NRL - F/57

DEPARTMENT OF HEALTH
NEW ZEALAND

ENVIRONMENTAL RADIOACTIVITY ANNUAL REPORT

1977

NATIONAL RADIATION LABORATORY
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ACKNOWLEDGEMENT

We gratefully acknowledge the assistance given by the staff of this and other Government Departments, and in particular the New Zealand Meteorological Service and the managers of milk processing plants. Without their continued co-operation in making collections and providing samples the Laboratory's monitoring programme would not be possible.

The Environmental Radioactivity Section of the Laboratory organised the monitoring operations and analysed the samples. The Officer in Charge of this section, Mr L. P. Gregory, was responsible for reporting and interpreting results. He was assisted professionally by Mr T. Baltakmens and Dr K. M. Matthews, and technically by Mr G. N. Connor and Miss M. Roberts.

for H. R. Atkinson
(Director)

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UNITS AND REFERENCE LEVELS

Units

The unit of radioactivity, the "Curie" (Ci), equal to 3.7×10^{10} disintegrations per second, is too large for environmental levels, and subdivisions are used in this report: the millicurie (mCi) = 10^{-3} Ci, and the picocurie (pCi) = 10^{-12} Ci or 2.22 disintegrations per minute.

Deposition of radioactivity is given as millicuries per square kilometre (mCi/km^2)

Concentration of radioactivity

in air: is given as picocuries per cubic metre (pCi/m^3)

in rain: is given as picocuries per litre (pCi/l) and is derived from the relationship:

$$pCi/l = \frac{mCi/km^2 \times 100}{\text{centimetres of rain}}$$

in milk: strontium-90 (^{90}Sr) concentration is given as picocuries per gram of calcium (pCi/gCa)

caesium-137 (^{137}Cs) concentration is given as picocuries per gram of potassium (pCi/gK)

(One litre of milk contains about 1.2 g of calcium and about 1.4 g of potassium)

Reference Levels

The following reference levels, against which measured levels reported herein may be compared, have been adopted for New Zealand:

Mixed fission products between 10 and 80 days old (Total Beta Activity)

	in air:	300 pCi/m^3
	in rain:	6000 pCi/l
strontium-90	in milk:	270 pCi/gCa
caesium-137	in milk:	7000 pCi/gK

SUMMARY

During 1977 the deposition of strontium-90 at nine New Zealand stations averaged less than 0.1 millicuries per square kilometre. This was the lowest deposition since measurements commenced in 1960.

During 1964 a maximum deposition (averaging 3.6 mCi/km^2 for the New Zealand stations), resulted from the large scale USSR and USA atmospheric nuclear tests of 1961-62. Subsequently annual depositions decreased. During French atmospheric tests in the South Pacific from 1966 to 1974 average depositions in New Zealand ranged from 0.3 to 1.4 mCi/km^2 per year.

The concentrations of strontium-90 and caesium-137 in New Zealand milk have reflected the changes in fallout deposition. The average concentrations during the last two years were the lowest recorded since measurements commenced.

French underground nuclear tests in the South Pacific commenced in mid-1975. Since then continuous monitoring has also been conducted at five Pacific Island stations. No fresh fission products, from possible venting during underground tests, have been detected since this programme started.

The levels recorded during 1977 were very small fractions of the reference levels and thus do not constitute a public health hazard. Moreover, the radiation dose to the general population resulting from the long-term average levels, summarised herein, is small compared not only with the dose from the natural background but also with that from common variations in the natural background.

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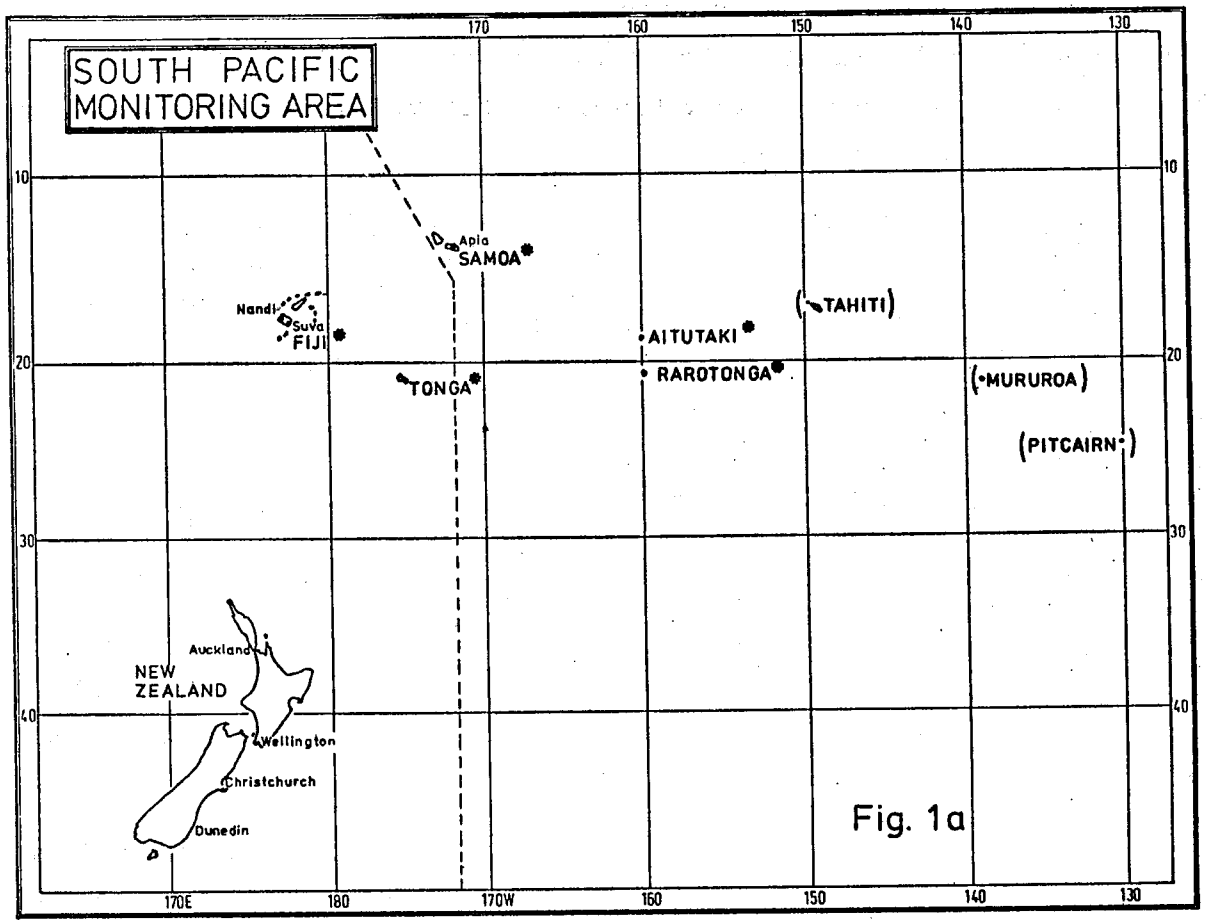

Fig. 1a

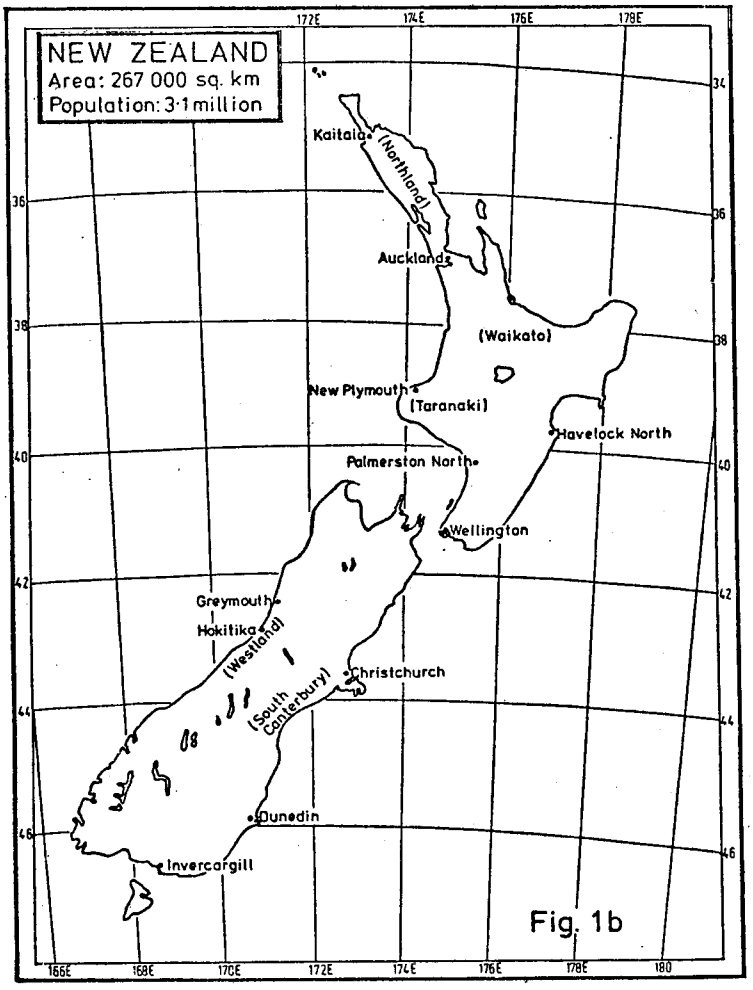

Fig. 1b

FIG. 1 MONITORING AND COLLECTING STATIONS ON PACIFIC ISLANDS AND IN NEW ZEALAND.

INTRODUCTION

This report continues the series of annual reports on levels of environmental radioactivity in New Zealand and in the South Pacific area.

In September 1974 France terminated the series of atmospheric nuclear tests which had been conducted in the Tuamotu Archipelago in the South Pacific, and in June 1975 commenced underground testing in the same area. Consequently the Laboratory's monitoring programme was modified in mid-1975. During 1977 this programme, designed to detect any venting to the atmosphere of fission products from underground tests, consisted of continuous collection of air filter and rainwater samples from five Pacific Island and four New Zealand stations. The samples were sent to the Laboratory for measurement of total beta activity.

The routine programme for measurement of long-term radioactive fallout from the earlier atmospheric tests was also continued during 1977. In this programme emphasis is given to the measurement of the two most potentially hazardous long-lived radionuclides, strontium-90 and caesium-137. Monthly depositions of strontium-90 in rain were measured at nine New Zealand and two Pacific Island stations. (Naturally-occurring lead-210 was also evaluated concurrently.) Strontium-90 and caesium-137 concentrations were measured in milk from nine New Zealand stations.

Monitoring and sample collecting stations are shown in Figs. 1 a and b.

Fallout levels during recent years and particularly during 1976 and 1977 have been very low. This report (and the previous one, NRL-F/56) has been considerably shortened. The reader is referred to the earlier annual reports (1), and the special reports (2) on monitoring of French atmospheric nuclear tests (1966-1974). These give additional information on terms of reference, potential health hazard, adoption of reference levels, and technical information on procedures. They also include graphical presentations of results allowing historical and geographical comparisons.

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(1) "Environmental Radioactivity":

Annual Report 1971, Report No. NRL-F/48, June 1972
Annual Report 1972, Report No. NRL-F/50, April 1973
Annual Report 1973, Report No. NRL-F/52, June 1974
Annual Report 1974, Report No. NRL-F/54, June 1975
Annual Report 1975, Report No. NRL-F/55, June 1976
Annual Report 1976, Report No. NRL-F/56, April 1977 (shortened version)

(2) "Environmental Radioactivity. Fallout from Nuclear Weapons Tests Conducted by France in the South Pacific . . . and comparisons with previous test series." Report Nos: NRL-F/47, March 1972 (Summarising all previous monitoring results since 1966); NRL-F/49, October 1972; NRL-F/51, November 1973, and NRL-F/53, November 1974.

TOTAL BETA ACTIVITY IN AIR AND RAIN

Normally the short-lived decay products of naturally-occurring radon account for most of the beta activity in air. Ground level air over continents has a beta activity commonly ranging between 60 and 600 picocuries per cubic metre, but under certain conditions the beta activity may be up to ten times the upper value of this range.

Air filter and rainwater samples are measured four days after collection. After this delay the naturally-occurring beta activity has decayed and the residual beta activity, from radioactive fallout, may be assessed. Hereafter the term "total beta activity" refers to this residual fission product radioactivity in the sample and excludes naturally-occurring radioactivity.

1. Fission Products in Air

During 1977 air was monitored continuously at the New Zealand and Pacific Island stations listed in Table 1 below. The filters, which were changed three times each week, were measured for total beta activity at the Laboratory. Average levels each month during 1977 did not exceed the limit of detection at any station. Therefore the individual results and monthly averages are not tabulated in the Appendix. However, the 1977 results are included in Table 1 for comparison with annual averages obtained previously.

TABLE 1 - Total Beta Activity in Air - Annual Averages (pCi/m^3)

	New Zealand				Pacific Islands				
	AK	WN	HK	CH	FJ	SM	TO	AI	RA
1966	0.14	(0.10)		0.11					
1967	0.08	0.05		0.06					
1968	0.12	0.10		0.07					
1969	0.12	0.09		0.07					
1970	0.16	0.12	(0.12)	0.10					
1971	0.21	0.12	0.16	0.15					
1972	0.06	0.05	0.05	0.05					
1973	0.02	0.01	0.02	0.02					
1974	0.08	0.05	0.07	0.05					
1975	0.03	0.03	0.03	0.02	<0.01	<0.01	0.01	<0.01	0.01
1976	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1977	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.02	<0.02	<0.01

Average levels ranged from 0.04 - 6.22 pCi/m^3 in the South Pacific area during the special monitoring programmes

Notes:
1. The stations are: Auckland, Wellington, Hokitika, Christchurch, Fiji, Samoa, Tonga, Aitutaki, and Rarotonga.
2. Values in parenthesis are estimates: At Wellington measurements commenced 12 July 1966; at Hokitika, 1 May 1970.
3. At the Pacific Islands the 1975 results are for June-Dec. only (during this period the New Zealand results were similar, averaging 0.01 pCi/m^3).
4. Starting 1977 the limit of detection is either 0.01 or 0.02 pCi/m^3 depending on the air sampling equipment in use.

It can be seen that levels in New Zealand have been latitude dependent during the period of French atmospheric tests (1966-1974). For example, levels at Auckland are higher in most cases than those at Christchurch. Moreover, levels at the Pacific Islands, during the 3-6 month special monitoring programmes covering these tests, were significantly higher than New Zealand levels, averaging from 0.04 to 6.22 pCi/m^3, depending on the locality monitored, the extent of nuclear testing, and meteorological conditions.

Since mid-1975, about nine months after the termination of the French atmospheric nuclear tests, levels have not exceeded the limit of detection at any station. There has been no indication of fresh fission products in the atmosphere from venting of underground tests.

All levels of fission products in air tabulated here and particularly those during recent years have been very small fractions of the reference levels.

2. Fission Products in Rain

During 1977 weekly funnel and bottle collections of rainwater were made at the same stations providing air filter samples. The rainwater samples were despatched to the Laboratory where they were processed and measured for total beta activity. The annual totals, since measurements started, are listed for each station in Table 2 below. (Individual weekly results during 1977 are given in Table 7 Appendix.)

TABLE 2 - Total Beta Activity in Rain - Weekly Depositions Summed Annually (mCi/km^2)

	New Zealand				Pacific Islands				
	AK	WN	HK	CH	FJ	SM	TO	AI	RA
1963				28					
1964				15					
1965				17					
1966			106	32					
1967			77	14					
1968			205	28					
1969			61	18					
1970	101	75	133	26					
1971	98	80	99	32					
1972	25	22	33	15					
1973	5	7	8	4					
1974	59	60	42	22					
1975	9	13	19	13	3	4	2	3	4
1976	3	3	4	2	3	3	4	4	3
1977	2	3	3	2	3	5	4	4	4

Average depositions ranged from 3 - 540 mCi/km^2 in the South Pacific area during the special monitoring programmes

Notes:
1. See Table 1 (Note 1) for station names.
2. Measurements commenced in Westland at Greymouth in July 1966 (the first result is for July-Dec. 1966 only). The station was transferred to Hokitika starting Jan. 1976.
3. Measurement commenced at AK and WN in May 1970 (the first results are for May-Dec. only).
4. At the Pacific Islands the 1975 results are for June-Dec. only (during this period the New Zealand results were similar, averaging about 4 mCi/km^2).

During 1976 and 1977 the annual depositions ranged from 2 to 5 mCi/km^2 and were the lowest recorded. The average concentrations ranged from 1 to 3 pCi/l (see Table 7 Appendix). These concentrations are very small fractions of the reference level.

STRONTIUM-90 DEPOSITION

1. Routine Measurement

The measurement of strontium-90 deposition started at 6 stations in New Zealand in 1960, and at Suva in 1961. Since 1963 measurements have been made continuously at 9 New Zealand stations, and since 1967 at Rarotonga also. Collections are made

each month in high walled stainless steel pots. The collected rainwater is passed through a column of cation exchange resin at the collecting site. The resin is then mailed to the Laboratory for measurement of strontium-90.

Annual depositions at each station since measurements commenced are listed in Table 3 below. The average deposition at the New Zealand stations is also listed for each year. (Individual results, aggregated quarterly during 1977, are given in Table 8 Appendix.)

TABLE 3 - Annual Deposition of Strontium-90 (mCi/km^2), Mean Annual Rainfall (cm)

	New Zealand Stations									Pacific Islands	
	KA	AK	NP	HN	WN	HK	CH	DN	IN	Average	SU	RA
1960		1.2		0.7	0.8	1.5	0.5		0.5	0.9		
1961		1.1		0.8	1.1	2.2	0.7		1.2	1.2	1.0	
1962		1.8		1.0	1.8	2.8	0.7		1.2	1.6	1.6	
1963	1.8	2.0	2.0	1.0	2.0	3.7	1.2	1.0	1.7	1.8	2.4	
1964	4.1	4.0	5.3	1.6	3.4	7.8	1.3	1.8	3.0	3.6	2.5	
1965	3.1	2.9	4.2	1.7	3.9	5.9	1.7	2.0	2.8	3.1	2.0	
1966	1.6	1.3	1.9	0.8	1.6	2.2	0.7	0.7	1.1	1.3	1.2	
1967	1.0	0.9	1.3	0.5	1.0	1.7	0.4	0.6	0.9	0.9	0.8	(0.9)
1968	0.9	0.7	1.0	0.6	0.9	1.4	0.4	0.4	0.5	0.8	1.0	0.7
1969	1.5	1.3	1.5	0.7	1.1	2.2	0.7	0.7	1.2	1.2	1.3	0.7
1970	1.0	0.9	1.2	0.6	1.2	2.1	0.5	0.5	0.7	1.0	0.9	1.0
1971	2.0	1.3	1.9	1.0	1.2	2.5	0.7	0.8	1.1	1.4	(1.5)	(0.9)
1972	0.9	0.7	0.9	0.5	0.8	1.8	0.4	0.6	0.9	0.8	0.9	0.8
1973	0.4	0.3	0.3	0.2	0.4	0.6	0.2	0.2	0.3	0.3	0.4	0.6
1974	0.3	0.2	0.3	0.2	0.3	0.5	0.2	0.2	0.2	0.3	0.3	0.3
1975	0.3	0.2	0.3	0.2	0.3	0.6	0.2	0.2	0.3	0.3	0.2	0.1
1976	0.1	0.1	0.1	<0.1	0.2	0.2	<0.1	<0.1	<0.1	0.1	0.1	0.1
1977	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Rainfall	136	116	149	79	138	241	61	63	104		308	206

Notes:
1. The New Zealand stations are: Kaitaia, Auckland, New Plymouth, Havelock North, Wellington, Hokitika, Christchurch, Dunedin, and Invercargill.
   The Pacific Island stations are: Suva (Fiji), and Rarotonga
2. The station in Westland (HK) was at Greymouth from 1960-1975 inclusive and was resited at Hokitika starting Jan. 1976.
3. Values in parenthesis are estimates.
4. The mean annual rainfall is for 1963 to 1977 inclusive (at Rarotonga for 1967-1977). At Westland annual rainfalls at the actual collecting sites were used to obtain the mean.

The large scale Northern Hemisphere (USSR) and Pacific area (USA) nuclear tests, which were conducted in 1961 and 1962 before the signing of the Partial Test Ban Treaty, resulted in a delayed stratospheric fallout over New Zealand. Maximum annual depositions (exceeding a station average of 3 mCi/km^2) occurred in New Zealand in 1964 and 1965, (the peak occurring in the last half 1964 and first quarter 1965). Annual depositions then decreased steadily until 1968.

During the years 1966 to 1974 a series of smaller scale nuclear tests was conducted by France in the South Pacific each year except 1969. Each series, lasting from one to three months and comprising from three to eight nuclear explosions, has taken place during the Southern Hemisphere winter. During these tests a total of 41 nuclear devices was reported to have been exploded in the atmosphere, most of them being in the low to medium power (kiloton) range. However, megaton explosions were reported to have occurred twice in 1968, twice in

1970, and once in 1971 (2). The annual deposition of strontium-90 in New Zealand increased again during the period 1969 to 1971 reaching a second maximum in 1971 which, however, was less than one-half of the 1964 maximum. Since then the annual depositions have again decreased.

During 1976 monthly results were nearing the limit of detection. Therefore the monthly samples collected during 1977 were aggregated on a quarterly basis in order to obtain sufficient analytical sensitivity. The annual deposition at any station during 1977 did not exceed 0.1 mCi/km^2. The 1977 depositions are the lowest recorded since this programme started.

Estimates of the French nuclear tests' contribution to the total strontium-90 deposition in New Zealand, and also comparisons of New Zealand and Northern Hemisphere depositions were made in earlier reports (1).

Unlike the deposition of fresh fission products from the troposphere after the French Southern Hemisphere tests, the long term strontium-90 deposition, which includes a significant stratospheric component, has shown no latitude dependence within New Zealand. The deposition, however, is rainfall dependent and high rainfall areas such as Greymouth or Hokitika in Westland have shown elevated values compared to low rainfall areas such as Christchurch on the east coast: excluding the last two years of minimal fallout, the mean annual deposition (normalised for rainfall) at the nine New Zealand stations during 1963-1975 inclusive was 1.08 ± 0.06 mCi/km^2 per 100 cm of rain.

In 1964, the year of maximum strontium-90 fallout, the deposition at Suva, however, was less than that in New Zealand despite the much higher rainfall at Suva. This demonstrates a characteristic feature of stratospheric fallout, namely that the tropics receive less stratospheric fallout than mid-latitudes. Since then depositions at the two Pacific Islands have been similar to the average depositions in New Zealand. It seems that during the period of French Pacific nuclear testing, the smaller stratospheric component and larger tropospheric component of the fallout at the Pacific Islands resulted in depositions similar to those in New Zealand where the relative contribution of the two components was reversed.

2. Cumulative Deposition

Direct measurement of strontium-90 in soil to determine the cumulative deposition has been made at selected sites since 1953. The most recent routine measurements were made on soils sampled at the end of 1972. Results for this and all previous measurements were tabulated in the 1973 Annual Report (1). The sampling depth was initially 15 cm in 1953. The depth was increased to 20 cm in 1960 and to 30 cm in 1970.

During 1976 a special survey to measure the extent of penetration of strontium-90 (and caesium-137) in soil at selected sites was completed (3). The object of the survey was to relate the findings to the ion exchange properties of the soils and to the known levels of milk contamination in the same districts. The soils used in the survey had been sampled at the end of 1974 to a depth of 75 cm at Northland, Taranaki, Wellington, Greymouth, and South Canterbury. The total strontium-90 depositions measured at these stations were 19, 25, 16, 31, and 9 mCi/km^2 respectively. It was found that strontium-90 had penetrated below 60 cm at three of these stations. However, at least 60% was still in the top 15 cm, and at least 75% was in the top 30 cm at each station. The exchange properties of the soils for caesium explained the relatively high levels of caesium-137 measured in milk from some collecting areas and in particular from Taranaki.

(3) "Profiles of ^{90}Sr and ^{137}Cs Concentrations in Selected New Zealand Soils and Their Bearing on Milk Contamination Levels." T. Baltakmens and L.P. Gregory, N.Z. Journal of Science Vol. 20, No. 4, 425-32, December 1977.

LEAD-210 DEPOSITION

Lead-210 is a naturally-occurring radionuclide produced in the atmosphere by decay of gaseous radon which is exhaled from land surfaces. Like strontium-90 the subsequent deposition of lead-210 is rainfall dependent and high rainfall areas such as Hokitika show elevated values compared to low rainfall areas such as Christchurch.

Measurement of lead-210 deposition was continued during 1977. Evaluation was made in the same monthly rainwater samples collected for strontium-90 measurement. Earlier results, including higher levels during 1965 at four stations, and also levels in milk, were discussed in the 1971 annual report (1). Annual depositions at each station since 1968 are listed in Table 4 below. The average annual depositions at the New Zealand stations is also listed. (Individual monthly results during 1977 are given in Table 9 Appendix.)

TABLE 4 - Annual Deposition of Lead-210 (mCi/km^2)

	New Zealand Stations										Pacific Islands	
	KA	AK	NP	HN	WN	HK	CH	DN	IN	Average	SU	RA
1967*	0.62	1.15	1.72	0.73	1.02	2.38	0.36	0.56	0.99	1.06	1.25	0.60
1968	1.75	1.64	2.08	0.84	1.86	3.20	0.64	0.76	1.06	1.54	2.46	0.61
1969	1.83	1.33	1.54	0.88	1.20	3.94	0.56	0.92	1.29	1.50	1.91	0.98
1970	1.43	1.00	1.82	0.63	1.52	3.09	0.65	0.74	0.92	1.31	1.85	0.85
1971	2.07	1.04	0.96	0.65	1.26	2.34	0.52	0.74	1.09	1.19	1.83	-
1972	2.28	1.62	1.99	0.88	1.70	3.41	0.70	1.22	1.31	1.68	2.65	-
1973	1.92	1.42	2.29	0.80	1.80	3.31	0.48	0.67	0.81	1.50	2.11	-
1974	1.24	1.08	1.76	0.76	1.61	2.85	0.71	0.66	0.58	1.25	1.86	4.00
1975	1.61	1.51	1.81	1.12	1.97	3.94	0.92	0.91	1.11	1.66	2.91	1.40
1976	1.41	1.33	1.43	0.93	1.46	2.73	0.70	0.71	0.76	1.27	2.03	-
1977	1.33	1.10	1.68	0.75	1.55	2.61	0.63	0.74	1.09	1.27	1.68	-

Notes: 1. See Table 3 (Notes 1 and 2) for station names and the resiting of the Westland station at Hokitika.
*2. The 1967 results are for May-Dec. only.
3. Estimates have been made for some missing monthly deposition results in order to reduce the resulting bias in the annual total. Where this has not been practicable annual totals are omitted.

During the last ten years the annual deposition in New Zealand has averaged about 1.4 mCi/km^2. During the same period the annual deposition of weapons test strontium-90 at the same stations has averaged about 0.7 mCi/km^2. At the Pacific Island stations lead-210 depositions at Suva are generally somewhat higher, and at Rarotonga generally somewhat lower, than those in New Zealand.

Since 1967, there does not appear to have been any marked seasonal variation nor, unlike strontium-90, any significant change in the average annual deposition.

STRONTIUM-90 AND CAESIUM-137 IN MILK

Strontium-90 measurement in New Zealand milk started in 1961 and caesium-137 measurement in 1964. Since 1965 continuous measurements have been made in samples from nine collecting stations. Caesium-137 and potassium are determined directly in monthly samples by gamma spectroscopy. Samples are then aggregated quarterly for radiochemical analysis for strontium-90 and also for the determination of calcium.

1. Strontium-90

The annual average concentrations of strontium-90 in milk at individual collecting stations are listed in Table 5 below for each year since 1961. The all-station averages each year are also listed. (Individual quarterly results during 1977 are given in Table 10 Appendix.)

TABLE 5 - Strontium-90 in Milk - Annual Averages (pCi/gCa)

	ND	AK	WK	TA	PN	WN	WD	CH	DN	Average
1961	4.5		4.1	7.1			12.7	1.6		6.0
1962	6.3	5.5	4.9	9.4	4.3		13.5	2.1	3.0	6.1
1963	7.5	5.3	5.6	9.9	4.9		17.2	2.7	3.7	7.1
1964	11.2	9.1	9.5	17.1	7.1		26.0	2.6	4.1	10.8
1965	10.6	9.4	9.8	16.7	8.4	8.8	28.8	4.3	7.4	11.6
1966	6.5	6.1	6.3	12.5	4.8	6.1	22.7	2.4	4.0	7.9
1967	5.1	5.2	5.0	10.4	3.9	5.4	17.8	1.9	3.1	6.4
1968	4.1	3.8	4.1	8.0	3.6	4.8	14.0	1.6	2.4	5.2
1969	6.3	6.0	5.4	9.4	5.8	5.1	17.9	1.7	3.0	6.7
1970	5.2	5.1	5.2	9.7	3.6	4.7	21.0	2.2	2.5	6.6
1971	7.3	5.8	6.0	10.2	5.0	4.8	18.3	2.0	3.0	6.9
1972	4.8	4.6	4.4	8.2	5.0	4.1	14.7	1.9	3.1	5.6
1973	3.8	3.4	3.5	5.7	2.7	3.5	10.8	1.2	1.9	4.1
1974	3.3	3.0	2.7	5.4	2.5	3.0	8.8	1.3	1.9	3.5
1975	3.1	2.7	3.0	5.1	2.4	3.4	8.7	1.2	1.6	3.5
1976	2.6	2.4	2.5	3.5	1.6	2.4	6.1	1.1	1.1	2.6
1977	2.1	2.1	2.4	3.9	1.4	2.1	5.0	1.0	1.2	2.3
Average	5.5	5.0	5.0	9.0	4.2	4.5	15.5	1.9	2.9	6.1

Note: The stations are: Northland, Auckland, Waikato, Taranaki, Palmerston North, Wellington, Westland, Christchurch, and Dunedin.

Average levels in New Zealand milk reached maximum values of 10.8 and 11.6 pCi/gCa during 1964 and 1965 when the rate of strontium-90 deposition was also a maximum. Milk levels then decreased steadily reaching a minimum of 5.2 pCi/gCa in 1968, about half the 1964-65 maximum. This indicated that the level in milk was dependent to a considerable extent on fallout rate. However, during the period 1965-68 milk levels decreased at a somewhat slower rate than the strontium-90 deposition, thus indicating some uptake by grass of the cumulative deposit in the soil. After the start of French Pacific nuclear tests in 1966, milk levels increased slightly during the period 1969-71. However, after the decrease in fallout deposition since 1973, milk levels decreased again. The average concentration during 1977, 2.3 pCi/gCa, was the lowest recorded since measurements commenced.

Milk samples from the lowest and highest rainfall stations, i.e. Christchurch and Westland, give the range of strontium-90 contamination in New Zealand milk. Generally the extent of this range is from about one-third to about $2\frac{1}{2}$ times the country-wide average.

2. Caesium-137

The annual average concentrations of caesium-137 in milk at individual collecting stations are listed in Table 6 below for each year since 1964. The all-station averages each year are also listed. (Individual monthly results during 1977 are given in Table 11 Appendix.)

TABLE 6 - Caesium-137 in Milk - Annual Averages (pCi/gK)

	ND	AK	WK	TA	PN	WN	WD	CH	DN	Average
1964	49	51	69	168	19		76	7	11	56
1965	54	53	84	185	26	29	77	11	18	60
1966	37	33	60	141	11	18	43	4	9	39
1967	26	26	48	123	7	13	33	3	5	31
1968	15	18	36	102	3	7	21	1	3	23
1969	27	26	41	101	5	9	38	2	4	28
1970	22	18	35	89	6	11	39	4	5	25
1971	23	18	36	80	7	9	30	3	5	23
1972	21	15	28	72	2	7	22	2	4	19
1973	14	9	21	49	3	4	14	1	2	13
1974	7	7	16	41	2	3	8	1	1	10
1975	9	7	14	34	1	3	8	1	1	9
1976	6	5	11	23	2	2	4	1	2	6
1977	6	4	12	29	1	2	6	1	1	7
Average	23	21	37	88	7	9	30	3	5	25

Note: See Table 5 for station names.

Again the highest levels were recorded in 1964 and 1965 when strontium-90 deposition and concentration in milk were at their highest. The levels have decreased steadily since then, except for a slight increase in 1969 and 1970. The average concentration during 1977 was 7 pCi/gK - about the same as that recorded during 1976. These levels over the last two years are the lowest recorded since measurements commenced. The higher levels at Taranaki are caused mainly by the "soil effect" (mentioned on p.5 under "cumulative deposition"). This effect has been discussed in the 1971 annual report (1), and has been the subject of further investigation (3).

3. Comparison of Measured Levels with the Reference Levels

When comparing measured levels in milk with the reference levels, long-term averages are more meaningful. Since measurements commenced, the "country-wide" average levels of strontium-90 (6.1 pCi/gCa) and caesium-137 (25 pCi/gK), have been 2.3% and 0.4% of the reference levels respectively. At the stations with the highest levels of contamination the corresponding percentages are about 2.5 times higher for strontium-90 and about 3.5 times higher for caesium-137.

Thus the long-term average levels, even at the stations with highest concentrations, are very small fractions of the reference levels and do not constitute a public health hazard.

MISCELLANEOUS

International Intercomparison

During 1977 the Laboratory again participated successfully in the intercomparison of measurements on environmental samples:

The International Reference Centre, WHO, provided an animal bone sample for measurement of strontium-90 and calcium, and also a sea fish sample for measurement of strontium-90, calcium, caesium-137, caesium-134, ruthenium-106, and potassium.

The U.S. Environmental Protection Agency provided on two occasions milk samples for measurement of strontium-89, strontium-90, iodine-131, caesium-137, barium-140, and potassium. The Agency also provided on three occasions water samples for measurement of radium-226, plutonium, and total alpha/beta radioactivity respectively.

TABLE 7 - Total Beta Activity of Weekly Rainwater Samples 1977 : Deposition (mCi/km^2), Rainfall (cm)

The collection period is from the date shown to the start of the next collection.
N.S. No sample or result available, ( ) estimated result.

AUCKLAND			WELLINGTON			HOKITIKA			CHRISTCHURCH			FIJI			SAMOA			TONGA			AITUTAKI			RAROTONGA		
Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2
Jan 7	3.9	<0.1	Dec 31	2.2	<0.1	Dec 31	11.0	<0.1	Dec 31	1.8	<0.1	Dec 29	10.0	<0.1	Dec 31	1.2	<0.1	Dec 31	2.7	<0.1	Jan 3	20.7	<0.1	Jan 5	3.5	<0.1
Jan 14	0.7	<0.1	Jan 14	10.5	0.2	Jan 7	3.6	<0.1	Jan 7	0.5	<0.1	Jan 4	8.7	<0.1	Jan 7	0.8	<0.1	Jan 7	18.4	<0.1	Jan 7	3.3	<0.1	Jan 7	3.9	<0.1
Jan 21	0.3	<0.1	Jan 21	0.3	<0.1	Jan 14	9.9	<0.1	Jan 14	4.2	<0.1	Jan 12	20.9	<0.1	Jan 14	8.0	0.2	Jan 14	18.9	<0.1	Jan 17	<0.1	<0.1	Jan 14	2.6	<0.1
Jan 28	<0.1	<0.1	Jan 28	0.2	<0.1	Jan 21	6.2	0.1	Jan 21	nil	<0.1	Jan 20	12.1	<0.1	Jan 21	21.2	0.2	Jan 21	0.8	<0.1	Jan 24	6.9	<0.1	Jan 21	3.8	<0.1
						Jan 29	9.3	0.3	Jan 28	<0.1	<0.1	Jan 25	23.3	0.2	Jan 28	8.0	<0.1	Jan 28	9.3	<0.1				Jan 28	5.5	<0.1
Jan	4.9	<0.1	Jan	13.2	0.2	Jan	40.0	0.5	Jan	6.6	<0.1	Jan	75.0	0.3	Jan	39.2	0.4	Jan	50.1	<0.1	Jan	30.9	0.1	Jan	19.3	<0.1
Feb 4	1.4	<0.1	Feb 4	4.2	<0.1	Feb 4	2.4	<0.1	Feb 4	0.9	<0.1	Feb 3	0.7	<0.1	Feb 4	4.0	<0.1	Feb 4	18.7	<0.1	Jan 31	0.9	<0.1	Feb 4	1.4	<0.1
Feb 11	0.3	<0.1	Feb 11	4.3	<0.1	Feb 11	-	N.S.	Feb 11	<0.1	<0.1	Feb 9	8.5	<0.1	Feb 11	0.3	<0.1	Feb 11	4.2	<0.1	Feb 7	1.6	<0.1	Feb 11	5.7	<0.1
Feb 18	0.3	<0.1	Feb 18	6.7	<0.1	Feb 18	4.0	<0.1	Feb 18	3.2	<0.1	Feb 16	2.8	<0.1	Feb 18	18.0	0.2	Feb 18	1.1	<0.1	Feb 14	7.2	<0.1	Feb 18	11.3	<0.1
			Feb 25	4.2	<0.1	Feb 25	4.5	<0.1	Feb 25	<0.1	<0.1	Feb 24	3.4	<0.1	Feb 25	3.3	<0.1	Feb 25	0.1	<0.1	Feb 20	11.1	<0.1	Feb 24	1.7	<0.1
Feb	2.0	<0.1	Feb	19.4	0.2	Feb	10.9	0.2	Feb	4.1	<0.1	Feb	15.4	<0.1	Feb	25.6	0.3	Feb	24.1	<0.1	Feb	20.8	<0.1	Feb	20.1	<0.1
Mar 4	0.3	<0.1	Mar 4	nil	<0.1	Mar 4	5.3	<0.1	Mar 4	0.2	<0.1	Mar 2	12.9	0.1	Mar 4	11.2	<0.1	Mar 4	16.8	<0.1	Feb 27	5.5	0.1	Mar 4	10.5	<0.1
Mar 11	0.3	<0.1	Mar 11	<0.1	<0.1	Mar 11	2.7	<0.1	Mar 11	<0.1	<0.1	Mar 9	26.6	<0.1	Mar 11	18.0	<0.1	Mar 10	5.8	<0.1	Mar 8	2.5	<0.1	Mar 11	18.1	<0.1
Mar 18	5.2	<0.1	Mar 18	2.2	<0.1	Mar 18	1.3	<0.1	Mar 18	<0.1	<0.1	Mar 16	5.1	<0.1	Mar 18	9.3	0.1	Mar 18	3.7	<0.1	Mar 14	1.3	<0.1	Mar 22	3.7	0.2
Mar 25	0.2	<0.1	Mar 25	0.2	<0.1	Mar 25	4.0	<0.1	Mar 25	<0.1	<0.1	Mar 23	2.6	<0.1	Mar 25	5.0	0.2	Mar 25	1.4	0.1	Mar 21	10.2	<0.1	Mar 25	4.5	<0.1
Mar	6.0	<0.1	Mar	2.4	0.1	Mar	13.3	0.2	Mar	0.3	<0.1	Mar	47.2	0.1	Mar	43.5	0.3	Mar	27.7	0.1	Mar	19.5	0.1	Mar	36.8	0.2
Apr 1	0.6	<0.1	Apr 1	0.2	<0.1	Apr 1	3.3	<0.1	Apr 1	<0.1	<0.1	Mar 30	1.9	<0.1	Apr 1	1.0	<0.1	Apr 1	3.4	<0.1	Mar 29	5.6	<0.1	Apr 4	0.6	<0.1
Apr 8	1.5	<0.1	Apr 8	5.7	<0.1	Apr 8	5.8	0.1	Apr 8	0.5	<0.1	Apr 6	1.2	<0.1	Apr 9	0.8	0.2	Apr 12	<0.1	<0.1	Apr 5	4.2	0.4	Apr 9	0.6	0.1
Apr 15	1.2	<0.1	Apr 15	5.4	0.1	Apr 15	0.5	<0.1	Apr 15	2.1	<0.1	Apr 13	4.3	<0.1	Apr 15	0.9	0.2	Apr 15	0.7	<0.1	Apr 12	3.7	<0.1	Apr 15	8.0	0.1
Apr 24	2.8	<0.1	Apr 22	1.5	<0.1	Apr 22	6.7	<0.1	Apr 22	0.4	<0.1	Apr 20	2.4	<0.1	Apr 22	3.5	<0.1	Apr 24	0.3	<0.1	Apr 19	0.2	<0.1	Apr 27	4.2	<0.1
												Apr 27	nil	0.3												
Apr	6.1	<0.1	Apr	12.8	0.2	Apr	16.3	0.2	Apr	3.1	0.1	Apr	9.8	0.4	Apr	6.2	0.4	Apr	4.4	0.2	Apr	13.7	0.4	Apr	13.4	0.2
Apr 29	3.2	<0.1	Apr 28	7.1	<0.1	Apr 29	9.7	<0.1	Apr 29	3.1	<0.1	May 4	nil	<0.1	Apr 29	2.8	0.2	Apr 29	1.1	<0.1	Apr 29	9.9	0.1	May 4	4.7	<0.1
May 6	<0.1	<0.1	May 6	2.0	<0.1	May 6	nil	<0.1	May 6	1.1	<0.1	May 11	nil	<0.1	May 6	4.6	<0.1	May 6	1.5	<0.1	May 6	11.8	<0.1	May 9	0.7	<0.1
May 13	1.9	<0.1	May 13	0.5	<0.1	May 13	1.8	<0.1	May 13	1.2	<0.1	May 18	4.7	<0.1	May 13	4.3	<0.1	May 13	<0.1	<0.1	May 12	3.3	<0.1	May 13	2.7	<0.1
May 20	9.0	<0.1	May 20	6.2	<0.1	May 20	11.9	<0.1	May 20	0.7	<0.1	May 25	0.1	<0.1	May 20	<0.1	<0.1	May 20	2.1	<0.1	May 19	1.4	<0.1	May 20	1.9	<0.1
May 27	3.0	<0.1	May 27	2.3	<0.1	May 27	6.3	<0.1	May 27	1.1	<0.1				May 27	0.2	<0.1				May 29	1.0	<0.1	May 28	3.5	<0.1
May	17.2	0.2	May	18.1	<0.1	May	29.7	0.2	May	7.2	<0.1	May	4.8	<0.1	May	11.9	0.3	May	4.7	<0.1	May	27.4	0.3	May	13.5	<0.1
Jun 3	2.0	<0.1	Jun 3	8.2	<0.1	Jun 3	2.6	<0.1	Jun 3	3.4	<0.1	Jun 1	0.2	<0.1	Jun 3	4.4	<0.1	Jun 3	0.8	<0.1	Jun 2	<0.1	<0.1	Jun 3	0.9	<0.1
Jun 10	2.0	<0.1	Jun 10	0.8	<0.1	Jun 10	5.8	<0.1	Jun 10	<0.1	<0.1	Jun 8	0.7	<0.1	Jun 10	0.4	<0.1	Jun 10	0.4	<0.1	Jun 9	0.3	0.2	Jun 10	0.1	<0.1
Jun 17	6.9	<0.1	Jun 17	2.7	<0.1	Jun 17	0.9	<0.1	Jun 17	1.0	<0.1	Jun 22	nil	<0.1	Jun 17	0.1	<0.1	Jun 17	0.6	0.1	Jun 16	0.4	<0.1	Jun 17	3.1	<0.1
Jun 24	3.9	<0.1	Jun 24	8.0	0.1	Jun 24	9.8	<0.1	Jun 24	4.0	<0.1				Jun 26	3.8	<0.1	Jun 24	<0.1	<0.1	Jun 24	0.6	0.2			
Jun	14.8	0.1	Jun	19.7	0.3	Jun	19.1	0.2	Jun	8.4	<0.1	Jun	0.9	<0.1	Jun	8.7	0.1	Jun	1.8	0.1	Jun	1.3	0.4	Jun	4.1	0.1

(continued)

TABLE : (continued)

AUCKLAND			WELLINGTON			HOKITIKA			CHRISTCHURCH			FIJI			SAMOA			TONGA			AITUTAKI			RAROTONGA		
Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2	Date	cm	mCi/km^2
Jul 1	4.1	<0.1	Jul 1	4.0	<0.1	Jul 1	5.2	0.1	Jul 1	10.3	0.2	Jun 29	nil	<0.1	Jul 1	<0.1	<0.1	Jul 2	<0.1	0.2	Jul 4	6.8	0.2	Jul 1	2.7	0.3
Jul 8	5.0	<0.1	Jul 8	0.5	<0.1	Jul 8	1.8	<0.1	Jul 8	<0.1	<0.1	Jul 6	1.0	0.2	Jul 8	0.5	<0.1	Jul 8	2.1	<0.1	Jul 15	3.9	<0.1	Jul 8	6.0	0.2
Jul 15	5.6	<0.1	Jul 15	7.8	0.2	Jul 15	3.8	<0.1	Jul 15	5.5	<0.1	Jul 13	0.1	<0.1	Jul 15	<0.1	<0.1	Jul 15	2.0	<0.1	Jul 22	8.5	<0.1	Jul 18	<0.1	<0.1
Jul 22	2.4	<0.1	Jul 22	3.1	<0.1	Jul 22	0.9	<0.1	Jul 22	0.5	<0.1	Jul 20	<0.1	<0.1	Jul 22	nil	0.2	Jul 22	3.1	0.2				Jul 22	2.5	<0.1
Jul	17.1	0.2	Jul	15.4	0.3	Jul	11.7	0.1	Jul	16.4	0.3	Jul	1.1	0.2	Jul	0.6	0.2	Jul	7.3	0.5	Jul	19.2	0.3	Jul	11.2	0.5
Jul 29	1.3	<0.1	Jul 29	1.5	<0.1	Jul 29	nil	<0.1	Jul 29	2.2	<0.1	Jul 27	0.3	<0.1	Jul 29	nil	0.1	Jul 29	nil	<0.1	Jul 25	5.8	0.2	Jul 29	1.6	<0.1
Aug 5	1.0	<0.1	Aug 5	5.6	<0.1	Aug 5	1.5	<0.1	Aug 5	2.3	<0.1	Aug 3	0.1	0.1	Aug 5	0.3	<0.1	Aug 5	0.3	<0.1	Aug 22	6.9	0.2	Aug 5	1.3	0.2
Aug 12	2.1	<0.1	Aug 12	3.8	<0.1	Aug 12	4.4	<0.1	Aug 12	nil	<0.1	Aug 10	nil	<0.1	Aug 12	nil	0.2	Aug 12	2.4	0.1				Aug 12	1.0	0.1
Aug 19	1.0	<0.1	Aug 19	4.4	<0.1	Aug 19	nil	<0.1	Aug 19	0.3	<0.1	Aug 14	3.3	<0.1	Aug 19	<0.1	0.1	Aug 19	1.1	0.1				Aug 19	0.1	<0.1
Aug 26	1.8	<0.1	Aug 26	5.8	0.1	Aug 26	3.6	<0.1	Aug 26	2.3	<0.1	Aug 24	0.4	<0.1	Aug 26	4.1	<0.1	Aug 26	3.6	0.1				Aug 26	5.0	0.2
Aug	7.2	0.1	Aug	21.1	0.2	Aug	9.5	<0.1	Aug	7.1	0.1	Aug	4.1	0.3	Aug	4.4	0.5	Aug	7.4	0.4	Aug	12.7	0.4	Aug	9.0	0.6
Sep 2	3.3	<0.1	Sep 2	5.6	<0.1	Sep 2	2.2	<0.1	Sep 2	2.4	<0.1	Aug 31	0.2	0.2	Sep 2	<0.1	0.1	Sep 2	2.9	0.2	Sep 5	5.2	<0.1	Sep 2	21.6	0.4
Sep 9	3.1	<0.1	Sep 9	2.9	<0.1	Sep 9	4.1	<0.1	Sep 9	1.5	<0.1	Sep 7	nil	<0.1	Sep 9	nil	<0.1	Sep 9	0.2	<0.1	Sep 12	7.4	<0.1	Sep 9	1.1	0.1
Sep 16	0.8	<0.1	Sep 16	5.8	<0.1	Sep 16	0.6	<0.1	Sep 16	3.6	<0.1	Sep 14	1.1	0.1	Sep 16	0.4	0.1	Sep 16	2.2	0.3				Sep 16	4.6	0.2
Sep 23	1.7	<0.1	Sep 23	1.3	<0.1	Sep 23	9.4	0.2	Sep 23	3.5	<0.1	Sep 21	0.9	<0.1	Sep 23	0.8	<0.1	Sep 23	<0.1	<0.1						
Sep	8.9	0.2	Sep	15.6	0.3	Sep	16.3	0.3	Sep	11.0	0.2	Sep	2.2	0.3	Sep	1.2	0.3	Sep	5.4	0.6	Sep	12.6	0.1	Sep	27.3	0.7
Sep 30	2.5	<0.1	Sep 30	5.0	<0.1	Sep 30	2.3	<0.1	Sep 30	<0.1	<0.1	Sep 29	1.7	<0.1	Sep 30	7.3	0.2	Sep 30	0.7	0.2	Sep 26	6.8	0.6	Sep 23	4.1	0.2
Oct 7	2.2	0.2	Oct 7	2.7	<0.1	Oct 7	0.1	<0.1	Oct 10	1.2	0.1	Oct 5	0.9	0.3	Oct 7	1.3	0.2	Oct 7	0.8	<0.1	Oct 21	2.2	0.1	Oct 14	6.9	0.3
Oct 14	0.9	<0.1	Oct 14	<0.1	0.1	Oct 14	6.3	0.2	Oct 14	nil	<0.1	Oct 12	0.2	0.1	Oct 14	0.9	<0.1	Oct 14	<0.1	<0.1				Oct 20	2.6	0.2
Oct 21	0.6	<0.1	Oct 21	1.5	0.1	Oct 21	6.8	<0.1	Oct 21	0.5	<0.1	Oct 19	N.S.	N.S.	Oct 21	8.2	0.2	Oct 21	<0.1	0.1						
Oct	6.2	0.2	Oct	9.2	0.3	Oct	15.5	0.2	Oct	1.7	0.2	Oct	2.8	0.4	Oct	17.7	0.7	Oct	1.5	0.4	Oct	9.0	0.7	Oct	13.6	0.7
Oct 28	3.6	0.1	Oct 28	2.3	<0.1	Oct 28	4.9	<0.1	Oct 28	0.3	<0.1	Nov 7	nil	0.2	Oct 30	0.2	0.1	Oct 28	0.2	0.2	Nov 2	1.2	0.1	Oct 28	4.1	0.2
Nov 6	1.1	<0.1	Nov 4	1.9	<0.1	Nov 4	14.0	0.1	Nov 4	0.4	<0.1	Nov 15	0.3	0.1	Nov 4	1.8	<0.1	Nov 4	0.3	<0.1	Nov 18	0.7	0.2	Nov 16	1.0	0.2
Nov 11	0.9	<0.1	Nov 11	nil	<0.1	Nov 11	4.0	0.1	Nov 11	0.4	<0.1	Nov 23	1.0	0.1	Nov 11	2.7	0.1	Nov 11	<0.1	<0.1						
Nov 18	1.8	0.1	Nov 18	8.6	0.2	Nov 18	6.0	0.2	Nov 18	0.2	<0.1				Nov 18	8.6	0.3	Nov 18	0.3	0.2						
Nov 25	<0.1	0.1	Nov 25	<0.1	<0.1	Nov 25	0.8	<0.1	Nov 25	1.8	<0.1				Nov 24	1.7	0.1	Nov 25	<0.1	<0.1						
Nov	7.5	0.5	Nov	12.8	0.3	Nov	29.7	0.5	Nov	3.1	0.2	Nov	1.3	0.4	Nov	15.0	0.6	Nov	0.8	0.5	Nov	1.9	0.3	Nov	5.1	0.4
Dec 2	<0.1	<0.1	Dec 2	0.5	<0.1	Dec 2	5.2	0.1	Dec 2	nil	<0.1	Nov 30	0.8	<0.1	Dec 2	0.1	<0.1	Dec 2	0.3	0.1	Nov 28	0.1	0.3	Dec 2	0.8	0.1
Dec 9	5.9	0.2	Dec 9	8.1	0.1	Dec 9	6.8	<0.1	Dec 9	2.6	0.1	Dec 8	1.3	0.2	Dec 9	N.S.	N.S.	Dec 9	0.2	0.3	Dec 5	0.4	0.2	Dec 12	0.3	0.1
Dec 16	1.6	<0.1	Dec 16	1.9	0.1	Dec 16	9.7	0.3	Dec 16	1.2	<0.1	Dec 14	0.3	<0.1	Dec 13	<0.1	<0.1	Dec 16	<0.1	0.1	Dec 12	0.1	0.1	Dec 15	7.0	0.3
Dec 23	0.5	<0.1	Dec 23	<0.1	<0.1	Dec 23	2.7	<0.1	Dec 23	<0.1	<0.1	Dec 21	1.0	0.1	Dec 16	6.5	0.2	Dec 23	4.0	<0.1	Dec 19	0.9	<0.1	Jan 6		
												Dec 28	2.2	<0.1	Dec 23	3.1	0.2				Dec 26	2.7	<0.1			
Dec	8.1	0.2	Dec	10.5	0.3	Dec	24.4	0.5	Dec	3.8	0.2	Dec	5.6	0.4	Dec	9.7	0.4	Dec	4.5	0.5	Dec	4.2	0.7	Dec	8.1	0.5
TOTAL	106	1.9	TOTAL	170	2.8	TOTAL	236	3.2	TOTAL	73	1.6	TOTAL	170	3.0	TOTAL	184	4.5	TOTAL	140	3.5	TOTAL	173	3.9	TOTAL	182	4.1
Average Concentration (pCi/l)																										
	2			2			1			2			2			2			3			2			2	

APPENDIX

TABLE 8 - Strontium-90 in Rain 1977: Rainfall (cm), Deposition (mCi/km^2), Concentration (pCi/l)

Station		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total	Av
Kaitaia	Rainfall	13.3	41.9	32.4	24.7	112	
	Deposition	0.01	0.02	0.02	0.02	0.07	
	Concentration	<0.1	<0.1	<0.1	<0.1		<0.1
Auckland	Rainfall	14.7	38.0	28.8	22.9	104	
	Deposition	0.03	0.02	0.01	0.02	0.08	
	Concentration	0.2	<0.1	<0.1	<0.1		<0.1
New Plymouth	Rainfall	26.8	54.4	39.8	28.3	149	
	Deposition	0.02	0.02	0.01	0.02	0.07	
	Concentration	<0.1	<0.1	<0.1	<0.1		<0.1
Havelock North	Rainfall	14.7	34.9	32.9	13.6	96	
	Deposition	0.02	<0.01	0.01	0.01	0.04	
	Concentration	0.1	<0.1	<0.1	<0.1		<0.1
Wellington	Rainfall	30.6	60.8	62.6	45.0	199	
	Deposition	0.03	0.02	0.02	0.03	0.10	
	Concentration	0.1	<0.1	<0.1	<0.1		<0.1
Hokitika	Rainfall	65.8	66.0	37.8	75.2	245	
	Deposition	0.05	0.03	0.02	0.04	0.14	
	Concentration	<0.1	<0.1	<0.1	<0.01		<0.1
Christchurch	Rainfall	10.7	31.0	24.1	11.0	77	
	Deposition	0.01	<0.01	<0.01	<0.01	0.03	
	Concentration	<0.1	<0.1	<0.1	<0.1		<0.1
Dunedin	Rainfall	13.1	18.6	14.6	23.5	70	
	Deposition	0.02	<0.01	<0.01	0.01	0.04	
	Concentration	0.1	<0.1	<0.1	<0.01		<0.1
Invercargill	Rainfall	23.6	38.8	16.9	30.9	110	
	Deposition	0.02	0.01	<0.01	0.02	0.05	
	Concentration	0.1	<0.1	<0.1	<0.1		<0.1
New Zealand Country-wide Average	Rainfall	23.7	42.7	32.2	30.6	129	
	Deposition	0.02	0.02	0.01	0.02	0.07	
	Concentration	0.1	<0.1	<0.1	<0.1		<0.1
Suva, Fiji	Rainfall	168.7	44.5	39.0	26.3	279	
	Deposition	0.01	0.02	0.02	0.03	0.08	
	Concentration	<0.1	<0.1	<0.1	0.1		<0.1
Rarotonga	Rainfall	66.0	45.2	41.7	22.8	176	
	Deposition	<0.01	<0.01	0.01	0.01	0.03	
	Concentration	<0.1	<0.1	<0.1	<0.01		<0.1

TABLE 9 - Lead-210 in Rain 1977: Deposition (mCi/km^2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kaitaia	0.09	0.03	0.05	0.06	0.09	0.18	0.14	0.07	0.10	0.24	0.14	0.14	1.33
Auckland	0.07	0.06	0.05	0.08	0.10	0.15	0.09	0.04	0.12	0.16	0.10	0.08	1.10
New Plymouth	0.07	0.09	0.16	0.10	0.13	0.21	0.10	0.11	0.19	0.10	0.17	0.25	1.68
Havelock North	0.06	0.05	0.07	0.07	0.03	0.09	0.07	0.08	0.06	0.04	0.07	0.06	0.75
Wellington	0.10	0.09	0.06	0.09	0.08	0.20	0.09	0.12	0.21	0.13	0.29	0.09	1.55
Hokitika	0.26	0.16	0.25	0.18	0.17	0.18	0.12	0.11	0.34	0.27	0.26	0.31	2.61
Christchurch	0.05	0.05	0.03	0.04	0.03	0.10	0.06	0.05	0.07	0.05	0.02	0.08	0.63
Dunedin	0.07	0.04	0.03	0.05	0.04	0.04	0.04	0.02	0.05	0.14	0.11	0.11	0.74
Invercargill	0.17	0.06	0.03	0.12	0.07	0.05	0.04	0.03	0.11	0.17	0.13	0.11	1.09
NZ Average	0.10	0.07	0.08	0.09	0.08	0.13	0.08	0.07	0.14	0.14	0.14	0.14	1.27
Suva	0.21	0.08	0.05	0.32	0.17	0.02	0.16	0.25	0.14	0.10	0.18		1.68
Rarotonga	0.05	N.S.	0.08	0.12	0.10	0.04	0.06	N.S.	0.14	N.S.	0.03	N.S.	-

N.S. No result available

APPENDIX

TABLE 10 - Strontium-90 in Milk 1977: (pCi/gCa)

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Average
Northland	2.1	1.7	2.3	2.1	2.1
Auckland	2.3	2.0	2.3	1.8	2.1
Waikato	2.3	2.8	2.3	2.0	2.4
Taranaki	5.0	3.2	3.7	3.9	3.9
Palmerston North	1.3	1.3	1.8	1.3	1.4
Wellington	2.1	1.9	2.6	1.9	2.1
Westland	5.2	4.7	5.1	5.1	5.0
Christchurch	1.2	0.7	1.0	0.9	1.0
Dunedin	1.4	0.8	1.2	1.2	1.2
NZ Average	2.5	2.1	2.5	2.2	2.3

TABLE 11 - Caesium-137 in Milk 1977: (pCi/gK)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av
Northland	<1	7	7	6	6	4	5	6	6	8	6	9	6
Auckland	4	5	8	4	3	3	4	4	2	4	3	3	4
Waikato	11	12	18	20	11	N.S.	15	7	6	10	10	12	12
Taranaki	32	35	60	39	31	22	22	19	14	21	28	26	29
Palmerston North	1	1	1	N.S.	1	<1	2	N.S.	<1	2	4	<1	1
Wellington	1	2	2	3	1	1	<1	2	<1	4	2	<1	2
Westland	7	6	13	15	1	12	1	2	1	4	4	6	6
Christchurch	<1	<1	6	1	<1	<1	1	<1	<1	<1	<1	<1	1
Dunedin	<1	<1	<1	<1	1	2	<1	1	<1	<1	1	2	1
NZ Average	6	8	13	11	6	6	6	5	3	6	7	7	7

N.S. No Sample