of being in a state of "relaxed readiness" for an incident or accident, a tugboat crew would have on board protective clothing, individual dosimeters (to measure radiation exposure), potassium-iodate tablets[49] and service respirators for their crew. The Department of Health would also issue Ministry of Defence, Police, Ministry of Transport, Wellington Free Ambulance, Wellington Regional Fire Board and Wellington Harbour Board with their requirements of potassium-iodate tablets. Police, who would also be supplied with protective clothing, individual dosimeters and service respirators, were also required to have available roadblock signs saying, STOP –

[46] Newnham 1986, p12.
[47] *New Zealand Herald,* 1 October 1976, Section 1, pp1, 5; *New Zealand Herald,* 2 October 1976, Section 1, page 1; Newnham 1986, pp12-19; Clements 1988, p87.
[48] New Zealand Atomic Energy Committee 1976; Report of the Special Committee on Nuclear Propulsion 1992.
[49] The tablets were for taking in the event of a nuclear accident: iodine concentrates in the thyroid gland and taking a non-radioactive form of iodine would protect the individual from the accumulation of cancer-causing radioactive iodine-131 released as a fission product.

RADIOACTIVE HAZARD AREA.[50] The Wellington civil defence plan first sprang into action for the 1976 visit of the USS *Truxtun*. In the days before the ship arrived, *The Dominion* reported the installation by the National Radiation Laboratory of radiation monitoring devices at 20 sites around Wellington Harbour, and the arrival of two busloads and a planeful of Police officers from Auckland. The day before the ship arrived, the national civil defence nerve centre was activated under Parliament buildings, with *The Dominion* reporting the arrival of five Land Rovers carrying troops with technical equipment and sleeping bags.[51]

The next nuclear ship visit was in January 1978, when the USS *Pintado* was confronted with about 80 protest vessels – canoes, surfsailers, motorboats and yachts – on its approach to Auckland. This time, anticipating the nuclear-powered submarine's reception, the HMNZS *Waikato* helped the *Pintado* navigate her way through the protest craft into Auckland. Along with the frigate was a fleet of Navy and Police vessels and two navy helicopters, which escorted the submarine and harassed protest vessels.[52] The protesters had wide support: the next day, the *New Zealand Herald* reported that a flow of letters to the editor on the subject were running at a ratio of 9:7 against nuclear-powered ships coming to New Zealand.[53]

The Labour Party fought the 1978 election on a promise to close the country's ports and airports to all nuclear-powered and nuclear-weapon-carrying craft but the Muldoon Government was re-elected.[54] The visit of the nuclear submarine USS *Haddo* on 19 January 1979 met with a large protest fleet including yachts, dinghies, kayaks and surfboards. On land, street protesters – who the *New Zealand Herald* described as "predominantly young, generally sandaled and mostly white" – marched through central Auckland then massed at the waterfront chanting "one, two, three, four, we don't want your nuclear war". The American commander of the *Haddo* described the approach to Auckland as "frightening because of the danger the protesters put themselves in". The head of the Auckland Police district was not so polite, describing them as "seagoing hoodlums rather than protestors". Two men managed to climb aboard the submarine, while fellow protesters threw yellow paint bombs at the vessel, earning the headline "Nuclear Haddo a 'yellow submarine' as protestors get far too close" in Wellington's *Evening Post*.[55]

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[50] Ministry of Civil Defence, *Public Safety Plan, Port of Wellington, Nuclear Powered Shipping,* Wellington, August 1976.
[51] *The Dominion*, 27 August 1976, p1; *The Dominion*, 25 August 1976, p1.
[52] Clements 1988, p111; Newnham 1986, p22-33; *New Zealand Herald,* 17 January 1978, p1.
[53] *New Zealand Herald,* 18 January 1978, section 1, p4.
[54] David Lange, *Nuclear Free – the New Zealand Way*, Penguin Books, Auckland, 1990, p29
[55] Newnham 1986, p35-47; *New Zealand Herald*, 20 January 1979, p1; *The Evening Post*, 19 January 1976, p1.

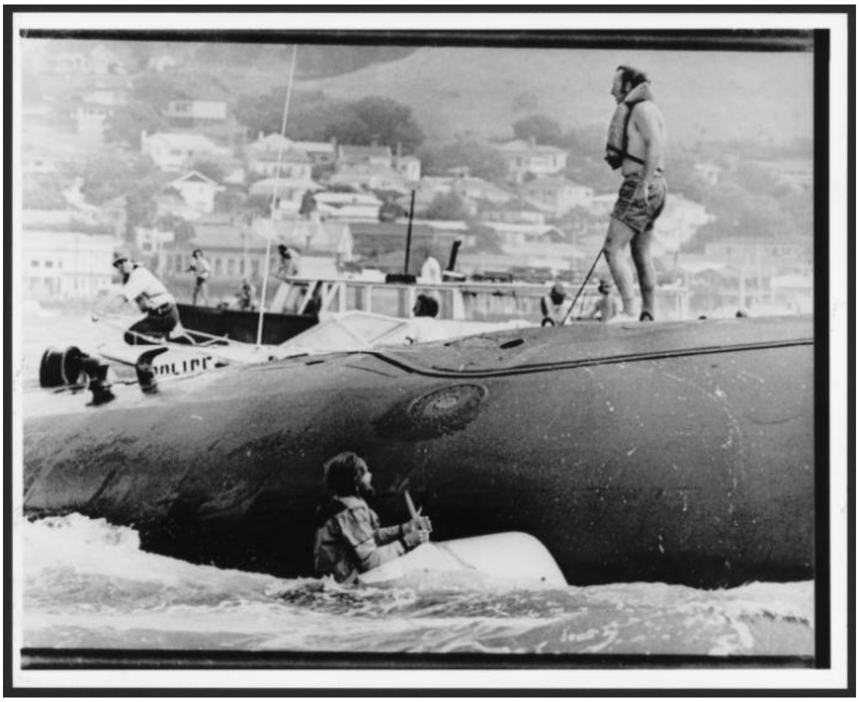

Figure 10.3: Protestor Stephen Sherie on the bow of the USS *Haddo* in Auckland Harbour, 20 January 1979. Source: EP-Navy-Warships-USS Haddo-02, Alexander Turnbull Library, Wellington, NZ.

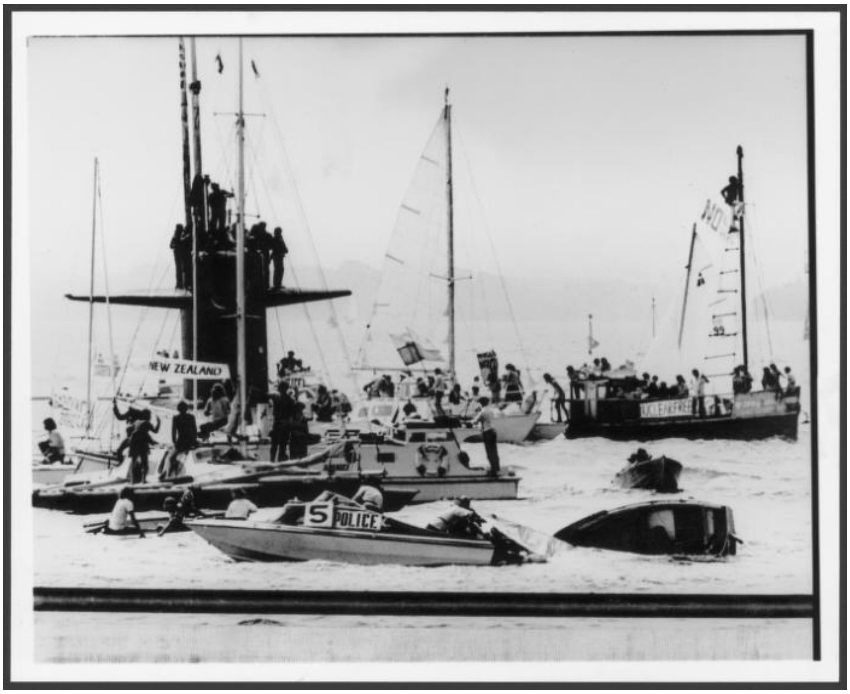

Figure 10.4: The USS *Haddo* is met in Auckland Harbour by a flotilla of protesting boats. Source: EP-Navy-Warships-USS Haddo-01, Alexander Turnbull Library, Wellington, NZ..

The National Party remained in power and American nuclear cruisers and submarines continued to visit Auckland and Wellington. The USS *Truxtun* visited Wellington in September 1980 and May 1982, the USS *Texas* visited Auckland and Wellington in August 1983 and the USS *Phoenix* visited Auckland in November 1983. Peace Squadron boats on the harbour and protesters marching through the city streets greeted each nuclear ship. The last nuclear ship to visit New Zealand was the submarine USS *Queenfish*, which docked in Auckland in March 1984. The nuclear-powered submarine was confronted by a Peace Squadron protest fleet the *New Zealand Herald* described as consisting of "58 yachts, 12 canoes, about 30 other small craft, a surf sailor and a naked man on a surfboard". The *Auckland Star* described the protest as the "most spectacular" yet, with boats firing red flares and flying black flags and protesters chanting and beating drums as the *Queenfish* slid into her mooring.[56]

The revisiting of the nuclear-powered ships debate had the effect of re-igniting the anti-nuclear movement. In 1981, the New Zealand Nuclear-Free Zone Committee was established in Christchurch, and began organising a signature campaign and publicity that included bumper stickers and badges. The Committee encouraged local groups to declare themselves nuclear-free.[57] As well as ideological reasons for wanting a nuclear-free New Zealand and South Pacific, there were genuine concerns about the potential health impact of the continuing French nuclear testing programme. Greenpeace was beginning to focus media attention on the effect of the American nuclear testing programme on the Marshall Islanders. There were reports of multiple miscarriages, babies born with birth defects, and high rates of cancer amongst the islanders, and in May 1985 the Greenpeace ship the *Rainbow Warrior* evacuated 320 people from the radiation-contaminated Rongelap Atoll to a nearby atoll.[58]

Concern about the effects of radiation from the French nuclear test series was growing. In 1983 France invited a number of scientists from South Pacific countries to visit Moruroa Atoll to study the effects of the nuclear test programme (New Zealand had been pressing France for some years to allow scientists to visit). In October 1983 the National Radiation Laboratory's director, Hugh Atkinson, led a scientific mission to Moruroa. The team included five scientists from New Zealand, Australia and Papua New Guinea, including Atkinson and Andrew McEwan, Atkinson's successor as director of the National Radiation Laboratory. During their four days on Moruroa, the scientists collected shellfish, algae, coral, reef fish, and soil and vegetation samples from the atoll, as well as plankton and ocean fish from outside the reef. Air and water samples were also collected. The samples were then analysed by either the National Radiation Laboratory in Christchurch or the Australian Atomic Energy Research Laboratories at Lucas Heights. The scientists' report, released in July 1984, was reassuring. While it concluded that 20

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[56] Report of the Special Committee on Nuclear Propulsion 1992, p183; Newnham 1986, p48-54; *The New Zealand Herald,* 24 March 1984, Section 1, p12; *Auckland Star*, 23 March 1984, p1.
[57] Clements 1988, p114-5; Larry Ross, 'Nuclear Flashback' (letter to the editor), *New Zealand Listener*, 7 September 1985, p12.
[58] David Robie, 'The Day of Two Suns', *New Zealand Listener*, 10 August 1985, pp18-19; Szabo 1990, pp113-120.

per cent of long-lived fission products contributing radiation doses to New Zealanders came from French nuclear tests, as opposed to the earlier mostly northern hemisphere tests, it said that resulting radiation levels were not harmful. Even in French Polynesia, the report concluded, radiation doses "are lower than world average levels and do not lead to the expectation that any radiation-induced diseases would be detectable".[59] Newspapers, however, picked up on the report's comments that in a worst case scenario, fracturing of the volcanic rock beneath the atoll could lead to radioactivity leaking within five years.[60] Some people, however, saw the report's finding that the tests were not causing dangerous levels of radioactivity as fuelling French claims that the tests were harmless. Greenpeace released a counter-paper calling for independent scientists to be allowed access to the data, and arguing that new more comprehensive data should be collected on radioactive contamination of the limestone and coral beneath and within the lagoon, and for an anecdotal survey of the health of Polynesian people.[61]

The Fourth Labour Government and a "nuclear-free" New Zealand

David Lange became head of the opposition Labour Party in 1983. He later recalled that he "took it for granted that we would ban nuclear weapons from New Zealand as soon as Labour was elected".[62] This ended up being one of the defining issues of the next General Election.

Lange got his chance to run for Prime Minister after the introduction of yet another nuclear-free Bill led Muldoon to call a snap election in July 1984. According to Lange, who succeeded Muldoon as Prime Minister, and George Gair, a Minister in Muldoon's Cabinet, Muldoon's Government had run out of money and calling an early election avoided the need to produce a budget that would reveal this fact.[63] Whether the nuclear-free issue was therefore a reason or an excuse for a snap election is unclear, but it was certainly at least a catalyst.

Labour MP Richard Prebble, member for Auckland Central, again attempted to legislate a nuclear-free status for New Zealand by introducing a Private Member's Bill in June 1984. The Nuclear Free New Zealand Bill, Prebble told Parliament, would ban visits by nuclear-armed or nuclear-powered ships, prohibit the building of nuclear reactors or the dumping of nuclear waste in New Zealand, and would completely ban all nuclear weapons. "Our isolation and our small

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[59] H. R. Atkinson etc al, *Report of a New Zealand, Australian and Papua New Guinea Scientific Mission to Mururoa Atoll, October-November 1983*, New Zealand Ministry of Foreign Affairs, Wellington, 1984, pp1-12.
[60] *The Dominion*, 10 July 1984, pp1, 3.
[61] Miles and Shaw 1990, pp81-82.
[62] Lange 1990, p31.
[63] Lange 1990, p49; George Gair, 'Muldoon and His Cabinet'. In Margaret Clark (ed), *Muldoon Revisited*, Dunmore Press, Palmerston North, 2004, p56.

size" Prebble said, "enable us to make a bold and imaginative initiative that would capture the imagination of the world".[64] The National Government was against the Bill, saying it would spell an end to the ANZUS alliance, the security agreement between Australia, New Zealand and the United States signed in 1951. But when the Bill was put to the vote, National MPs Marilyn Waring and Mike Minogue voted with the Labour Party and Social Credit in favour of a second reading. The National Government, which had a majority of only one in the house, won the vote (there were 40 votes against the Bill and 39 for it) only because two former Labour MPs, now acting as Independents, voted with them against the Bill.[65] The next day, National MP Marilyn Waring withdrew from the party caucus, saying she would no longer vote with the National Party on disarmament matters. Although the Nuclear Free New Zealand Bill had been narrowly defeated, Prime Minister Robert Muldoon acknowledged the Government's majority was now uncertain, and called a snap election to be held in one month's time, on 14 July 1984.[66]

Nuclear issues received a lot of attention in the month-long election campaign. Of the four political parties that fought the 1984 general election, only the National Party did not promise to ban nuclear-armed and -powered vessels from New Zealand ports. The Labour Party's stated policy on international affairs was to reaffirm its prohibition of visits by nuclear-armed and/or -powered warships, seek the establishment of a South Pacific Nuclear Weapons-Free zone, and prohibit the dumping of nuclear wastes and the testing of nuclear weapons in the Pacific. In the General Election of 14 July 1984 Labour won a landslide victory and David Lange became Prime Minister.[67]

Labour's nuclear-free policy was a reflection of what by now was the mood of New Zealanders. By November 1984, 94 areas of New Zealand had declared themselves nuclear-free, accounting for 2,075,747 people, or 65 per cent of the population.[68]

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[64] *NZPD* 456 (1984), pp255-6; Anthony Hubbard, 'Muldoon Opposes Nuclear Bill', *The Dominion*, 13 June 1984, p2.
[65] Anthony Hubbard, 'MacDonell Explains His Vote', *The Dominion*, 14 June 1984, p1; Bernard Lagan, 'Kirk Advised Government of Return', *The Dominion*, 14 June 1984, p1.
[66] *The Dominion*, 15 June 1984, p1.
[67] McMillan 1987, p13-16; Lange 1990. pp53-54.
[68] McMillan 1987, p31; Clements 1988, p116.

Figure 10.5: David Lange and Naomi Lange at Labour Party headquarters in Mangere on election night, 1984 General Election, photographed 16 July 1984 by Evening Post staff photographer Phil Reid. Source: EP/1984/3357/23-F, *ATL*.

The Ministry of Foreign Affairs, like the National Party, was concerned about the impact of a nuclear-free policy on ANZUS. The Ministry advised Lange's Government that pursuing its nuclear-free policy would be harmful to New Zealand's relationship with the United States and could negatively impact on New Zealand's security arrangements and economy.[69] Lange wished for New Zealand to remain in the ANZUS alliance and believed he could get around the issue by selecting an American ship to visit New Zealand that would not impinge on New Zealand's nuclear-free policy; a ship that was neither nuclear-powered or nuclear-armed. Lange discussed the issue with United States Secretary of State George Shultz in July and September 1984, then in November 1984 he sent Ewan Jamieson, the New Zealand Chief of Defence Staff, to Hawaii to discuss with the United States military authorities a suitable ship. The United States had a strict "neither confirm nor deny" policy when it came to questions about whether or not its ships were carrying nuclear weapons, but they understood New Zealand's situation and suggested the USS *Buchanan*, an aged oil-fired navy destroyer. Jamieson returned to New Zealand and told Lange the USS *Buchanan* would be the ideal ship to visit New Zealand. In January 1985 the United States made a request to the New Zealand Government for the USS *Buchanan* to visit New Zealand. The request was leaked to the media and there was wide speculation about the

[69] Lange 1990, pp65-66.

nuclear capabilities of the vessel. By now Lange was holidaying and unable to be contacted in the Tokelau Islands and public officials and his Government had to consider the request.[70]

Lange returned to New Zealand to advice from the Ministry of Foreign Affairs that the request be accepted, and a report from Deputy Prime Minister Geoffrey Palmer, agreed to by Cabinet, advising that because they could not conclusively say if the USS *Buchanan* was nuclear-armed or not the request be refused. Lange endorsed Palmer's report. In a private meeting between Prime Minister David Lange and the United States Ambassador, H. Monroe Brown, the United States was advised that the visit of the USS *Buchanan* could not proceed, as the ship did not conform to New Zealand policy. Lange suggested that a different ship – one that was not nuclear-capable – be sent in its place. New Zealand's refusal to give access to the USS *Buchanan* was announced publicly on 4 February to shock and anger from the United States, who had been under the impression that they had an informal agreement with Lange, and their request would be accepted. Support from the New Zealand public, however, was strong. The Lange Government's refusal of the *Buchanan* visit had coincided with 15,000 people marching down Queen Street in Auckland chanting "if in doubt, keep it out!"[71]

The United States Government responded to New Zealand's new nuclear-free policy by greatly reducing defence and intelligence cooperation with New Zealand under ANZUS, and by making it clear that if New Zealand wished to have an effective defence relationship with the United States, it must accept American nuclear weapons.[72] New Zealand was portrayed as "anti-ANZUS, anti-American, even anti-Western" with some Americans having the attitude that if "you're not with us in every particular, you must be against us".[73] Despite both Australia and the United States withdrawing from planned ANZUS military exercises, Lange stated that although New Zealand did not wish to be defended by nuclear weapons, the country remained committed to ANZUS.[74]

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[70] Gerald Hensley, 'The Bureaucracy and Advisors'. In Margaret Clarke (ed), *For The Record: Lange and the Fourth Labour Government*, Dunmore Publishing, Palmerston North, 2005, pp129-31; John Henderson, 'The Warrior Peacenik: Setting the Record Straight on ANZUS and The Fiji Coup'. In Clarke 2005, p138; Merwyn Norrish, 'The Lange Government's Foreign Policy'. In Clarke 2005, p150-7; Michael Bassett, *Working With David: Inside the Lange Cabinet*, Hodder Moa, Auckland, 2008, pp118-20, 138-41; Lange 1990, pp82-87.
[71] *NZFAR* 35, 1 (1985), pp3-5, 26-31; Clements 1988, pp134-5; McMillan 1987, p80-1; Lange 1990, pp85-90; *New Zealand Herald*, 6 February 1985, p1; Hensley 2005, p130.
[72] *NZFAR* 35, 1 (1985), pp3-5.
[73] Secretary of Foreign Affairs, Merwyn Norrish, in a speech to Devonport Rotary Club on 25 Feb 1985, *NZFAR* 35, 1 (1985), pp26-31.
[74] *NZFAR* 35, 1 (1985), pp3-7; Lange 1990, p90.

The United States response to New Zealand's stand strengthened New Zealanders' support for the nuclear-free policy.[75] Writer Stuart McMillan later claimed that the nuclear ships ban "assumed elements of an assertion of national identity. In the minds of some people, what it meant to be a New Zealander, partly, was to live in a nuclear free country".[76] On 18 February 1985 a nationwide public opinion poll conducted for *The Dominion* revealed that 56 per cent of respondents were against nuclear-armed warships visiting New Zealand. In addition, 42 per cent of respondents were against visits from warships that were nuclear-powered.[77]

The policy had an international impact. New Zealand's ban on nuclear ships, and the United States' response to it, put New Zealand's nuclear-free policy into world headlines and attracted the notice of other governments.[78] In March 1985, Lange's televised appearance at the Oxford Union debate at Oxford University also gained international media attention and boosted New Zealand's pride in their Prime Minister. At the 1 March debate, Lange spoke in the affirmative, against American Senator and Moral Majority leader Jerry Falwell, for the proposition "that nuclear weapons are morally indefensible".[79] His response to a young Rhodes Scholar who asked how Lange could justify New Zealand's continued membership of ANZUS – Lange suggested he would answer if the young man would hold his breath for a moment, adding "I can smell the uranium on it as you lean towards me!" – was received with laughter and applause from the audience.[80] Lange's intellect was praised by the British media, and his side won the debate 298 votes to 250.[81]

Bombing of the *Rainbow Warrior*

The bombing of the *Rainbow Warrior* in 1985 further reinforced New Zealand's emerging identity as an independent and nuclear-free nation willing to stand up for its principles in the face of bigger, more powerful nations. Since the New Zealand Government's 1973 frigate protest, many private yachts had continued to leave from New Zealand to protest against the French nuclear tests at Moruroa. In July 1985 the Greenpeace flagship *Rainbow Warrior* was docked at its berth in Auckland Harbour where it was preparing for a journey to Moruroa. On the evening of 10 July 1985 two explosions hit the *Rainbow Warrior*. The ship's lower regions

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[75] Clements 1988, p138; McMillan 1987, p94.
[76] McMillan 1987, p92.
[77] *The Dominion*, 18 February 1985, p1.
[78] McMillan 1987, p132; Lange 1990, p113.
[79] *NZFAR* 35, 1 (1985), pp7-11.
[80] Lange 1990, p113-5; David Lange at the Oxford Union debate, 1985, www.nzhistory.net.nz/media/sound/oxford-union-debate, downloaded 11 May 2010.
[81] Lange 1990, p115; *The Evening Post*, 4 March 1985, p2.

were flooded, partially submerging the boat and drowning Portuguese photographer Fernando Pereira who was trying to retrieve his camera.[82]

Figure 10.6: The *Rainbow Warrior* in Auckland Harbour after bombing by French secret service agents. © Greenpeace.

The *Rainbow Warrior* bombing captured the attention of the nation and led to the biggest Police operation in New Zealand history. When Police investigations revealed the likely participation of a team of agents from the French intelligence service the media attention intensified. On 23 July two French agents - they were later identified as Major Alain Marfart and Captain Dominique Prieur, members of a team of at least 13 agents - were charged with arson and the murder of Pereira. Police investigations followed with Police gathering evidence from France and Interpol. In turn, the French Government conducted its own investigation and initiated a programme of disinformation, in which they suggested Communist involvement in Greenpeace and in the bombing itself.[83] The French Prime Minister, however, later acknowledged that agents of the French secret services were responsible for sinking the *Rainbow Warrior,* acting under orders to that effect.[84] On the first day of Mafart's and Prieur's trial, 4 November 1985, their

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[82] *NZFAR* 35, 4 (1985), p9; Szabo 1985, p124.
[83] Michael King, *Death of the Rainbow Warrior,* Penguin Books, Auckland, 1986, pp148-9, 187, 196-7.
[84] *NZFAR* 35, 3 (1985), p24.

charges were reduced from murder and arson to manslaughter and wilful damage. The French agents pleaded guilty and were subsequently each sentenced to 10 years' imprisonment.[85]

Historian Michael King described the bombing of the *Rainbow Warrior* as being not an isolated incident, but part of the context of "40 years' use of the Pacific Ocean as a nuclear testing and dumping ground" and the result of France's belief "that it had the right to use any means to safeguard its own testing programme".[86] This act of state-sponsored terrorism, followed by France's continuation with the nuclear test series at Moruroa while the French agents were awaiting trial, outraged the New Zealand public and cemented support for the anti-nuclear movement. In the months after the bombing Greenpeace membership grew and donations to the organisation reached more than $200,000.[87] As Deputy Prime Minister Geoffrey Palmer said in an October speech in The Hague, "this outrageous incident has only helped to strengthen opposition in New Zealand and elsewhere to nuclear testing".[88] The challenges to New Zealand's nuclear-free identity only served to intensify it.

France retaliated by blocking or delaying imports of a range of New Zealand products in February and March 1986.[89] In July, amid claims that France would veto New Zealand butter exports to the EEC if the agents were not released, Mafart and Prieur left New Zealand. Under an agreement negotiated by the United Nations Secretary General, they were flown to Hao Atoll, 450 km NNW of Moruroa, where they were to remain for three years. In exchange, France was to pay New Zealand US$7 million compensation and issue a formal letter of apology. In December 1987, however, Mafart was repatriated to Paris for medical treatment, where he was promoted to the rank of major. Prieur returned to France in April 1988 amid reports she was pregnant. The New Zealand Government registered a formal protest. In May 1990 an international arbitration tribunal agreed that France had breached its international legal obligations by removing from and failing to return the agents to Hao, and recommended that France contribute US$2 million to a fund to promote friendly relations between the two countries.[90]

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[85] King 1986, pp219, 226-7; Szabo 1991, p132.
[86] King 1986, in Author's Note.
[87] King 1986, p240; Michael King, *The Penguin History of New Zealand*, Penguin, Auckland, 2003, p445.
[88] *NZFAR* 35, 4 (1985), p9.
[89] *NZFAR* 36, 1 (1986), p25.
[90] Miles and Shaw 1990, pp49, 64, 77; *NZFAR* 38, 3 (1988), p39; *NZEAR* 40, 3 (1990), pp34-35.

A nuclear-free zone at last

Other countries joined New Zealand in promoting a nuclear-free South Pacific. On 6 August 1985, one month after the bombing of the *Rainbow Warrior* (and 40 years after an atomic bomb was dropped on Hiroshima), New Zealand was one of eight countries to sign the South Pacific Nuclear Free Zone Treaty at the South Pacific Forum in Rarotonga. Initiated by Australia and New Zealand, the Rarotonga Treaty sought to establish the world's third nuclear-weapons-free zone by preventing the storage, dumping, manufacture and testing of nuclear weapons in the South Pacific.[91]

At a Labour Party regional conference the next month, the Minister of Defence, Frank O'Flynn, moved a resolution calling for the "urgent implementation of [anti-nuclear] legislation".[92] His resolution was successful and David Lange, as Minister of Foreign Affairs, introduced the draft legislation on 10 December 1985 as the New Zealand Nuclear Free Zone, Disarmament and Arms Control Bill. It had its first reading and was referred on to the Foreign Affairs and Defence Committee. On introducing the Bill, Lange said it fulfilled New Zealand's obligations under the South Pacific Nuclear Free Zone Treaty and reflected "the intention of the signatories to the Treaty that the destabilising elements of nuclear confrontation not be allowed to intrude into this region".[93]

Publicly, anti-nuclear sentiments continued to grow. In April 1986, an accident at the Chernobyl nuclear power plant in the Soviet republic of Ukraine killed 31 people, caused the relocation of more than 100,000 people, and sent a plume of radioactivity across Europe. The incident, the world's worst nuclear reactor accident, received huge publicity and further solidified public fear and antipathy to all things nuclear.[94] The 1986 Defence Review looked at New Zealanders' attitudes to defence and security issues and canvassed opinions on New Zealand's new nuclear-free policy. The Defence Committee of Enquiry ran a national poll that revealed that 92 per cent of respondents were opposed to nuclear weapons being stationed in New Zealand; 73 per cent wanted a nuclear-free defence policy; and 66 per cent wanted nuclear-armed ships banned from New Zealand ports (41 per cent wanted nuclear-powered ships banned too).[95] This was in

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[91] *NZFAR* 35, 3 (1985), pp16-17, 62-63.
[92] Clements 1988, p143.
[93] *NZFAR* 35, 4 (1985), pp4-5.
[94] Mark Mayell, *Nuclear Accidents*, Lucent Books, Farmington Hills, 2004, pp8-9; Zhores A. Medvedev, *The Legacy of Chernobyl,* W. W. Norton & Company, New York, 1990, p32; McEwan 2004, pp56-59.
[95] *Defence and Security: What New Zealanders Want,* Report of the Defence Committee of Enquiry, Government Printer, Wellington, 1986, pp42-4.

contrast to a similar survey, conducted in the late 1970s, that showed that more than 60 per cent of respondents were in *favour* of visits by American nuclear-armed warships.[96]

Figure 10.7: In June 1986, the United States made it clear that New Zealand would be kicked out of the ANZUS agreement. Here David Lange is seen being booted out of Cafe Anzus, while Australian Prime Minister Bob Hawke shares a drink with United States President Ronald Reagan. Source: Tom Scott, 5 July 1986, A-312-4-001, Alexander Turnbull Library, Wellington, NZ.

As feared by the Ministry of Foreign Affairs, New Zealand's nuclear-free policy spelt the end of the ANZUS agreement. In June 1986, United States Secretary of State George Schultz told the press that New Zealand and the United States "part company as friends, but we part company" indicating that in order to be treated as an ally by the United States, New Zealand would have to accept that from time to time she would be visited by a United States warship that was nuclear-armed.[97] In August, the United States announced it was formally suspending its security commitment to New Zealand under ANZUS pending adequate corrective measures over New Zealand's stance on nuclear ship visits.[98]

The South Pacific Nuclear Free Zone Treaty was ratified by New Zealand on 13 November 1986 and came into force on 11 December 1986.[99] Combined with the nuclear-free zones of Latin

[96] Lange 1990, p149.
[97] *NZFAR* 36, 2 (1986), p7.
[98] *NZFAR* 36, 3 (1986), p24.
[99] *NZFAR* 37, 1 (1986), p29.

America to the east and Antarctica to the south, it meant that 40 per cent of the Earth's surface was declared nuclear-free.[100]

The New Zealand Nuclear Free Zone, Disarmament and Arms Control Act entered into force on 8 June 1987.[101] The Act's stated purpose was "to establish in New Zealand a Nuclear Free Zone, to promote and encourage an active and effective contribution by New Zealand to the essential process of disarmament and arms control" and to implement the South Pacific Nuclear Free Zone Treaty and four other international treaties and conventions relating to disarmament and arms control.[102] The Act established a nuclear-free zone comprising all New Zealand land, water and airspace out to the limits of the territorial sea of New Zealand. Within this nuclear-free zone there was a full prohibition on the testing or transporting or stationing of nuclear weapons. Clause 11 of the Act banned the entry into the internal waters of New Zealand of any ship "whose propulsion is wholly or partly dependent on nuclear power". The Act also established a Public Advisory Committee on Disarmament and Arms Control to advise the Minister of Foreign Affairs and Prime Minister on matters related to disarmament and arms control and the implementation of the Act.[103]

The Act also amended the Marine Pollution Act 1974, making it an offence to dump any radioactive waste or other radioactive matter into New Zealand waters. On behalf of the Ministry of Health, the National Radiation Laboratory director Andrew McEwan had earlier made a submission against this aspect of the Act, pointing out that combining in one Bill legislative controls on nuclear-powered ships and the controlled disposal of radioactive waste "may reinforce public misconceptions relating to hazards associated with useful applications of radioactive materials and nuclear technology" and restated the National Radiation Laboratory's stance that the existing Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters, to which New Zealand was a signatory, was "a satisfactory control mechanism for the disposal of low-level radioactive wastes". McEwan also pointed out that risks

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[100] *NZFAR* 37, 2 (1987), p33.
[101] *NZFAR* 37, 3 (1987), p18; New Zealand Nuclear Free Zone, Disarmament and Arms Control Act 1987, www.legislation.govt.nz/act/public/1987/0086/latest/DLM115116.html, downloaded 12 May 2010.
[102] The Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water of 5 August 1963; the Treaty on the Non-Proliferation of Nuclear Weapons of 1 July 1968; the Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-bed and the Ocean Floor and in the Subsoil Thereof of 11 February 1971; and The Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction of 19 April 1972.
[103] New Zealand Nuclear Free Zone, Disarmament and Arms Control Act 1987, www.legislation.govt.nz/act/public/1987/0086/latest/DLM115116.html, downloaded 12 May 2010.

posed by nuclear-powered vessels docked in New Zealand ports were small in relation to those already posted by hazardous cargoes.[104]

As well as outlawing the stationing or testing of nuclear weapons in the zone, the Act prevented New Zealand's armed forces from possessing or controlling nuclear weapons whether inside or outside the zone. While it outlawed visits from nuclear-powered ships, the Act did not restrict scientific applications of nuclear technology or nuclear power for electricity generation, though this would be source of confusion as New Zealanders increasingly came to think of their country as "nuclear-free".[105]

Figure 10.9: The Labour Party's campaign poster for the 1987 General Election played up the Party's role in banning nuclear weapons from New Zealand land and waters. Source: Author's collection.

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[104] McEwan 2004, pp85-87.

[105] *NZFAR* 37, 3 (1987), p18; New Zealand Nuclear Free Zone, Disarmament and Arms Control Act 1987, www.legislation.govt.nz/act/public/1987/0086/latest/DLM115116.html, downloaded 12 May 2010.

Later that year Labour campaigned in the General Election on its success in making New Zealand nuclear-free. Labour won the election, but its programme of economic reforms rapidly lost the party popularity. But, as David Lange later wrote, as "the popularity of the Labour Government shrivelled", support for the nuclear-free legislation remained strong: "nuclear-free New Zealand had taken on a life of its own".[106]

New Zealand gets nuked too

Legislating for a nuclear-free New Zealand was a stand against the nuclear arms race and for the protection of New Zealanders from direct nuclear strikes or nuclear accidents but it didn't protect New Zealand from the impact of a northern hemisphere nuclear war. The United States and Soviet use of the nuclear threat throughout the Cold War has been described as "racking the nerves of generations" and New Zealanders' nerves were no exception.[107] After a series of successful moves to control and limit nuclear arms in the 1960s and 1970s – the Partial Test Ban Treaty of 1963, the Non-Proliferation Treaty of 1968, the strategic arms limitation treaty (SALT) of 1972 – the early 1980s had seen a deterioration of relations between the United States and the Soviet Union. Arms control talks failed during Ronald Reagan's first term in office (from 1981 to 1984), by which time the nuclear arsenals of the world contained tens of thousands of weapons.[108]

Nuclear war was considered to be a very real possibility. The 1974 Pugwash International Conference on Science and Public Affairs had put the likelihood of nuclear war at 50:50, a view the Australian office of National Assessment reiterated in 1981.[109] New Zealanders tended to agree. In envisaging New Zealand in 2001, environmental studies lecturer and peace campaigner Robert Mann wrote in 1981 that he expected New Zealand "only a couple of decades from now to be subjected to the effects of a major nuclear war".[110] Twenty-four per cent of Aucklanders polled in 1982 by the Commission for the Future's Study Group on Nuclear Disaster thought there was an even chance of nuclear war in the next 20 years, with a further 34 per cent thinking

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[106] Lange 1990, p161.
[107] Eric Hobsbawm, *The Age of Extremes: A History of the World, 1914-1991*, Pantheon Books, New York, 1994, p230.
[108] Hobsbawm 1994; William R. Keyler, *The Twentieth Century World: An International History*, Oxford University Press, New York, Oxford, 1996, pp320-6, 384-8.
[109] George Preddey, *Nuclear Disaster: A New Way of Thinking Down Under*, Asia Pacific Books: Futurewatch, Wellington, 1985, p34.
[110] Robert Mann, 'Environment' in George Bryant et al, *New Zealand 2001*, Cassell New Zealand, Auckland, 1981, p52.

it was likely there would be a nuclear war.[111] In the Commission for the Future report on Nuclear Disaster published in 1982, two local attack scenarios were considered, one a 1 kt tactical warhead launched at a nuclear-powered vessel docked in Devonport, the other a 1 Mt airburst. The first scenario envisaged:

> A guided missile cruiser (eg. US “Long Beach”) berthed at the Devonport Naval Base, is attacked by a hostile vessel using a 1 kt tactical nuclear weapon. Lethal nuclear radiation (600 rem) reaches out to a distance of 800m, while extensive blast damage (5psi) occurs out to 450m. The core of the 430 MW reactor is vaporised and combines with the radioactivity derived from the weapon itself; both rise with the fireball and return to earth in the manner characteristic of fallout from the explosion of a weapon alone. The plutonium from the nuclear weapons carried on board adds to strike weapon and reactor fission products … The attack causes thousands, or a few tens of thousands, of civilian casualties.[112]

The authors pointed out that New Zealand was out of range of Soviet land-based systems and the attacks were therefore unlikely, but not implausible, over the intended 30-year lifetime of the report.[113] In concluding, the authors of the report said the most serious impact on New Zealand of a northern hemisphere war were unlikely to result from fallout or other weapons effects but from the loss of trading partners. They recommended that rather than continuing to “ignore the possibility of nuclear war” New Zealand should be planning to survive a nuclear war.[114] The report was not well received by the National Government, with several Cabinet Ministers describing it as “vague” and “emotive”. Just two months later, the Government abolished the New Zealand Commission for the Future, saying, “recent publications show that the Commission’s work was no longer relevant to the issues facing New Zealand”.[115]

While New Zealand’s Ministry of Civil Defence was set up in 1960 specifically to deal with the threat of nuclear war, by the 1980s its emphasis had changed to deal almost exclusively with the threat of natural disasters, especially floods.[116] In a 1983 interview with *The Listener*, George Preddey, one of the authors of the Commission for the Future’s report and now assistant director-general of the Ministry of Civil Defence, said the British attitude to nuclear civil defence, with its little pamphlets suggesting people put brown paper over their windows in event of a nuclear disaster, might encourage morale, but it wasn’t realistic. “Our attitude here”, he said “is that it is quite misleading to suggest that there is any effective response to nuclear attack. We

[111] G. F. Preddey et al, *Future Contingencies 4. Nuclear Disaster: A Report to the Commission for the Future by A Study Group on Nuclear Disaster,* Commission for the Future, Wellington, 1982, p36.
[112] Preddey et al 1982, p25.
[113] Preddey et al 1982, p23.
[114] Preddey et al 1982, pp4, 169.
[115] Preddey 1985, p5.
[116] Preddey 1985, p147.

believe there is no effective civil defence response, that it is unrealistic to plan for a direct nuclear attack on this country."[117] Preddey's personal opinion was different. In his 1985 book *Nuclear Disaster: A New Way of Thinking Down Under.* Preddey suggested that preparing for a nuclear disaster could include:

> An infrastructure to co-ordinate the mobilisation of every element of New Zealand society and the economy in the event of a nuclear disaster;
>
> Deployment of emergency monitoring equipment (for fallout, ultraviolet light, acid rain, and other contingencies of nuclear war) and the training of personnel to use this;
>
> Distribution of appropriate emergency medical supplies, perhaps including potassium iodate tablets (to block iodine-131 uptake in the event of major attacks on Australia), sun filtering creams (to block ultraviolet light), eye protection, etc;
>
> Dissemination of authoritative, accurate information for the public on the likely immediate hazards, essential if mass panic and the worst psychological impacts were to be avoided.[118]

Preddey's was not a lone voice. Opinion polls taken as part of the 1986 Defence Review showed that New Zealanders thought the country should prepare or plan for coping with the aftermath of a nuclear war in the northern hemisphere. Some 60 per cent of people thought New Zealand should be developing all possible plans for coping with post-war conditions, with a further quarter of the opinion that there should be some preparation made for shelters and the storing of food and water.[119]

Meanwhile, another threat was looming. Atmospheric chemists first suggested in 1982 that there was a possibility of climate change induced by nuclear war. They calculated that the fires that would burn for weeks after a nuclear war – from burning cities, croplands and forest and stored fossil fuels – would produce a thick layer of smoke that would "drastically reduce the amount of sunlight reaching the earth's surface", having the effect of almost totally eliminating agricultural production in the northern hemisphere, meaning that no food would be available for any survivors of a nuclear war.[120] A subsequent study, the first to use the phrase "nuclear winter", found that a global nuclear war could lead to sub-freezing land temperatures in continental areas – down to minus 15-25°C – for many months.[121] Further studies supported the idea of a nuclear winter; as a nuclear winter would affect the southern as well as the northern hemisphere the

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[117] Sue McTagget, 'Defenceless', *New Zealand Listener*, 3 December 1983, p18.
[118] Preddey 1985, pp148-149.
[119] *Public Opinion Poll on Defence and Security: What New Zealanders Want,* carried out by National Research Bureau, Annex to the Report of the Defence Committee of Enquiry, Wellington, 1986.
[120] P. Crutzen and J. Birks, 'The Atmosphere After a Nuclear War: Twilight At Noon', *Ambio* 11 (1982), pp114-35.
[121] R. P. Turco, O. B. Toon, T. P. Ackerman, J. B. Pollack and Carl Sagan, 'Nuclear Winter: Global Consequences of Multiple Nuclear Explosions', *Science* 222, 4630 (1983), pp1283-1292.

matter caught the attention of the New Zealand media and public, and on 21 October 1984 a group of scientists took part in a nuclear winter debate on TV1's Sunday programme. [122] An Australian climate scientist, Barrie Pittock, looked at the impact of a nuclear winter on New Zealand and Australia in his 1987 book *Beyond Darkness*.[123]

Other individuals and organisations issued their own books and pamphlets about nuclear safety. Brian Hildreth's *A Nuclear Survival Manual for New Zealanders*, published in 1986, outlined preparation and protection measures for surviving in the aftermath of a nuclear war, including survival first aid, energy and self-reliance. It wasn't a pleasant world that was envisaged:

> One of the immediate consequences of a nuclear war will be the breakdown and probable collapse of the complex organisation of human society. As a survivor, you must be acutely aware at all times of the dangers this breakdown will produce. Part of your survival strategy must be to maintain constant vigilance against other human beings if your physical safety is to be ensured.

As well as plans to establish a hidden campsite (including a decoy site to foil would-be interlopers) and how to store and hide a food cache, the book included instructions for first aid, midwifery and dealing with "survival stress".[124]

A more moderate view was provided in *New Zealand After Nuclear War* in 1987. Funded by the Ministry for the Environment and published by the New Zealand Planning Council, the book was a national case study of the effect on New Zealand of a large-scale war in the northern hemisphere. Focused on the impact on food, health, energy, communications and transport, it updated the Commission for the Future's work by looking at nuclear winter and the effects of an electromagnetic pulse. The study concluded that while New Zealand was not likely to be a direct target or suffer direct effects of a nuclear war, the most serious long-term effects "would be caused by the loss of imported supplies on which every sector of activity in New Zealand depends and the loss of markets for export production which shapes much of the social and economic structure of the country". The authors recommended programmes be initiated to improve public knowledge of the likely impact on New Zealand of a nuclear war be improved, draw up contingency plans for action if war occurred be, and take action to reduce vulnerability to the effects of nuclear war.[125]

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[122] *New Zealand Met Service Quarterly Review* 141 (1984).
[123] A. Barrie Pittock, *Beyond Darkness: Nuclear Winter in Australia and New Zealand*, Sun Books, Melbourne, 1987.
[124] Brian Hildreth, *A Nuclear Survival Manual for New Zealanders*, Reed Methuen Publishers, 1986. Quote from p96.
[125] Wren Green, Tony Cairns, Judith Wright, *New Zealand After Nuclear War,* New Zealand Planning Council, Wellington, 1987, p146-8.

But by 1987, not only was New Zealand now “nuclear-free”, the international nuclear threat was diminishing. In December that year, Presidents Reagan and Gorbachev signed a historic agreement to eliminate all intermediate- and shorter-range nuclear forces, removing one-fifth of the nuclear weapons in the world. Two years later, in 1989, the Soviet Empire collapsed and the Berlin Wall, that had divided communist East Germany and capitalist West Germany since 1961, was opened. By 1991 the Soviet Union had disintegrated and the United States was the only remaining global superpower.[126]

Conclusion

By the time France started testing nuclear weapons in the Pacific, in 1966, the New Zealand Government opposed nuclear testing and was working towards disarmament and a comprehensive nuclear test ban. There was growing public concern about the health and environmental effects of nuclear weapons testing and some people were asking for more information about fallout and questioning authorities, including the National Radiation Laboratory, who said there was no danger from the tests. Opposition to nuclear weapons testing led to wider antipathy to things nuclear: as well as marching against French nuclear tests in the Pacific, New Zealanders protested against visits by nuclear-powered or nuclear-armed American warships and signed a petition against the introduction of nuclear power to New Zealand.

The concept of a “nuclear-free” New Zealand became a political issue with grass roots support. In 1981, the New Zealand Nuclear-Free Zone Committee was established in Christchurch, and began encouraging local groups to declare themselves nuclear-free. The two main political parties were now divided on nuclear issues: the Labour Party supported a South Pacific nuclear-weapons-free zone and opposed nuclear ship visits, and the National Party, highlighting the importance of the ANZUS alliance with the United States and Australia, saw both these things as politically unrealistic.

New Zealanders’ broad-based opposition to nuclear testing and nuclear warships culminated in the 1984 election of a Labour Government that campaigned on a platform that included banning nuclear vessels from New Zealand ports and establishing a South Pacific Nuclear Weapons Free Zone. Three years later this policy was enshrined in legislation with the passing of the New Zealand Nuclear Free Zone, Disarmament and Arms Control Act 1987. This was a bold and independent move that had costs as well as benefits. New Zealand’s strong and independent

[126] Hobsbawm 1994, pp249-251; Keyler 1996, pp453-67.

stance was lauded around the world, but it did cost New Zealand membership of the ANZUS alliance with the United States and Australia.

Perceived bullying by the United States and France over New Zealand’s decision helped cement New Zealanders’ allegiance to the new nuclear-free policy and incorporate it as a vital piece of national identity embraced by a majority of the population. While the nuclear-free policy was initially a Labour initiative, the National Government that was elected in 1990 rejected their initial stance and opted to continue Labour’s nuclear-free policy.

Chapter 11

A nuclear-free New Zealand?

The ideal and the reality

"We are no longer a colony, we are no longer hanging on to the skirts of major powers, we are a nation on our own and we are prepared to stand up and face the world on our own responsibility".[1]

Gerard Wall, MP, 1972

"In rightly trying to find all effective methods of opposing nuclear armaments, we can easily come to feel that we must oppose all things radioactive, thus wasting effort and putting ourselves in an indefensible position."

Jim McCahon, 1988[2]

New Zealand adopted a nuclear-free policy in 1985 that was legislated for in 1987, banning nuclear weapons and nuclear-propelled warships from New Zealand's land, air and waters. New Zealand's nuclear-free status is now an important part of national identity, and has been interpreted much more widely than the legislation, leading to bans on uranium prospecting, nuclear power, and most recently, outcry about shipments of Australian uranium ore stopping at New Zealand ports on its way to export markets.[3]

It would be easy to think that New Zealand's nuclear-free legislation, and the public opinion that it reflected, and then reinforced, reflects the courageous and independent way that New Zealanders have always thought, but this is only part of the story. As many other publications have shown, some New Zealanders were quick to recognise the hazards of radiation and the moral indefensibility of nuclear weapons. The "anti-nuclear" movement began with the first peace march in 1947 and evolved through decades of protest against nuclear testing in the Pacific and, later, protests against visits from nuclear-powered ships and against the introduction of nuclear power, and culminated in the introduction of the New Zealand Nuclear Free Zone, Disarmament and Arms Control Act 1987. As this thesis has shown, however, alongside this "anti-nuclear" movement was what can be seen as a "pro-nuclear" movement. Although they

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[1] *NZPD* 379 (1972), pp1000-1.
[2] Jim McCahon, personal notes on weekend newspapers on radioactivity, May 1988, Jim McCahon's collection.
[3] See, for example, NZPA, 'Uranium ore passes through NZ ports once a week, says ministry', http://www.stuff.co.nz/dominion-post/national/3847692/Uranium-ore-passes-through-NZ-ports-once-a-week-says-ministry, downloaded 25 June 2010.

were not a coherent group, and did not form an organised lobby, New Zealand contained many people and organisations with a pro-nuclear attitude, and was subject to the influence of outside organisations, most importantly, the United Kingdom Atomic Energy Authority (UKAEA) and the United States Atomic Energy Commission (USAEC), who had their own reasons for wanting New Zealand to adopt nuclear technology or engage in joint scientific projects. Between these two groups, or voices – the anti-nuclear and the pro-nuclear – options were considered and decisions made. Again and again it can be seen that rather than be pushed in one direction or another by groups or individuals with a particular opinion or agenda, the people with decision-making power made practical decisions based on economics and national interest when it came to deciding whether or not to adopt a certain piece of nuclear technology or whether or not to participate in projects or ventures with international agencies. The 1950s and 60s saw the United States and United Kingdom looking to establish in New Zealand a nuclear partner whose dependencies on the bigger nation would be to that nation's advantage. New Zealand officials, however, cooperated only in a self-interested way, moving forward in the field of nuclear science only to the extent that it would benefit the advancement of the nation and its own scientific endeavours.

New Zealand's nuclear-free story is well known. This thesis has revealed the lesser-known story of nuclear New Zealand. While there was never any call for New Zealand to have its own nuclear weapons, in the 1940s, 1950s and 1960s New Zealanders embraced nuclear technology and were as excited about the dawning atomic age as any nation's people. In the first few decades of the twentieth century New Zealand medics and scientists made great use of the discoveries of radium and X-rays, where the risks were relatively low but the benefits were very high. “The public are mad on radium” the Government balneologist said in 1914, and generosity by the New Zealand public, whose donations helped the hospitals to purchase radium for cancer treatment, meant that by 1929 New Zealand had a greater supply of radium per head than the United Kingdom. The field of nuclear physics began with the discovery of the atomic nucleus by New Zealander Ernest Rutherford. New Zealand's association with Rutherford did not drive New Zealand's uptake of the new technologies, but Rutherford did help educate the public on the new science in his lectures on visits back to New Zealand. He also helped New Zealand scientists procure supplies of radium, and most importantly, he facilitated the appointment of his past pupil, Ernest Marsden, to positions first at Victoria University College and then as head of the Department of Scientific and Industrial Research.

When the Second World War led to the search for a means to turn the energy known to reside in the atomic nucleus into a weapon, a group of young DSIR scientists were seconded to work with British teams on the North American project. New Zealand's support for the British nuclear programme in this way can be seen as an extension of the historical military and scientific association with the United Kingdom, but there were strong elements of self-interest there too. New Zealand scientists had access to the American nuclear projects because of the direct intervention of Ernest Marsden, who hoped to use the American-trained scientists to set up a nuclear science team at the DSIR after the war. After the bombs had been dropped on Japan, and New Zealand's involvement revealed, newspapers reported proudly about the scientists who worked on the Manhattan and Montreal projects during the war, and wrote hopefully about the search for uranium – the fuel for atomic weapons and power – that resumed, no longer as a secret, in 1946.

After the Second World War, there was promise of a new atomic age. There was a lot of enthusiasm, official and public, for nuclear power to provide electricity for New Zealand, and support for the search for uranium to boost the West Coast economy and provide a new export industry for New Zealand. Significant government and private resources were poured into this effort. The nuclear advocates promoting these ventures were more concerned with perceived economic benefits of nuclear technologies than any issues of safety or waste management, and in the 1950s there was no organised opposition to nuclear power or the possibility of a uranium mining industry.

New Zealand entered two partnerships with the United Kingdom Atomic Energy Authority in the 1950s, one to produce heavy water for the UKAEA and electricity for New Zealand at a geothermal power plant at Wairakei. In the second, the UKAEA funded prospecting efforts on the West Coast in return for the first right of refusal over any uranium mined. There were also partnerships with the USAEC. A bilateral agreement signed in 1956 allowed for the exchange of information regarding the design, construction and operation of a research reactor and allowed for the lease of up to 6 kg of enriched uranium for use as reactor fuel. The agreement resulted in gifts worth more than US$2 million in today's terms, including a sub-critical nuclear reactor, being given to New Zealand universities and the DSIR. In other agreements, DSIR scientists collected samples and conducted research for the USAEC and UKAEA as part of their monitoring the effects of radioactive fallout from their bomb tests. I have found no record of any opposition to any of these agreements with two of the world's nuclear powers.

New Zealand's involvement in these ventures can be seen as resulting from a series of pragmatic decisions made by officials acting in the national interest. New Zealand took advantage of opportunities that would be in New Zealand's best interest, for example, accepting gifts of laboratory equipment from the USAEC, entering agreements with the UKAEA that would have assisted the development of the Wairakei geothermal field and the Buller Gorge uranium deposits and led to jobs to boost to the local economies. But if it was not in New Zealand's interest, New Zealand said no. Officials at the DSIR and the SHED repeatedly refused or delayed the opportunity to set up a nuclear reactor in New Zealand, even after continued approaches from the United States, who were offering a research reactor for free, because it was not seen as necessary and the opportunity cost was high; at a time of tight science budgets its operating costs would take money from more useful projects. Similarly, in the 1950s New Zealand decided to deny New Zealand territory for use in British bomb testing and, in the 1980s, to refuse entry to American nuclear warships – it was not in the national interest to say yes, though in the latter case New Zealand was being far-sighted enough to be considering not just national but global interests and was making a point about the folly of nuclear weapons.

Alongside these "peaceful" uses of nuclear technology was the ever-present spectre of nuclear weapons tests in the Pacific, to which a segment of the New Zealand population was always opposed. The New Zealand Government initially supported the British nuclear testing programme, which ran from 1952 until 1958, by providing logistical support, most significantly in the form of two frigates to act as weather ships for the 1957 and 1958 series of hydrogen bomb tests. Significantly, however, New Zealand Prime Minister Sidney Holland refused a 1955 British request to test these bombs on New Zealand territory: Holland feared public opinion would be against using the Kermadec Islands for the test and was concerned it could upset his narrow majority in Parliament.

Opposition to nuclear weapons testing grew during the 1950s and 1960s, fuelled by growing information about the levels of radioactive bomb fallout being deposited in New Zealand and around the world, and the deepening Cold War. The 1962 American weapons test at Johnston Atoll upset radiocommunications throughout the South Pacific and filled the skies above New Zealand with an eerie glow that the *New Zealand Herald* described as doing "more than a hundred protest marches to fill men's minds with dread".[4] By the time France started testing nuclear weapons in the South Pacific, in 1966, the New Zealand Government was opposed to nuclear weapons testing and, in striking contrast to the earlier support for the British tests, in

[4] *New Zealand Herald*, 11 July 1962, p6.

1973 New Zealand sent a protest frigate to Moruroa to protest against the French tests. Opposition to nuclear weapons testing was now firmly established, and started to expand to include opposition to visits of warships carrying nuclear weapons or fuelled by nuclear power. Contrast the 1960 visit of the American nuclear submarine the USS *Halibut*, which was welcomed and marvelled at, with the colourful protests against American nuclear ship visits of the 1970s and 1980s, where people marched in the streets and ships were met by a peace squadron of protest boats.

Fuelled partly by opposition to nuclear-powered warships and concern about nuclear accidents and radiation leaks, antipathy to the idea of nuclear power began to grow. By the time of the report of the 1978 Royal Commission into Nuclear Power Generation in New Zealand most of the submissions were against the introduction of nuclear power to New Zealand, some for economic reasons and others because of health and safety concerns about the risks of nuclear power. The NZED had had nuclear power on the national power plan from 1964, but by the time the Commission released its report new indigenous fuel sources – gas and coal – had been found and electricity demand forecasts had been greatly reduced, so the question of whether or not to start building a nuclear power station did not need to be put to a full ideological or economic test. At the same time as nuclear power was being considered, however, New Zealand and international companies were continuing to prospect for uranium on the West Coast, with no political or grass roots opposition. In the 1990s uranium prospecting was made unlawful in New Zealand, probably as a reflection of the public's broad interpretation of what it means for New Zealand to be "nuclear-free". In the 1970s, however, the possibility of a uranium mining industry was not seen as a bad thing.

When New Zealand's nuclear-free legislation was introduced in 1987 it applied to nuclear weapons, nuclear-powered ships and nuclear waste. New Zealanders were immediately on the world stage, and lauded for being independent and courageous. In the years that followed, this nuclear-free ethos became deeply entrenched, a formidable part of national identity, that came to spread to nuclear power, uranium prospecting, and often, to anything associated with nuclear technology and radiation. Like other decisions in the country's nuclear history, New Zealand's rejection of any involvement with nuclear weapons can be seen as a continuation of a series of pragmatic and self-interested decisions. Nuclear weapons are in no-one's best interest and New Zealand was independent and bold enough to say so. But only a few years before the nuclear-free legislation was introduced, New Zealand had – coincidentally – rejected, for the time being, nuclear power for electricity generation. Companies had tired of spending money attempting to prove the uranium deposits on the West Coast and had abandoned their prospecting camps and drilling projects. The nuclear-free legislation, which was focused on nuclear weapons, therefore hit a New Zealand with limited so-called "peaceful" uses of nuclear technology – no nuclear power, no uranium mining, no research reactors – and the anti-nuclear attitude was able to spread, unchallenged, beyond the initial logical antipathy to nuclear weapons. This may seem obvious, but what is not so well known is, as this thesis has shown, New Zealand had only limited uses of peaceful nuclear technology by the 1980s not because of any ideological reasons, but because of a series of decisions that were based on national interest and economics.

New Zealand's "rejection" of nuclear power and uranium mining can now be seen as the result of economic decisions made in the 1970s. The fact that we do not have a nuclear reactor can be seen as a pragmatic decision made by a country with a limited budget for science that chose to focus on agriculture and supporting sciences, and the lack of a heavy water plant can be seen as the result of the British withdrawing from a planned joint venture. The fact that economic and national interest arguments were used to argue *against* these things makes it possible to see that economic and national interest arguments could be used to argue *for* these things – nuclear power and uranium mining in particular – in the future.

New Zealand is "nuclear-free" when it comes to nuclear weapons, nuclear power and uranium mining. But given the pattern of history, with its nuclear advocates as well as anti-nuclear lobbyists, and in light of recent calls for aspects of New Zealand's nuclear free policy to be reviewed, New Zealand's nuclear-free policy – in the broad sense in which it is currently interpreted – can not be taken for granted.

Bibliography

ABBREVIATIONS

AJHR Appendices to the Journals of the House of Representatives

NZMJ New Zealand Medical Journal

TPNZI Transactions and Proceedings of the New Zealand Institute

NZPD New Zealand Parliamentary Debates

NZJST New Zealand Journal of Science and Technology

PRIMARY SOURCES

UNPUBLISHED OFFICAL RECORDS

Archives New Zealand/Te Whare Tohu Tuhituhinga O Aotearoa, Head Office, Wellington[1]

AALR 873, W3158/194, 62/42/4, Govt Dept expenditure – DSIR – uranium

AAOQ, W3424 (box 16), World War II narrative No. 9

AAOQ, W3424 (box 5), 74/22/-, Atomic physics: production of heavy water, part 3

AAOQ, W3424, 74/2/1, Marsden’s DSIR file

AAOQ, W3424, 74/20/- (1947-55), Atomic energy – construction of ‘pile’ in NZ.

AAOQ, W3424, 74/20/- (1948-49), Atomic energy – construction of ‘pile’ in NZ.

AAOQ, W3434 (box 5), 74/-/-, Atomic energy, general,

AAOQ, W3434 (box 5), 74/-/-, Atomic energy, general, volume 1

AAOQ, W3872, 72/184/6, part 1, Atomic energy siting subcommittee

AATJ 6090 3/38, part 3, Atomic Energy Act

AATJ 6090, W4897/102, 5/22, Radioactive minerals, part 3

AATJ 6090, W4897/102, 5/22, Radioactive minerals, part 4

AATJ 6090, W4897/102, 5/22, Radioactive minerals, part 5

AATJ 6090, W4897/102, 5/22-1, Uranium policy, part 1

AATJ 6090, W4897/103, 5/22-1 Uranium policy, part 2

AATJ 6090, W4897/103, 5/22-1, Uranium policy, part 3

AATJ 6090, W4897/103, 5/22-1, Uranium policy, part 4

AATJ 6090, W4897/242, 23/2/1220, Application for assistance, Buller Uranium

AATJ 6090, W4993/25, 5/22/2, Rewards in respect of the discovery of uranium

AATJ 6090, W4993/262, 23/2/1220/1, Agreement and report by UKAEC

AATJ 6090, W5152/129, 12/46/1051, Mineral prospecting warrant 14553

AATJ 6090, W5152/131, 12/46/1156, Reports on prospecting

ABHS 950, W4627, 121/2/2, Atomic energy research, Wairakei heavy water project, part 2

ABHS 950, W4627, 121/2/2, Atomic energy research, Wairakei heavy water project, part 3

ABHS 950, W4627, 3405, 121/7/2, International affairs, atomic energy, part 1

ABHS 950, W4627/3534, 12/2/4, International affairs, atomic energy

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[1] Most of these files were found and accessed through Archives New Zealand old paper-based search system. In the process of Archives New Zealand’s file search system being digitised and put on ARCHWAY some file codes have changed. Changes are usually to the three or four letter agency code (eg, AAOQ) therefore the best way to find these files is through their accession numbers or record numbers which have not changed.

ABHS 950, W4627/3544, 121/5/2, Atomic energy, military uses, part 1

ABHS 950, W4627/3544, 121/5/2, Atomic energy, military uses, part 2

ABHS 950, W5422 (box 166), 111/18/3/1, Atomic energy, heavy water

ABLP W4215, 1/1, Formation, organisation, policy, part 1

ABLP, W4215, 1/1, Formation, organisation, policy, part 2

ABLP, W4215, 3/2, Nuclear power committee, siting, part 1

ABLP, W4215, 3/5, Manpower subcommittee, part 2

ABLP, W4215, 3/5, Manpower subcommittee, part 4

ABRR 7563, W4990, box 4, Radium Department 1914-1926

CO-W, W3445, box 146 (alt no 1911/16), Radium Polishes Ltd

EA1, W2619, 121/2/1, part 1, Int affairs – Atomic energy research in New Zealand, 1948-59

EA1, W2619, 121/1/1, Atomic energy general, part 1

EA2, (box 1948/6B), 111/18/3, part 1, Atomic research in New Zealand

ED, W2673, 2/0/65/3, Newspaper cuttings relating to Departmental activities, Geothermal

ED1, W2673, 2/0/22/5, Atomic power, part 1

ED1, W2673, 2/0/22/5, Atomic power, part 2

H1 15/1/6, (8486) Supplies – radium – general

H1, 131/1/6, Radium circulars

H1, 181/199 (24106) X-ray of female professional staff

H1, 26717, 108/11, Radiation hazards 1951-57

H1, 26758, 108/11, Radiation hazards 1957-58

H1, 27361, 108/11, Radiation hazards 1958-61

H1, 45543, 108/7/1, Luminous paint, 1944-61

H1, 45546, Self-luminous plastic powder, 1948-49

H1, 53/19 (28298), X-ray 1923-61

H1, 85/46 (19137), North Canterbury Hospital Board – radium

SIR1, W1414, 20/4/1, Radioactivity measurements

SIR, W3424 (box 5), 74/22/-, Atomic physics: production of heavy water, volume 1(a)

SIR, W3424 (box 5), 74/22/-, Atomic physics: production of heavy water, volume 1(b)

SIR, W3424 (box 5), 74/22/-, Atomic physics: production of heavy water, volume 2

SIR1, 20/4/2, Radioactivity – artificial

SIR1, 74/13/1, Radioisotopes committee circulars

SIR1, 74/2/6, Atomic physics project – cosmic ray research, volume 1

SIR1, 74/2/6, Atomic physics project – cosmic ray research, volume 2

SIR1, 74/38, Nuclear science – IAEA contract

SIR1, W1414, 20/4/1, Radioactivity measurements.

SIR1, W1414, 74/10, Atomic energy team

SIR1, W1414, 74/11, Pocket file, atomic energy

SIR1, W1414, 74/12, Dr Marsden’s report, 15 October 1945

SIR1, W1414, 74/13, Procurement of radioisotopes, volume 1

SIR1, W1414, 74/13, Procurement of radioisotopes, volume 2

SIR1, W1414, 74/2/4, Second Golden Hind expedition

SIR1, W1414, 74/27/6, USAEC contract

SIR1, W1414, 74/33, Bilateral agreement with USA

SIR1, W1414, 74/7, Publicity

SIR1, W1414, 74/8, Nuclear science equipment, volume 1

SIR1, W1414, 74/8, Nuclear science equipment, volume 2

SIR1, W1414, 74/8, Nuclear science equipment, volume 3

SIR1, W1414, 74/8, Nuclear science equipment, volume 4

SSC2, 8/3/4/2, Atomic energy

TO1, 24/34, Rotorua – radium water and apparatus

Archives New Zealand, Christchurch office

CABI, CH91, 13/704, Mass Miniature X-rays, 1953-71

CABI, CH56, 23/20/1, Antarctic reactors, 1961-66

CABI, CH56, 23/30/1, Antarctic reactors, 1967-68

CABI, CH56, 23/30/1, Antarctic reactors, 1969-75

CABI, CH91, 390, Victoria University Physics Dept, 1950-63

CABA 3140, CH130/Box 40, 16/1/85

CABH 3391, CH 58, 6/39, 1959-78

CABH 3391, CH58, 6/27, 1955-62

CABH 3391, CH58, 6/28, 1955-56

CABH 3391, CH58, 6/28, 1957-1979

CABH 3391, CH58, 6/39, 1959-78

CABH 3391, CH58, 7/134, 1958-1982, part 3

CABI CH91, 15/768, Canterbury University subcritical reactor, 1956-61

University of Canterbury Archives, Christchurch

MB 1281, 16578, Box 2, Item 1/12, Newspaper cuttings 1944-67, from University of Canterbury School of Engineering records

MB1281, Accession no 1385, Box 1, 1/1, School of Engineering, Campaign for Nuclear Disarmament, newspaper cuttings

PUBLISHED OFFICAL RECORDS

Atomic Energy Act 1945, *Reprint of the Statutes of New Zealand 1908-1957, volume 1*, Government Printer, Wellington, 1958, pp377-387.

Atomic Energy Amendment Act 1957, *Reprint of the Statutes of New Zealand 1908-1957, volume 1,* Government Printer, Wellington, 1958, pp387-388.

Electrical Wiring (X-ray) Regulations 1944, *New Zealand Statutory Regulations 1944*, pp429-436.

New Zealand Appendices to the Journals of the House of Representatives 1920-1945

New Zealand Nuclear Free Zone, Disarmament and Arms Control Act 1987, www.legislation.govt.nz/act/public/1987/0086/latest/DLM115116.html, downloaded 12 May 2010.

New Zealand Official Yearbook, Government Printer, Wellington, 1941, 1955

New Zealand Parliamentary Debates, Volume 269 (1945), 273 (1946), 303 (1954), 308, (1956), 311 (1959), 337 (1963), 355 (1968), 404 (1976), 405 (1976), 456 (1984).

Radiation Protection Act 1965, *Bound Reprinted Statutes, volume 10*, Thomson and Brookers, Wellington, 2005, pp961-988.

Radiation Protection Regulations 1973, *Statutory Regulations 1973, volume 1*, Government Printer, Wellington, 1974, pp234-261.

Radioactive Substances Act 1949, *New Zealand Statutes Reprint 1908-57*, *volume 13*, Government Printer, Wellington, pp97-112.

Social Security Act 1938, *Reprint of the Statues of New Zealand 1908-1957, volume 14,* Government Printer, Wellington, 1961, pp475-577

Transport of Radioactive Materials Regulations 1973, *Statutory Regulations 1973*, volume 1, Govt Printer, Wellington, 1974, pp292-328.

SPECIAL PRINTED REPORTS

Academy Council of the Royal Society of New Zealand, *Radiation and the New Zealand Community: A Scientific Overview*, The Royal Society of New Zealand Bulletin 34, Wellington, 1998.

Atkinson, H. R. et al. *Report of a New Zealand, Australian and Papua New Guinea Scientific Mission to Mururoa Atoll, October-November 1983,* New Zealand Ministry of Foreign Affairs, Wellington, 1984.

Crawford, John. *New Zealand Observers and Indoctrinees at Nuclear Weapon Tests: 1956-1958,* unpublished New Zealand Defence Force article, 2001.

Crawford, John. *The Involvement of the Royal New Zealand Navy in the British Nuclear Testing Programmes of 1957 and 1958,* New Zealand Defence Force, Wellington, 1989.

Defence and Security: What New Zealanders Want, Report of the Defence Committee of Enquiry, Government Printer, Wellington, 1986.

Department of Health Annual Report, *Appendix to the Journal of the House of Representatives,* 1951, volume 3, H-31.

Department of Scientific and Industrial Research, *Symposium on Nuclear Science*, DSIR Information Series No. 23, Wellington, 25 February 1959.

Grange, Les. *Prospecting for Radioactive Minerals in New Zealand*, DSIR Information Series No. 8, Government Printer, Wellington, 1954

Gregory, L. P. *Fallout From Nuclear Weapons Tests Conducted by France in the South Pacific from June to August 1971,* National Radiation Laboratory, Christchurch, 1972.

Matthews, K. M. *Radioactive Fallout in the South Pacific: A History. Part 2: Radioactivity Measurements in the Pacific Islands,* National Radiation Laboratory, Christchurch, 1992.

Matthews, Murray. *Radioactive Fallout in the South Pacific: A History. Part 1: Deposition in New Zealand,* National Radiation Laboratory, Christchurch, 1989.

Matthews, Murray. *Radioactive Fallout in the South Pacific: A History. Part 3: Strontium-90 and Caesium-137 Deposition in New Zealand and Resulting Contamination of Milk*, National Radiation Laboratory, Christchurch, 1993.

Ministry of Civil Defence, *Public Safety Plan, Port of Wellington, Nuclear Powered Shipping,* August 1976.

Ministry of Foreign Affairs, *French Nuclear Testing in the Pacific: International Court of Justice Nuclear Tests Case, New Zealand v. France*, Ministry of Foreign Affairs publication no 446, Wellington, 1973.

Ministry of Foreign Affairs, *New Zealand at the International Court of Justice: French Nuclear Testing in the Pacific*, New Zealand Ministry of Foreign Affairs, Wellington, 1996.

National Research Bureau, *Public Opinion Poll on Defence and Security: What New Zealanders Want,* Annex to the Report of the Defence Committee of Enquiry, Wellington, 1986.

New Zealand Atomic Energy Committee, *New Zealand Code for Nuclear Powered Shipping (AEC 500),* The Committee, Wellington, 1976.

Nuclear Free New Zealand, New Zealand Government, Wellington, 1986.

Preddey, G. F. et al, *Future Contingencies 4. Nuclear Disaster: A Report to the Commission for the Future by a Study Group on Nuclear Disaster, Commission for the Future,* Wellington, 1982.

Report of the Planning Committee on Electric Power Development in New Zealand, New Zealand Electricity Department, 1964-77.

Report to the New Zealand Government of the Fact Finding Group on Nuclear Power, Government Printer, Wellington, 1977.

Robertson, M K. *Radioactive Waste Disposal – Policies and Practices in New Zealand*, National Radiation Laboratory Report 1996/2, Christchurch, 1996.

Roth, George. *Radiation Hazards: A Survey*, Department of Health, Wellington, 1952.

Royal Commission of Inquiry into Nuclear Power Generation in New Zealand, *Nuclear Power Generation in New Zealand: Report of the Royal Commission of Inquiry*, Government Printer, Wellington, 1978.

Royal Commission on Nuclear Power Generation in New Zealand, Submissions, volume 1-4, Government Printer, Wellington, 1978.

Special Committee on Nuclear Propulsion, *The Safety of Nuclear Powered Ships,* Department of the Prime Minister and Cabinet, Wellington, 1992.

Ward, Graham (ed). *New Zealand Met Service Quarterly Review* 141, New Zealand Meteorological Service, Wellington, 1984.

The Report of the Royal Commission into British Nuclear Tests in Australia, Australian Government Publishing Service, Canberra, 1985, volume 1.

UNOFFICIAL RECORDS

Alexander Turnbull Library, National Library of New Zealand

C. S. Jacobsen, Reminiscences, FMS-Papers-4253

Hutt City Council papers, MS-papers-1293-119/03, Misc records

Sir Ernest Marsden (1889-1970) Papers, MS-papers-1342

Personal interviews, oral accounts and personal papers

Nazla Carmine, MFAT, Vienna, 14 October 2002 by email.

Brassington, Ruth. Recollection written for the author, 2005.

Campbell, John. Personal email of 16 April 2010.

Catton, Philip. Email to author of 10 June 2010.

Cotton, Paul. Personal email of 3 July 2002.

Crowley, Katy. Email to author from MFAT, Vienna, 24 March 2010.

Duke, Richard. Personal email of 21 April 2010.

Hill, Richard. Personal communication, 11 June 2010.

Hitchcock, Henry Coleridge. Interview by Judith Fyfe, 19 and 23 February 1987, NZOHA Electricity Centenary Oral History Project, Alexander Turnbull Library OHInt-0003/04.

Jones, D. H. New Zealand Nuclear Group general report on attachment to UKAEA and other related assignments, October 1969 (Rob Aspden collection).

McCahon, Jim. Author's interview with McCahon, Wellington, 16 October 2002.

McCahon, Jim. Personal recollections recorded by McCahon over 14-16 August 1998 as notes for talk to Kaikoura Probus Club.

McCahon, Jim. Undated press clippings and personal recollections, October 2002.

McCahon, Jim. *Voyage to Mururoa – HMNZS Otago and Canterbury*, unpublished diary, 1973.

Williams, Robin. Personal archives, including letter to Clement Attlee, signed by Williams and others, 19 September 1945.

Williams, Robin. *Reflections on My involvement in the Manhattan Project*, seminar at Victoria University, 10 August 2001.

NEWSPAPERS AND JOURNALS

Auckland Star, 1908, 1956, 1959, 1984

Christchurch Star Sun, 1956

Christchurch Star, 1925, 1975

Christchurch Sun, 1924

Daily Express (Sydney), 1961

Daily News, 1955

Daily Telegraph, 1955

Dominion, 1923, 1925, 1930, 1952, 1955, 1956, 1957, 1961, 1963, 1965, 1962, 1965, 1972, 1976, 1984, 1985, 2001

Dunedin Evening Star, 1966

Evening Post, 1932, 1939, 1955, 1956, 1957, 1958, 1961, 1962, 1965, 1973, 1974, 1976, 1977, 1985, 1999

Gisborne Herald, 1958

Greymouth Evening Star, 1972

Here & Now, 1955, 1957

Manawatu Daily Times, 1955

New Zealand Herald, 1914, 1956, 1958, 1961, 1962, 1976, 1978, 1979, 1984, 1985

New Zealand Mail, 1896

News, 1999

Otago Daily Times, 1914, 1956, 1958

People's Voice, 1956

Post, 1974

Press 1898, 1900, 1902, 1905, 1914, 1924, 1953, 1955, 1956, 1957, 1961, 1997, 1954

Rotorua Post, 1956

Southland News, 1955

Sunday Star, 1988.

Taumaranui Press, 1958

Te Puke Times, 1955

Timaru Herald, 1931, 1956

Journal of the Hospital Boards Association of New Zealand, September 1933

New Zealand External Affairs Review, 4, (1954), 5, (1955), 6 (1956), 13 (1963), 14 (1964), 18 (1968), 40, (1990)

New Zealand Foreign Affairs Review, 22 (1972), 25 (1975), 35 (1985), 36 (1986), 37 (1987), 38 (1988)

New Zealand Medical Journal, 1896

Student Engineer 1961-69

Transactions and Proceedings of the New Zealand Institute, 23 (1890) to 60 (1930)

University of Canterbury, School *of Engineering Prospectuses* for 1963-70

BOOKS

Boorse, Henry A. and Motz, Lloyd (eds), *The World of the Atom*, Basic Books, New York, 1966.

Marsden Editorial Committee. *Sir Ernest Marsden 80th Birthday Book*, A. H. & A. W. Reed, Wellington, 1969.

Hayman, Maurice. *These Useless Wings: Operation Grapple*, M. Hayman, Riverton, 1997.

Hildreth, Brian. *A Nuclear Survival Manual for New Zealanders*, Reed Methuen Publishers, Auckland, 1986.

Needham, Joseph and Pagel, Walter. *Background to Modern Science*, Cambridge University Press, Cambridge, 1938.

Rutherford, Ernest. *The Collected Papers of Lord Rutherford of Nelson*, Vol 1, George Allen & Unwin Ltd, London, 1962.

Thomson, J. J. *Recollections and Reflections*, G. Bell and Sons, London, 1936.

Wells, H G. *The World Set Free: A Story of Mankind*, Macmillan and Co, London, 1914.

ARTICLES AND PAPERS

‘Nuclear Testing Potential Danger’, *Salient*, 29 June 1965, p14.

Anderson, C. C. ‘Results of X-ray and Radium Therapy at the Dunedin Hospital’, *NZMJ* 28, 146 (1929), pp200-211.

Anderson, C. C. ‘Radon Ointment in Superficial Radiation Injuries’, *NZMJ* 58, 323 (1959), pp69-71.

Anderson, C. C. ‘The X-ray Examination of the Kidney Pelvis’, *NZMJ* 28, 145 (1929), pp149-156.

Becquerel, Henri. ‘On Radiations Emitted with Phosphorescence’, and ‘On the Invisible Radiations Emitted by Phosphorescent Bodies’, *Comptes Rendus de l’Académie des Sciences* 122 (1896), reproduced in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp404-6.

Bohr, Niels. ‘On the Constitution of Atoms and Molecules’, *Philosophical Magazine* 26 (1913), pp1-19, reproduced in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp751-765.

Cameron, P. D. ‘Demonstration of Radium Emanation Plant, Wellington’, *NZMJ* 28, 146 (1929), pp240-241.

Campbell, John L. ‘Thirty-six Years in Radiography’, *Health and Service* 8, 1 (1953), pp49-52.

Cockayne, L. ‘Presidential Address’, *TPNZI* 51 (1919), pp485-495.

Crosthwait, L. B. ‘A Measurement of Atmospheric Radioactivity at Wellington’, *NZJST* 37B (1955), pp382-4.

Crutzen, P. and Birks J., ‘The Atmosphere After a Nuclear War: Twilight At Noon’, *Ambio* 11 (1982), pp114-35.

Curie, Pierre and Curie, Marie. ‘On a New Radioactive Substance Contained in Pitchblende’, *Comptes Rendus de l’Académie des Sciences*, 127 (1898), pp175-8, reproduced in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp432-434.

Curie, Pierre, Curie, Marie and Bemont, G. ‘On a New Substance Strongly Radioactive, Contained in Pitchblende’, *Comptes Rendus de l’Académie des Sciences*, 127 (1898), pp1215-7, reproduced in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp434-436.

de Lautour, Harry A. ‘On the Localisation of Foreign Bodies by Means of the X-rays’, *NZMJ* 1, 2 (1900), pp67-74.

Editorial, ‘A Bomb Falls’, *New Zealand Listener*, 12 July 1946, p5.

Editorial, ‘Horror With Some Hope’, *New Zealand Listener*, 17 August 1945.

Evans, W. P., ‘Refraction and Reflexion of X-rays’, *TPNZI* 29 (1896), pp573-4.

Farr, C. C. and Florance, D. C. H. ‘On the Radio-activity of the Artesian Water System of Christchurch, New Zealand, and the Evidence of its Effect on Fish-life’, *TPNZI* 42 (1909), pp185-90.

Fieldes, M. ‘Radioactivity of Niue Island Soils’, *New Zealand Soil News* 3 (1959), pp116-20, MS papers 1342-270, *ATL*.

Fowler, K. T. ‘The “New Golden Hind” Looks for Uranium’, *The Public Service Journal*, May 1946, pp196-99.

Grigg, F. J. T. and Rogers, M. N. ‘Radioactivity and Chemical Composition of Some New Zealand Thermal Waters’, *NZJST* 11, 4 (1929), pp216-8.

Hess, Viktor F. ‘Penetrating Radiation in Seven Free Balloon Flights’, *Physikalische Zeitschrift* 13 (1912), pp1084-91, reproduced in translation in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp672-5.

Hines, Charles F. ‘The Use and Care of Radium in Hospital Practice’, *The New Zealand Nursing Journal* 34, 12 (1941), pp400-4.

Howell, J. H. ‘On the Radio-activity of Certain Soils’, *TPNZI* 39 (1906), pp223-6.

Hubbard, Anthony. ‘MacDonell Explains His Vote’, *The Dominion*, 14 June 1984, p1.

Hubbard, Anthony. 'Muldoon Opposes Nuclear Bill', *The Dominion*, 13 June 1984, p2.

Laby, T. H. and Burbidge, P. 'The Nature of Gamma Rays', *TPNZI* 44 (1911), pp30-1.

Laby, T. H. and Burbidge, P. 'The Observation by Means of a String Electrometer of Fluctuations in the Ionization Produced by γ Rays', *Proceedings of the Royal Society of London* A86 (1912), pp333-48.

Lagan, Bernard. 'Kirk Advised Government of Return', *The Dominion*, 14 June 1984, p1.

Marsden, E. 'Radioactivity of Soils, Plants and Bones', *Nature* 187, 4733 (1960), pp192-5.

Marsden, E. and C. Watson-Munro. 'Radioactivity of New Zealand Soils and Rocks', *NZJST* 26, 3B (1944), pp99-114.

Marsden, Ernest. 'Some Aspects of the Relationship of Radioactivity to Lung Cancer', *NZMJ* 64, 395 (1965), pp367-76.

Milligan, R. R. D. and Rogers, N. M. 'Radium Emanation and Goitre', *TPNZI* 59 (1928), pp389-94.

Nicholson, D. S. 'Wartime Search for Uranium', *NZJST* 36B (1955), pp375-96.

Rafter, T.A. and Fergusson, G.J. 'The Atom Bomb Effect: Recent Increase in the 14C Content of the Atmosphere, Biosphere, and Surface Waters of the Oceans', *NZJST* 38, 8 (1957B), pp 872–83.

Rafter, Athol. Extract from 'Problems in the Establishment of a Carbon-14 and Tritium Laboratory', paper presented at the Sixth International Conference on Radiocarbon and Tritium Dating, Washington State University, 1965. Reproduced in Rebecca Priestley (ed), *The Awa Book of New Zealand Science*, Wellington, Awa Press, 2008, pp250-4.

Rogers, M. N. 'An Examination of the Radon and Iodine-content of Certain Christchurch Artesian and Other Waters, with Respect to the Incidence of Goitre', *TPNZI* 57 (1927), pp893-9.

Roth, G. E. 'Radiation Protection: Historical Aspects and Radiographer Responsibilities', *Shadows* 16, 4 (1973), pp6-14.

Roth, G. E. 'The Physical Services to Radiology in New Zealand', *NZMJ* 45, 248 (1946), pp384-8.

Rutherford, E. 'Magnetic viscosity', *TPNZI*, 28 (1895), pp182-204.

Rutherford, E. 'Magnetization of Iron by High-Frequency Discharges', *TPNZI* 27 (1894), pp481-513.

Rutherford, E. 'The Scattering of Alpha and Beta Particles by Matter and the Structure of the Atom', *Philosophical Magazine* Series 6, 21 **(**1911), pp669-88.

Rutherford, Ernest, Oliphant, Marcus and Harteck, Paul. 'Transmutation Effects Observed with Heavy Hydrogen', *Nature* 133, 17 March 1934, p413.

Rutherford, Ernest. 'The Development of the Theory of Atomic Structure'. In Joseph Needham and Walter Pagel, *Background to Modern Science*, Cambridge University Press, Cambridge, 1938, pp61-74.

Rutherford, Ernest. 'The History of Radioactivity'. In Joseph Needham and Walter Pagel, *Background to Modern Science*, Cambridge University Press, Cambridge, 1938, pp49-60.

Ryder, N.V. and Watson-Munro, C.N. 'The Detection of Radioactive Dust from the British Nuclear Bombs of October 1953', *NZJST* 36B, 2 (1954), pp155-9.

Stanton, Arthur. 'Wilhelm Conrad Röntgen On a New Kind of Rays: Translation of a Paper Read Before the Wurzburg Physical and Medical Society 1895', *Nature* 53 (1896), pp274-6.

Thomson, J. J. 'Cathode Rays', *Philosophical Magazine* 44 (1897), pp293-311. In Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp416-26.

Tiller, L. W. and Cooper, E. R., 'X-ray Detection of Mouldy-core in the Delicious Apple', *NZJST* 21, 3A (1939), pp168-9.

Tingey, J. M. C. 'Luminizing Army Radio Equipment', *NZJST* 27B (1945), pp138-46.

Turco, R. P., Toon, O. B., Ackerman, T. P., Pollack, J. B. and Sagan. 'Nuclear Winter: Global Consequences of Multiple Nuclear Explosions', *Science* 222, 4630 (23 December 1983), pp1283-1292.

Villard, Paul. 'On the Reflection and Refraction of Cathode Rays and Deviable Rays of Radium', *Comptes Rendus de l'Académie des Sciences*, 130 (1900), 1010-1012. Reproduced in translation in Henry A. Boorse and Lloyd Motz (eds), *The World of the Atom*, Basic Books, New York, 1966, pp446-8.

Wodzicki, A. 'Geochemical Prospecting for Uranium in the Lower Buller Gorge, New Zealand', *NZJGG* 2 (1959), pp602-12.

Wodzicki, A. 'Radioactive Boulders in Hawks Crag Breccia', *New Zealand Journal of Geology and Geophysics* 2 (1959), pp385-93.

X-ray and Radium Protection Committee Preliminary Report, *New Zealand Journal of Health and Hospitals*, 4, 9 (1921), pp249-51.

X-ray and Radium Protection Committee Recommendations, Third Revised Report, Part VII, *Journal of the Hospital Boards Association of New Zealand* (1933), pp24-27.

Yeabsley, H. J. 'No Danger in N.Z. from Atomic Fallout', *Parent and Child*, 3, 5, 1960, p26.

WEBSITES

Nobel Prize organisation web pages at http://nobelprize.org/ downloaded May-October 2005.

Eisenhower, Dwight D. President of the United States of America, address to the 70th Plenary Meeting of the United Nations General Assembly, www.iaea.org/About/history_speech.html, downloaded 15 September 2009.

USS *Halibut* Nuclear Submarine"', www.nzhistory.net.nz/media/video/uss-halibut-nuclear-submarine, downloaded 20 April 2010.

CNN transcript of Bush's 2002 State of the Union address at http://archives.cnn.com/2002/ALLPOLITICS/01/29/bush.speech.txt/.

UNPUBLISHED

Marsden, E. The Atomic Age, unpublished talk to National Dairy Association of New Zealand in 1947, MS papers 1342-269, *ATL*.

Nevill, A. de T.1952, *Some Observations of Atmospheric Radioactivity*, thesis, Victoria University College.

Roth, G. E. *The Strong Memorial Lecture 1963 (unpublished)*

Klaric, R. *Uranium Exploration of Buller Gorge, Pororari River and Fox River Mouth Areas, New Zealand*, CRA Exploration Co Ltd, Ministry of Economic Development New Zealand, unpublished mineral report MR1250, R, 1967.

SECONDARY SOURCES

BOOKS

Angus, John, *A History of the Otago Hospital Board and its Predecessors*, The Otago Hospital Board, Dunedin, 1984.

Arnold, Lorna and Smith, Mark. *Britain, Australia and The Bomb: The Nuclear Tests and Their Aftermath*, second edition, Palgrave Macmillan, Houndmills, 2006.

Arnold, Lorna and Smith, Mark. *British Atomic Weapons Trials in Australia*, 2nd edition, Palgrave Macmillan, Basingstoke, 2004.

Arnold, Lorna. *A Very Special Relationship: British Atomic Weapon Trials in Australia*, HMSO, London, 1987.

Arnold, Lorna. *Britain and the H-bomb*, Palgrave Macmillan, Houndmills, 2001.

Asimov, Isaac. *Asimov's Guide to Science, third edition*, Basic Books, New York, London, 1972.

Badash, Lawrence, Scientists *and the Development of Nuclear Weapons: From Fission to the Limited Test Ban Treaty 1939-1963*, Humanities Press, New Jersey, 1995.

Barrowman, Rachel. *Victoria University of Wellington, 1899-1999: A History*, Victoria University Press, Wellington, 1999.

Beaglehole, John Cawte. *Victoria University College: An Essay Towards a History*, New Zealand University Press, Wellington, 1949.

Belanger, Dian Olson. *Deep Freeze: The United States, The International Geophysical Year, and the Origins of Antarctica's Age of Science*, University Press of Colorado, Boulder, 2006.

Belich, James. *Paradise Reforged: A History of the New Zealanders From the 1880s to the Year 2000*, Allen Lane, Auckland, 2001.

Bennett, F. O. *Hospital on the Avon: The History of the Christchurch Hospital 1862-1962,* North Canterbury Hospital Board, Christchurch, 1962.

Birks, J. B. (ed). *Rutherford at Manchester,* Heywood and Company, London, 1962.

Bishop, Graham. *The Real McKay: The Remarkable Life of Alexander McKay, Geologist*, Otago University Press, Dunedin, 2008.

Bodanis, David. *$E=mc^2$: A Biography of the World's Most Famous Equation*, Macmillan, London, 2000.

Bolitho, Elaine E. *Reefton School of Mines, 1886-1970: Stories of Jim Bolitho,* Friends of Waiuta in association with Reefton School of Mines and the Bolitho family, Reefton, 1999.

Boorse, Henry A. and Motz, Lloyd (eds). *The World of the Atom*, Basic Books, New York, 1966.

Bothwell, Robert. *Eldorado: Canada's National Uranium Company,* University of Toronto Press, Toronto, 1994.

Bothwell, Robert. *Nucleus: The History of Atomic Energy of Canada Limited*, University of Toronto Press, Toronto, 1998.

Brocklebank, Laurie. *Jayforce: New Zealand and the Military Occupation of Japan 1945-48,* Oxford University Press, Auckland, 1997.

Broinowski, Richard. *Fact or Fission: The Truth About Australia's Nuclear Ambitions*, Scribe Publications, Melbourne, 2003.

Bunge, Mario and Shea, William R (eds). *Rutherford and Physics at the Turn of the Century,* Dawson and Science History Publications, New York, 1979.

Burrows, Colin J. *Julius Haast in the Southern Alps*, Canterbury University Press, Christchurch, 2005.

Campbell, John, *Rutherford: Scientist Supreme*, AAS Publications, Christchurch, 1999.

Carey, John (ed). *The Faber Book of Science,* Faber, London, 1995.

Cathcart, Brian, *The Fly in the Cathedral: How a Small Group of Cambridge Scientists Won the Race to Split the Atom,* Viking, London, 2004.

Catley, Christine Cole. *Bright Star: Beatrice Hill Tinsley, Astronomer*, Cape Catley, Auckland, 2006.

Caulfield, Catherine, *Multiple Exposures: Chronicles of the Radiation Age,* Penguin Books, London, 1989.

Cawte, Alice. *Atomic Australia, 1944-1990,* New South Wales University Press, Sydney, 1992.

Clarke, Margaret (ed). *For The Record: Lange and the Fourth Labour Government*, Dunmore Publishing, Palmerston North, 2005.

Clements, Kevin. *Back From the Brink: The Creation of a Nuclear-Free New Zealand*, Allen & Unwin/Port Nicholson Press, Wellington, 1988.

Copeland, Douglas. *Generation X*, Abacus, London, 1991.

Cross, Roger. *Fallout: Hedley Marston and the British Bomb Tests in Australia,* Wakefield Press, Kent Town, 2001.

Da C. Andrade, E. N. *Rutherford and the Nature of the Atom,* Peter Smith, Gloucester, Mass., 1978.

Danielsson, Bengt and Danielsson, Marie-Therese. *Poisoned Reign: French Nuclear Colonialism in the Pacific,* Penguin Books, Ringwood, Vic., 1986.

Dewes, Kate and Green, Robert. *Aotearoa/New Zealand at the World Court*, The Raven Press, Christchurch, 1999.

Dow, Derek A., *Safeguarding the Public Health: A History of the New Zealand Department of Health*, Victoria University Press, Wellington, 1995.

Duncan, T. and Stout, M., *Medical Services in New Zealand and the Pacific*, War History Branch, Department of Internal Affairs, Wellington, 1958.

Duncan, T. and Stout, M., *War Surgery and Medicine*, War History Branch, Department of Internal Affairs, Wellington, 1954.

Dyson, John. *Sink the Rainbow! An Enquiry into the 'Greenpeace Affair'*, Reed Methuen, Auckland, 1986.

Evans, Ivor B. N. *Man of Power: The Life Story of Baron Rutherford of Nelson*, Stanley Paul & Co Ltd, London, 1939.

Eve, A. S. *Rutherford: Being the Life and Letters of the Rt Hon Lord Rutherford, O. M.*, Cambridge University Press, Cambridge, 1939.

Fairburn, Miles. *The Ideal Society and its Enemies*, Auckland University Press, Auckland, 1989.

Feather, Norman. *Lord Rutherford*, Blackie & Son Limited, London, 1940.

Fenwick, P. C. *North Canterbury Hospital and Charitable Aid Board*, Andrews Baty and Co., Christchurch, 1926.

Firth, Stewart. *Nuclear Playground*, Allen & Unwin, Sydney, 1987.

Gaddis, John Lewis. *The Cold War*, Allen Lane, London, 2005.

Galbreath, Ross. *DSIR: Making Science Work for New Zealand*, Victoria University Press, Wellington, 1998.

Galbreath, Ross. *Scholars and Gentlemen Both: G.M. & Allan Thomson in New Zealand Science & Education*, Royal Society of New Zealand, Wellington, 2002.

Galbreath, Ross. *Walter Buller: The Reluctant Conservationist*, GP Books, Wellington, 1989.

Gardner, W. J., Beardsley, E. T. and Carter, T. E. *A History of the University of Canterbury, 1873-1973*, University of Canterbury, Christchurch, 1973.

Gowing, Margaret. *Britain and Atomic Energy 1939-1945*, Macmillan and Co Ltd, London, 1964.

Gowing, Margaret. *Independence and Deterrence: Britain and Atomic Energy 1945-52, Volume 1, Policy Making*, Macmillan, London, 1974.

Gowing, Margaret. *Independence and Deterrence: Britain and Atomic Energy 1945-52, Volume 2, Policy Execution*, Macmillan, London, 1974.

Green, Wren, Cairns, Tony and Wright, Judith. *New Zealand After Nuclear War*, New Zealand Planning Council, Wellington, 1987.

Gribbin, John. *Science: A History 1543-2001*, Allen Lane, London, 2002.

Gustafson, Barry. *His Way: A Biography of Robert Muldoon*, Auckland University Press, Auckland, 2000.

Hall, Tony. *Nuclear Politics: The History of Nuclear Power in Britain*, Penguin, Harmondsworth, 1986.

Harremoes, Paul (ed), *The Precautionary Principle in the 20th Century: Late Lessons from Early Warnings*, Earthscan Publications, London, Sterling VA, 2000.

Hellemans, Alexander and Bunch, Bryan. *The Timetables of Science: A Chronology of the Most Important People and Events in the History of Science*, Simon and Schuster, New York, 1988.

Hercus, Sir Charles and Bell, Sir Gordon, *The Otago Medical School under the First Three Deans*, E & S Livingstone Ltd, Edinburgh and London, 1964.

Hewlett, Richard G. and Jack M. Holl, *Atoms for Peace and War, 1953-1961: Eisenhower and the Atomic Energy Commission*, University of California Press, Berkeley, 1989.

Hobsbawm, Eric. *The Age of Extremes: A History of the World, 1914-1991*, Pantheon Books, New York, 1994.

Jamieson, H. D. (ed), *The Development of Medical Physics and Biomedical Engineering in New Zealand Hospitals 1945-1995*, H. D. Jamieson, Dannevirke, 1995.

Kellaway, Jo and Maryan, Mike, *A Century of Care: Palmerston North Hospital 1893-1993*, Focus Books, Double Bay, 1993.

Keyler, William R. *The Twentieth Century World: An International History*, Oxford University Press, New York, Oxford, 1996.

King, Michael. *Death of the Rainbow Warrior*, Penguin Books, Auckland, 1986.

King, Michael. *The Penguin History of New Zealand*, Penguin, Auckland, 2003.

Lange, David. *Nuclear Free – the New Zealand Way*, Penguin Books, Auckland, 1990.

Locke, Elsie. *Peace People: A History of Peace Activities in New Zealand*, Hazard Press, Christchurch, 1992.

Maclean, F. S. *Challenge for Health: A History of Public Health in New Zealand*, Government Printer, Wellington, 1964.

Mann, W. B. *The Cyclotron,* 4th edition, Methuen and Co, London, 1953.

Martin, John E. (ed). *People, Politics and Power Stations: Electric Power Generation in New Zealand 1880-1998, second edition*, Electricity Corporation of New Zealand and Historical Branch, Department of Internal Affairs, Wellington, 1998.

May, Philip Ross. *The West Coast Gold Rushes*, Pegasus, Christchurch, 1967.

Mayell, Mark. *Nuclear Accidents*, Lucent Books, Farmington Hills, 2004.

McEwan, A. C. *Radiation Protection and Dosimetry in New Zealand: A History of the National Radiation Laboratory,* New Zealand Department of Health, Wellington, 1983.

McEwan, Andrew. *Nuclear New Zealand: Sorting Fact From Fiction*, Hazard Press, Christchurch, 2004.

McEwen, Mary. *Charles Fleming, Environmental Patriot: A Biography*, Craig Potton, Nelson, 2005.

McGibbon, Ian (ed), *Undiplomatic Dialogue: Letters Between Carl Berendsen and Alister McIntosh, 1943-52*, Auckland University Press, Auckland, 1993.

McKinnon, Malcolm. *Independence and Foreign Policy: New Zealand in the World Since 1935,* Auckland University Press, Auckland, 1993.

McLintock, A. H. (ed). *An Encyclopaedia of New Zealand,* Vol 2, Government Printer, Wellington, 1966.

McMillan, Stuart. *Neither Confirm Nor Deny: The Nuclear Ships Dispute Between New Zealand and the United States*, Allen & Unwin/Port Nicholson Press, Wellington, 1987.

Meduna, Veronika and Rebecca Priestley, *Atoms, Dinosaurs & DNA: 68 Great New Zealand Scientists,* Random House, Auckland, 2008.

Medvedev, Zhores A. *The Legacy of Chernobyl,* W. W. Norton & Company, New York, 1990.

Mein Smith, Philippa. *Maternity in Dispute: New Zealand 1920-1939,* Department of Internal Affairs, Wellington, 1986.

Mein Smith, Philippa. *A Concise History of New Zealand,* Cambridge University Press, Cambridge, 2005.

Miles, Julie and Shaw, Elaine. *Chronology: The French Presence in the South Pacific, 1838-1990,* Greenpeace, Auckland, 1990.

Mitchell, Alan. *84 Not Out: The Story of Sir Arthur Sims*, Hennel Locke in association with George G. Harrap & Co., London, 1962.

Morgan, Robin and Whitaker, Brian. *The Sunday Times Insight Rainbow Warrior,* Arrow Books, London, Auckland, 1986.

Morrell, W. P. *The University of Otago: A Centennial History,* University of Otago Press, Dunedin, 1969.

Muirhead, Ed. *A Man Ahead of his Times: T. H. Laby's Contribution to Australian Science,* The University of Melbourne, Melbourne, 1996.

Nathan, Simon. *Harold Wellman: A Man Who Moved New Zealand,* Victoria University Press, Wellington, 2005.

Neutze, Diana and Eric Beardsley, *Design for a Century,* University of Canterbury Publication No. 37, Christchurch, 1987.

Newnham, Tom. *Peace Squadron: The Sharp End of Nuclear Protest in New Zealand*, Graphic Publications Ltd, Auckland, 1986.

Oliphant, Mark. *Rutherford: Recollections of the Cambridge Days*, Elsevier Publishing Company, New York, 1972;

Palmer, Geoffrey and Palmer, Matthew. *Bridled Power: New Zealand Government Under MMP, third edition,* Oxford University Press, Auckland, 1997.

Parry, Gordon, *Clipping the Claws: The Story of the First 60 years of the Otago and Southland Division of the Cancer Society of New Zealand*, Otago and Southland Division of the Cancer Society of New Zealand, Dunedin, 1989.

Peat, Neville. *Subantarctic New Zealand: A Rare Heritage*, Department of Conservation, Invercargill, 2003.

Pittock, A. Barrie. *Beyond Darkness: Nuclear Winter in Australia and New Zealand,* Sun Books, Melbourne, 1987.

Porter, Roy and Ogilvie, Marilyn (eds). *The Biographical Dictionary of Scientists, third edition, Volume 3,* Oxford University Press, New York, 2000.

Powaski, Ronald E. *March to Armageddon: The United States and the Nuclear Arms Race, 1939 to the Present*, Oxford University Press, Oxford, 1987.

Preddey, George. *Nuclear Disaster: A New Way of Thinking Down Under*, Asia Pacific Books: Futurewatch, Wellington, 1985.

Priestley, Rebecca (ed). *The Awa Book of New Zealand Science,* Awa Press, Wellington, 2008.

Quinn, Susan, *Marie Curie: A Life*, Heinemann, London, 1995.

Reynolds, Wayne. *Australia's Bid for the Atomic Bomb,* Melbourne University Press, Melbourne, 2000.

Rhodes, Richard. *The Making of the Atomic Bomb*, Touchstone, New York, 1986.

Rice, Geoffrey W. (ed). *The Oxford History of New Zealand, second edition*, Oxford University Press, Auckland, 1992.

Rockel, Ian. *Taking the Waters: Early Spas in New Zealand,* Government Print, Wellington, 1986.

Ryan, James, Sutton, Keith & Baigent, Malcolm. *Australasian Radiology: A History*, McGray-Hill Book Company, Sydney, 1996.

Shears, Richard and Gidley, Isobelle. *The Rainbow Warrior Affair,* Irwin Publishing, Toronto, 1986.

Shurcliff, W. A. *Bombs at Bikini*, W. H. Wise, New York, 1947.

Sinclair, Keith. *A History of the University of Auckland 1883-1983,* Auckland University Press, Auckland, 1983.

Spencer R. Weart, *Nuclear Fear: A History of Images*, Harvard University Press, Cambridge, Mass., 1988.

Sutphen, Mary P. and Andrews, Bridie (eds), *Medicine and Colonial Identity*, Rutledge, London and New York, 2003.

Szabo, Michael. *Making Waves: The Greenpeace New Zealand Story*, Greenpeace New Zealand, Auckland, 1991.

Taylor, Nancy. *The New Zealand People at War: The Home Front,* Volume 2, Government Printer, Wellington, 1986.

Templeton, Malcolm. *Standing Upright Here: New Zealand in the Nuclear Age 1944-1990,* Victoria University Press, Wellington, 2006.

Trapeznik, Alexander and Fox, Aaron (eds). *Lenin's Legacy Down Under: New Zealand's Cold War,* University of Otago Press, Dunedin, 2004.

Trotter, Chris. *No Left Turn: The Distortion of New Zealand's History by Greed, Bigotry and Right-Wing Politics*, Random House, Auckland, 2007.

Walker, J Samuel. *Permissible Dose: A History of Radiation Protection in the Twentieth Century,* University of California Press, Berkeley, 2000.

Wilfrid Eggleston, *Canada's Nuclear Story*, Clarke, Irwin, Toronto, 1965.

Wilson, D. Macdonald, *A Hundred Years of Healing: Wellington Hospital 1847-1947,* A. H. & A. W. Reed, Wellington, 1948.

Wilson, David. *Rutherford: Simple Genius,* The MIT Press, Cambridge, Massachusetts, 1983.

ARTICLES, PAPERS AND CHAPTERS

'Atomic Energy in Harness', *The Economist*, 23 July 1955, pp1-17.

'New Zealand Strontium-90 Figures "A warning"', *New Zealand Public Service Journal*, December 1959, p8.

'X-Day at Bikini', *New Zealand Listener*, 5 July 1946, pp6-8.

Anderson, C. C., 'The Development of Radiology in New Zealand', *Australasian Radiology* 10 (1966), pp296-307.

Avery, Donald Howard. 'Atomic Scientific Co-operation and Rivalry Among Allies: The Anglo-Canadian Montreal Laboratory and the Manhattan Project 1943-1946', *War in History* 2, 3 (1995), pp274-305.

Barber, David. 'New Zealand Frigate Making Headlines in Europe as She Continues to Defy France', *The Evening Post*, 11 July 1973, p1.

Beavis, Cindy. 'Handling "Hot" Rubbish', *New Zealand Listener*, 22 October 1976, pp16-17.

Begg, A C. 'The Father of Radiology in New Zealand', *NZMJ* 83, 543 (1975), pp1-5.

Binnie, Anna. 'Oliphant, the Father of Atomic Energy', *Journal and Proceedings of the Royal Society of New South Wales* 139 (2006), pp11-22.

Borrie, J. F., 'A History of Training for the Diploma of the Society of Radiographers (London)', *Shadows* 16, 1 (1973), pp15-27.

Brady, Anne-Marie. 'The War That Never Was: New Zealand-China Relations in the Cold War Era'. In Alexander Trapeznik and Aaron Fox (eds), *Lenin's Legacy Down Under: New Zealand's Cold War,* University of Otago Press, Dunedin, 2004, pp131-51.

Brown, Shaun. 'On Protest with Otago', *New Zealand Listener*, 20 August 1973.

Bryder, Lynda. 'Tuberculosis in New Zealand'. In A. J. Proust (ed), *History of Tuberculosis in Australia, New Zealand and Papua New Guinea*, Canberra, Brolga Press, 1991, pp79-89.

Calcott, Dean. 'Strontium Powered, Antarctica's Nuclear Past is Little Known, *The Press*, 27 December 1996, p14.

Calder, Ritchie. 'Burying Live Atoms is as Expensive as Burying Dead Pharoahs', WHO Special Feature, November 1958.

Campbell, Diane J., 'A Brief History of Dental Radiography', *New Zealand Dental Journal* 91 (1995), pp127-33.

Chapple, Geoff. 'Energy Which Never Ceases', *New Zealand Listener*, 28 May 1977, pp24-25.

Chapple, Geoff. 'Nuclear Power Slows Down', *New Zealand Listener*, 24 February 1979, pp22-23.

Crawford, John. ' "A Political H-Bomb": New Zealand and the British Thermonuclear Weapon Tests of 1957-58', *The Journal of Imperial and Commonwealth History* 26, 1 (1998), pp127-50.

Curie, Eve. 'The Colour of Radium'. In John Carey (ed), *The Faber Book of Science,* Faber, London, 1995, pp191-201.

Dow, Derek. 'Electricians Left to Run Early X-ray Machines', *New Zealand Doctor,* 30 September 1998, p35.

Editorial, 'The Deadly Dust', *New Zealand Listener,* 29 June 1956, p4.

Farley, F. J. M. 'The Fewer the Better', *Here & Now*, 60 (Sept 1957), pp11-12.

Fermi, Laura. 'In the Black Squash Court'. In John Carey (ed), *The Faber Book of Science*, Faber, London, 1995, pp324-334.

Gair, George. 'Muldoon and His Cabinet'. In Margaret Clark (ed), *Muldoon Revisited*, Dunmore Press, Palmerston North, 2004, pp41-57.

Galbreath, Ross. 'The Rutherford Connection: New Zealand Scientists and the Manhattan and Montreal Projects', *War in History* 2, 3 (1995), pp306-19.

Goldschmidt, Bertrand. 'A Historical Survey of Nonproliferation Policies', *International Security* 2, 1 (1977), pp69-87.

Gregory, J. G. 'Run Out, Fallout, All Fall Down', *New Zealand Science Review* 31, 4 (1974), p75.

Gregory, L. P. 'Radioactive Fallout', *Health and the Environment* 24, 4 (1972), pp14-15.

Health, 24, 3, Spring 1972.

Henderson, John. 'The Warrior Peacenik: Setting the Record Straight on ANZUS and The Fiji Coup'. In Margaret Clarke (ed), *For The Record: Lange and the Fourth Labour Government*, Dunmore Publishing, Palmerston North, 2005, pp136-43.

Hensley, Gerald. 'The Bureaucracy and Advisors'. In Margaret Clarke (ed), *For The Record: Lange and the Fourth Labour Government*, Dunmore Publishing, Palmerston North, 2005, pp129-35.

Holland, Sidney. 'Nuclear Test Explosions', *External Affairs Review* 7, 5, (1957), pp17-20.

Knox, W. A. 'Protective Measures in Dental Roentgenology', *New Zealand Dental Journal*, March 1920, pp136-9.

Kos, J. Stephen. 'Interim Relief in the International Court: New Zealand and the Nuclear Tests Cases', *Victoria University Wellington Law Review* 14 (1984), pp357-87. Quoted in Kate Dewes and Robert Green, *Aotearoa/New Zealand at the World Court,* The Raven Press, Christchurch, 1999, p10.

Lake, Marilyn. 'Female Desires: The Meaning of World War II', *Australian Historian Studies* 24, 95, (1990), pp267-84.

Mann, Robert. 'Environment'. In George Bryant et al, *New Zealand 2001*, Cassell New Zealand, Auckland, 1981, p52.

McIntyre, W. David. 'From Dual Dependency to Nuclear Free'. In Geoffrey W. Rice (ed), *The Oxford History of New Zealand, second edition*, Oxford University Press, Auckland, 1992, pp520-38.

McTagget, Sue. 'Defenceless', *New Zealand Listener*, 3 December 1983, p18.

Mein Smith, Philippa. 'New Zealand Milk for "Building Britons"'. In Mary P. Sutphen and Bridie Andrews (eds), Medicine *and Colonial Identity*, Rutledge, London and New York, 2003, pp79-102.

National Radiation Laboratory, 'Peaceful Plutonium', in *Radiation Protection News & Notes*, No 34, April 1996, pp7-8.

Nicholson, D. S. Wartime Search for Uranium, *NZJST*, 36B (1955), pp375-96.

Norrish, Merwyn. 'The Lange Government's Foreign Policy'. In Margaret Clarke (ed), *For The Record: Lange and the Fourth Labour Government*, Dunmore Publishing, Palmerston North, 2005, p150-7.

O'Meagher, Matthew. 'Prospects for Enrichment: New Zealand Responses to the Peaceful Atom in the 1950s', *Journal & Proceedings of the Royal Society of New South Wales* 139 (2006), pp51-62.

Pauling, Linus. 'Atomic Power and Radiation Hazards', *New Zealand Listener*, 18 December 1959, pp6-7.

Philips, Jock. 'New Zealand Celebrates Victory'. In John Crawford (ed), *Kia Kaha: New Zealand in the Second World War*, Oxford University Press, Melbourne, pp302-16.

Priestley, Rebecca. 'Lord of the Atoms', *New Zealand Listener*, 15 November 2008, pp28-32.

Priestley, Rebecca. 'Material Evidence', *New Zealand Listener*, 27 August 2005, pp36-37.

Priestley, Rebecca. 'Seismic Stations Play Role in Policing Nuclear Bangs', *Evening Post*, 22 June 1999, p5.

Priestley, Rebecca. 'The Search for Uranium in "Nuclear-free" New Zealand: Prospecting on the West Coast, 1940s to 1970s.' *New Zealand Geographer* 62 (2006), pp121–134.

Priestley, Rebecca. 'Ernest Marsden's Nuclear New Zealand: from Nuclear Reactors to Nuclear Disarmament', *Journal and Proceedings of the Royal Society of New South Wales* 139 (2006), pp23-38.

Reid, Francis. ' "The Democratic Politician Does Not Trouble Himself With Science": Class and Professionalism in the New Zealand Institute, 1867-1903', *Tuhinga* 16 (2005), pp16-31.

Richardson, Boyce. 'The Nuclear Decision: A Debate About New Zealand's Future: Part 1', *New Zealand Listener*, 22 November 1975, pp14-16.

Robie, David. 'The Day of Two Suns', *New Zealand Listener*, 10 August 1985, pp18-9.

Ross, Larry. 'Nuclear Flashback' (letter to the editor), *New Zealand Listener*, 7 September 1985, p12.

Roth, G. E. 'The Problem of Radiation Safety', *The New Zealand Radiographer* 1, 4 (1949), pp3-14.

Sparks, Rodger. 'Radiocarbon Dating – New Zealand Beginnings', *New Zealand Science Review* 61, 2 (2004), pp39-41.

Strange, Glyn. 'Popper's A-bomb Dilemma', *Evening Post*, 14 August 1995, p5.

Waddington, C. H. 'Atomic Power and its Hazards', *The Press*, 1 June 1957.

Walker, D. 'Power, Thermo-Nuclear Research, Nuclear Physics'. In DSIR, *Symposium on Nuclear Science*, DSIR Information Series No. 23, Wellington, 25 February 1959.

Weiner, Charles, 'Physics in the Great Depression', *Physics Today* 23, 10 (1970), p31-8.

Wilkes, Owen. 'New Zealand and the Atom Bomb'. In John Crawford (ed), *Kia Kaha: New Zealand in the Second World War*, Oxford University Press, Auckland, 2002.

Williamson, B. D. P. 'Luminous Paint: No Significant Hazards Detected', *N. Z. Horological Journal* 14, 4 (1960), pp6-9.

Williamson, B. D. P. 'Luminous Paint', *N. Z. Horological Journal* 17, 5 (1963), pp17-23.

Wood, F. L. W. 'New Zealand Foreign Policy 1945-1951'. In *New Zealand in World Affairs, volume 1*, Price Milburn/New Zealand Institute of International Affairs, Wellington, 1977, pp91-113

WEBSITES AND ELECTRONIC MEDIA

Parliamentary debate on New Zealand Nuclear Free Zone, Disarmament, and Arms Control (Nuclear Propulsion Reform) Amendment Bill at http://www.parliament.nz/miNZ/PB/Debates/Debates/7/c/1/47HansD_20050727_00001577-New-Zealand-Nuclear-Free-Zone-Disarmament.htm, downloaded 23 July 2008.

AAS biography of Watson-Munro, www.science.org.au/academy/memoirs/watson-munro.htm, downloaded 10 December 2009.

American Institute of Physics internet entry on J J Thomson at www.aip.org/history/electron/jjhome.htm, downloaded 23 June 2005.

ANSTO website www.ansto.gov.au/discovering_ansto/history_of_ansto/hifar, downloaded 20 April 2010.

Baumgart, Ian L, 'Hamilton, William Maxwell 1909–1992', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded 8 April 2010.

Baumgart, Ian L. 'Hamilton, William Maxwell 1909–1992', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded on 8 April 2010.

Brennan, M. H. 'Charles Watson-Munro, 1915-1991', *Australian Academy of Science Biographical Memoirs*, www.science.org.au/academy/memoirs/watson-munro.htm, downloaded 17 September 2008.

Brodie, James W. 'Howell, John Henry 1869-1944', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded 21 June 2005.

Bush, Graham W. A. 'Bloodworth, Thomas 1882 – 1974', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz/, downloaded 11 June 2010.

Clark, Helen. Prime Minister's address on 'New Zealand and Peaceful Conflict Resolution' in Cairo, Egypt, www.beehive.govt.nz/speech/new+zealand+and+peaceful+conflict+resolution downloaded 23 June 2010.

Nuclear test yields from www.ratical.org/ratville/nukes/testChrono95-8.html, downloaded 12 December 2004.

Department of Conservation website: www.doc.govt.nz/Conservation/Marine-and-Coastal/Marine-Reserves/Kermadec.asp, downloaded 15 July 2004

Dow, Derek A. 'Watt, Michael Herbert 1887-1967', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz, downloaded on 20 June 2010.

Exchange rates over time calculated at www.measuringworth.com on 19 October 2009.

Fischer, David. *History of the IAEA: The First Forty Years*, Vienna, The Agency, 1997, pp471-474, www-pub.iaea.org/MTCD/publications/PDF/Pub1032_web.pdf, downloaded 21 October 2009.

Frame, Paul W. 'Radioactive Curative Devices and Spas', originally published in the Oak Ridger newspaper, 5 November 1989, downloaded from www.orau.org/ptp/articlesstories/quackstory.htm on 1 June 2004.

Full text of the Convention on the High Seas Done at Geneva, on 29 April 1958, http://sedac.ciesin.org/entri/texts/high.seas.1958.html, downloaded 14 December 2009.

Galbreath, Ross. 'Marsden, Ernest 1889 – 1970', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz/, downloaded 21 November 2005.

Goldschmidt, Dr Bertrand. *Uranium's scientific history 1789-1939*, originally presented at the 14th International Symposium held by the Uranium Institute in London, September 1989. Downloaded from www.world-nuclear.org/ushist.htm on 27 June 2005.

Gustafson, Barry. 'Holland, Sidney George 1893-1961', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz/, downloaded 8 March 2010.

Home, R. W. 'Burhop, Eric Henry Stoneley (1911–1980), *Australian Dictionary of Biography*, http://adbonline.anu.edu.au/biogs/A130339b.htm, downloaded 6 December 2008.

Lange, David at the Oxford Union debate, 1985, www.nzhistory.net.nz/media/sound/oxford-union-debate, downloaded 11 May 2010.

Marshall, Russell. 'Bledisloe, Charles Bathurst 1867–1958', *Dictionary of New Zealand Biography*, www.dnzb.govt.nz/, downloaded 12 June 2010.

McLintoch, A. H. (ed). 'North and South Island Electrical Interconnection Including the Cook Strait Cable', *An Encyclopedia of New Zealand*, 1966, www.teara.govt.nz/en/1966/power-resources/10, downloaded 23 November 2009.

McLintoch, A. H. (ed). 'Recent Research', *An Encyclopaedia of New Zealand*, 1966, www.TeAra.govt.nz/en/1966/nuclear-science-in-new-zealand/4, downloaded 15 March 2010.

Ministry of Civil Defence, *Civil Defence in New Zealand: A Short History*, Ministry of Civil Defence, Wellington, 1990, napier.digidocs.com/userfiles/file/cd_short_history.pdf, downloaded 10 February 2010.

MIT Inventor of the Week entry on Johannes Geiger at http://web.mit.edu/invent/iow/geiger.html, downloaded 22 August 2005.

New York Times, 7 August 1955, quoted in Canadian Nuclear Society website www.cns-snc.ca/media/toocheap/toocheap.html downloaded 24 November 2009.

NZPA, 'Reactor Tempers Hutt City's Nuke Fee Declaration', www.rsnz.govt.nz/archives/news_pre_oct99/news/y_1995/m__09/d_18/a_3.php, downloaded 12 January 2000.

NZPA, 'Uranium ore passes through NZ ports once a week, says ministry', http://www.stuff.co.nz/dominion-post/national/3847692/Uranium-ore-passes-through-NZ-ports-once-a-week-says-ministry, downloaded 25 June 2010.

Oak Ridge Associated Universities Internet article on 'Shoe-fitting Fluoroscope (ca. 1930-1940), www.oran.org/ptp/collection/shoefittingfluor/shoe.htm, downloaded 2 June 2004.

Priestley, Rebecca. 'The Search for Uranium in New Zealand', *Te Ara Encyclopaedia of New Zealand* www.teara.govt.nz/EarthSeaAndSky/MineralResources/RadioactiveMinerals/en.

Richardson, Keith. *Fatal Legacy: A Nuclear Story,* Alexander Turnbull Library Sound Recordings Collection Phono CD9755.

Simon, S. L. and Robison, W. L. 'A compilation of nuclear weapons test detonation data for U.S. Pacific Ocean tests', Journal of Health Physics 73, 1 (1997), pp258-264, www.hss.energy.gov/HealthSafety/IHS/marshall/marsh/journal/rpt-22.pdf, downloaded 26 March 2009.

Thain, Iain A. *A Brief History of the Warakei Geothermal Power Project*, http://geoheat.oit.edu/bulletin/bull19-3/art69.htm, downloaded 27 November 2004, reproduced from *Geo-Heat Bulletin* 19, 3.

Topp, Jules. The Topp Twins interview, Nine to Noon, Tuesday 31 March 2009, www.radionz.co.nz/national/programmes/ninetonoon/20090331, downloaded 21 March 2010.

United Nations website, www.un.org/aboutun.milestones.htm.

UNSCEAR official website, www.unscear.org/unscear/en/about_us/history.html, downloaded 15 December 2009.

USAEC, Report on Project Gabriel, July 1954, www.hss.energy.gov/HealthSafety/IHS/marshall/collection/data/1hp1b/5674_.pdf , downloaded 15 December 2009.

Wilson, James Oakley. 'Holland, Sir Sidney George', from A. H. McLintock (ed), *An Encyclopaedia of New Zealand*, 1966, www.TeAra.govt.nz/en/1966/holland-sir-sidney-george/1, downloaded 8 March 2010.