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REPORT
AWTSC No. 4

ATOMIC WEAPONS TESTS SAFETY COMMITTEE

STRONTIUM 90 AND CAESIUM 137 IN THE AUSTRALIAN ENVIRONMENT DURING 1970

and some results for 1971

SEPTEMBER 1972

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The Atomic Weapons Tests Safety Committee is constituted by the Minister for Supply and is responsible for

- safety aspects of the use or testing of nuclear explosive devices in Australia
- evaluation of proposals by other countries to explode nuclear devices outside Australia which might give rise to increased levels of radioactivity in Australia
- monitoring of levels of radioactivity in the Australian environment arising from activities with nuclear explosive devices either in this country or elsewhere.

The Committee, which reports to the Minister for Supply, has the following membership

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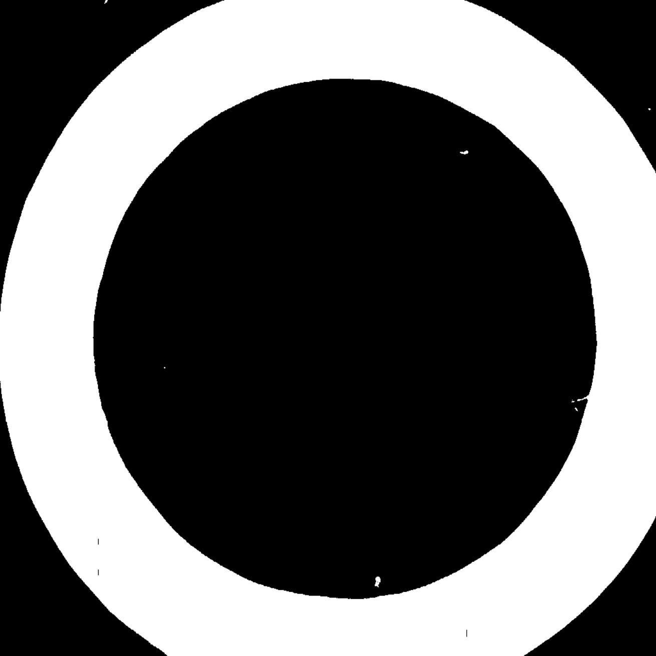
Dr. W. J. Gibbs OBE

D. J. Stevens OBE

J. R. Moroney



FOREWORD

This series of reports* is devoted to the publication of the data obtained in the programmes in Australia for monitoring radioactive contaminants in the environment, especially those from nuclear weapons tests. The programmes are carried out under the auspices of the Atomic Weapons Tests Safety Committee.

Many authorities throughout Australia co-operate with the Committee in the monitoring operations and specific reference to some of them is made at page 9 of this Report. The major contributors are the Defence Standards Laboratories of the Commonwealth Department of Supply, the Commonwealth Radiation Laboratory of the Department of Health and the Commonwealth Bureau of Meteorology of the Department of the Interior.

* Copies of these reports may be obtained from the Atomic Weapons Tests Safety Committee PO Box 50, Ascot Vale, Victoria 3032.

ABSTRACT

In this paper, measurements are reported of strontium 90 and caesium 137 in fallout in Australia for 1970 and 1971. The measurements were part of a survey of the Australian environment which has been in progress since 1957. The radioisotopes concerned are from nuclear weapons tests and were monitored in fallout deposition from the atmosphere, in key foodstuffs and in representative members of the population.

Any biological effect of strontium 90 on individuals within the population would arise from the radiation doses it delivers to bone tissue in which it may have been incorporated after ingestion in foodstuffs. During 1970 and 1971 these radiation doses to Australians corresponded to less than 4 per cent of the average annual background radiation from natural sources.

The most important effect of caesium 137 relates to the whole population exposed rather than to the individual. This is because the effect arises from irradiation of the reproductive cells and potentially affects the hereditary material. During 1970 and 1971 these radiation doses to Australians, due to caesium 137 both in their bodies and in the environment, corresponded to less than 1 per cent of the average annual background radiation from natural sources.

These radiation doses to the bone tissue and to the genetic material of the population take account of strontium 90 and caesium 137 in fallout over Australia up to the end of 1971 from all nuclear weapons tests in both the northern and the southern hemispheres.

Attention is drawn to the assessment made by the National Radiation Advisory Committee in July, 1972, of the biological significance for the Australian population of radiation doses from strontium 90 and caesium 137 during 1969 and 1970. The National Radiation Advisory Committee concluded that "(the radiation doses) are too small to present a hazard to the Australian population as can be seen by a comparison with the average annual background radiation from natural sources of about 100 millirads".

CONTENTS

Chapter 1:

RADIATION DOSES TO THE AUSTRALIAN POPULATION FROM STRONTIUM 90 AND CAESIUM 137

W. J. Gibbs[1], J. R. Moroney[2], D. J. Stevens[3] and E. W. Titterton[4]

1. MONITORING OF STRONTIUM 90 AND CAESIUM 137 IN FALLOUT IN AUSTRALIA

It is generally agreed that strontium 90 and caesium 137 are potentially the most hazardous of the long-lived radioactive materials released to the environment during the testing of nuclear weapons. Because of this they have received close and continuous attention in programmes conducted by the Atomic Weapons Tests Safety Committee (AWTSC) to allow assessment of possible hazards to the Australian population as a result of nuclear explosions in the atmosphere.

When reporting results for 1969 (Gibbs et al., 1971b), the AWTSC outlined the main processes governing contamination of the environment with strontium 90 and caesium 137 from nuclear explosions and briefly reviewed the general position on their concentrations in the Australian environment during the period 1958 to 1969. This review covered production of the radioisotopes in nuclear explosions, their dispersion in the atmosphere, deposition to ground, entry into foodchains and, finally, incorporation into body tissues of the population – strontium 90 into bone and caesium 137 into soft tissues. In addition, detailed descriptions were given of the programmes conducted in Australia to monitor the radioisotopes, together with a discussion of the underlying bases for the chosen content and coverage of the surveys being undertaken. These programmes have continued unchanged during 1970 and 1971 and complete data for 1970, together with available results for 1971, are presented in this Report in chapters 2 and 3.

As already discussed in detail by Gibbs et al. (1971b), the monitoring programmes provide information on strontium 90 and caesium 137 in fallout deposit, in foodstuffs and in man, for the major cities and their environs – Perth, Adelaide, Melbourne, Hobart, Launceston, Sydney and Brisbane – which contain some 75 per cent of the Australian population. Data are obtained, also, for other centres such as Darwin, Townsville, Port Hedland and Alice Springs, to provide wider geographical coverage of the continent.

The measurements on representative members of the population provide a basis for direct calculation of average radiation doses to tissue from strontium 90 and caesium 137 and hence assessment of hazards to health. The accumulated data from measurements on fallout deposition and foodstuffs, and the additional data coming forward progressively from the monitoring, allow evaluation of trends in the concentrations of the radioisotopes in the foodchain and prediction of changes in advance of their reaching and affecting the population.

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2 Commonwealth Department of Supply; Member and Executive Officer, Atomic Weapons Tests Safety Committee.

3 Director, Commonwealth Radiation Laboratory; Member, Atomic Weapons Tests Safety Committee.

4 Director, Research School of Physical Sciences, Australian National University; Chairman, Atomic Weapons Tests Safety Committee.

2. SUMMARY AND CONCLUSIONS – RADIATION DOSES TO THE AUSTRALIAN POPULATION FROM STRONTIUM 90 AND CAESIUM 137

Caesium 137, introduced throughout the Australian environment from nuclear weapons tests, is embodied in the soft tissues of all members of the population. Its most important effect arises from irradiation of the reproductive cells, potentially affecting the hereditary material; this effect is of consequence to the whole population rather than to the individual. Radiation doses to soft tissues of Australians during 1970 and 1971 are derived in chapter 3, page 8. Caesium 137, on the ground, delivered external radiation doses to Australians of about 0.2 millirad per annum. Internal radiation doses to soft tissues, from caesium 137 incorporated in the bodies of the population, added a further 0.4 millirad per annum. Thus, the total radiation dose from the radioisotope during each of 1970 and 1971, some 0.6 millirad, corresponds to 0.6 per cent of the average annual background radiation from natural sources.

Strontium 90 from nuclear weapons tests, like naturally occurring boneseeking radioisotopes, is incorporated in the skeletons of all Australians. Its effects are confined to bone tissue where the radiation dose it delivers might be expected to increase the risk of induction of bone cancer due to irradiation of the endosteal cells*, or of leukaemic changes in bone marrow due to irradiation of that tissue. As described in chapter 2, page 5, during 1970 and 1971, strontium 90 was responsible for radiation doses to bone marrow of up to 2.6 millirad per annum and to endosteal tissue of up to 3.6 millirad per annum. These radiation doses are the only source of hazard to the population as a consequence of the strontium 90 contamination.

During 1970 and 1971, caesium 137 in fallout delivered doses of some 0.6 millirad per annum to both endosteal cells and to bone marrow, which are to be added to those from strontium 90 to give the total doses for the two radioisotopes. Thus the total doses to bone tissue of Australians from strontium 90 and caesium 137, during 1970 and 1971, ranged up to 3.2 and 4.2 millirad per annum for bone marrow and endosteal tissue, respectively. These doses correspond to some 3 to 4 per cent of the average annual background radiation from natural sources.

Attention is drawn to the pronouncements by the National Radiation Advisory Committee (NRAC) in July, 1972, based on the radiation doses to the Australian population from strontium 90 and caesium 137, reported from the AWTSC monitoring programmes for 1969 and 1970 (Gibbs et al., 1971b). The NRAC concluded that "(the radiation doses) are too small to present a hazard to the Australian population as can be seen by a comparison with the average annual background radiation from natural sources of about 100 millirads".

* endosteal tissue lines interior surfaces of compact or mineralised bone and merges with connective tissue of bone marrow.

Chapter 2:

MEASUREMENTS OF STRONTIUM 90

J. Bonnyman[1], J. H. Harley[2] and J. R. Moroney[3]

1. THE SURVEY OF STRONTIUM 90 IN THE AUSTRALIAN ENVIRONMENT

A country-wide survey of strontium 90 in the Australian environment was initiated by the AWTSC in 1957 and has been operating continuously since then. Details of the structure and coverage of the survey have been described elsewhere (Bonnyman et al., 1971a). Briefly, it is directed towards monitoring the radioisotope in its passage from fallout through the foodchains to human bone tissue. Thus, measurements are made of the radioisotope in precipitation and in soil, in the groups of foodstuffs responsible for the main intake of strontium 90 by the population and in human bone tissue. Most emphasis is given to the major centres of population: Perth, Adelaide, Melbourne, Hobart, Launceston, Sydney and Brisbane; but data are also obtained for Darwin, Townsville, Port Hedland and Alice Springs and for agricultural districts in each State.

All results obtained for the year 1970 are presented in this section of the chapter together with available data for early 1971; radiation doses to bone tissue are discussed in section 2.

(a) *Precipitation and Soil*

Fallout particles deposited to ground in rain or by dry precipitation processes are collected continuously, and analysed for strontium 90, to monitor the rate of deposition of the radioisotope in fallout as well as the accumulation at ground surface. During 1970 and 1971, monthly precipitation samples and annual soil samples were obtained for this purpose from the stations shown in Figure 1.

In December 1970 soil samples were taken from the ten sites introduced in 1964 for this purpose. Each sample consisted of 25 cores taken on a grid of 3 metre in an area of 15 metre by 15 metre. A standard tool giving a core of 7.0 centimetre diameter was used throughout. All sites are in relatively flat, open, undisturbed pasture with minimum run-on or run-off of rainwater. The analyses were undertaken by Commonwealth Radiation Laboratory (CRL) and the results are presented in Table 1.

Monthly fallout deposition samples were obtained at the 16 stations, all equipped with the special funnel ion exchange fallout samplers (FIEFS) designed by the AWTSC. Briefly, these fallout collectors comprise a cylindrical polyethylene funnel, 0.07 square metres collecting area, mounted 1.2 metres above ground and draining into a replaceable ion exchange column of 80 millilitre Permutit ZeoKarb 225 (NG) resin. The ion exchange columns are supplied for field use from Defence Standards Laboratories (DSL) to which they are returned after exposure. The resins and filters are ashed at 450°C for some 50 hours before submission to CRL and to the USAEC Health and Safety Laboratory (HASL) for analysis.

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2 Director, Health and Safety Laboratory, US Atomic Energy Commission, New York

3 Member and Executive Officer, Atomic Weapons Tests Safety Committee; Defence Standards Laboratory, Commonwealth Department of Supply, Melbourne

Monthly strontium 90 deposits for the eight stations, Perth, Adelaide, Melbourne, Hobart, Sydney, Brisbane, Townsville and Darwin, are presented in Table 2 for 1970 and 1971 from measurements by HASL; they are plotted in the composite diagrams of Figure 2 for the period June 1958 to December 1971. The diagrams also show the total accumulation of strontium 90 in precipitation at each station since November 1954, as derived by Gibbs et al. (1965).

Tables 3(a) and (b) give the strontium 90 data for measurements by CRL on the monthly samples from the remainder of the network during 1970 and 1971; namely, the six stations, Wokalup, Meadows, Warragul, Hadspen, Berry and Samford, in major dairying areas supplying the nearby capital cities, and Alice Springs and Port Hedland. Data from these stations, from commencement of their operation in 1964 to December 1970, have already been reported (Fletcher et al., 1967, 1968a, 1968b; Gibbs et al., 1969a, 1971b). Since July 1966, the monthly samples have also been analysed for strontium 89 when it is expected to be present in fallout over Australia from French nuclear weapons tests in Polynesia (Gibbs et al., 1967a, 1967b, 1969b, 1971a, 1971c).

Representative figures for Australia for mean annual deposit of strontium 90 in precipitation have been derived from the monthly results for the six major population centres and their associated dairying areas. These values – 0.8 millicuries per square kilometre for 1970 and 0.9 millicuries per square kilometre for 1971 – confirm the expectation of the AWTSC (Gibbs et al., 1971b) of elevated levels of strontium 90 deposition as a result of the programmes of megaton weapons testing by France in Polynesia during 1968 and 1970-71.

(b) *Foodstuffs*

The consumption of foodstuffs containing strontium 90 is responsible almost entirely for the population's intake of the radioisotope from fallout. Dietary sources of strontium 90 are similar to those of calcium and, as discussed by Bonnyman et al., (1971a), extensive measurements are made on milk and wheaten flour and, from these, regular estimates are made of the lesser contributors such as vegetables, meats and so on. The data are combined annually to provide a single figure for the mean strontium 90 content of the total diet in Australia.

Milk and milk products are the dominant source of strontium 90 in the diet of the Australian population, and milk has been given most attention in the monitoring of foodstuffs. Through the co-operation of authorities in Perth, Adelaide, Melbourne, Hobart, Launceston, Sydney and Brisbane, specimens of liquid milk are taken on one day each week by continuous sampling of milk being processed for consumption in the city. The method of sampling ensures that a high proportion of the milk being consumed is represented in the specimen. For Adelaide, Hobart, Launceston, Sydney and Brisbane, this representation is greater than 95 per cent; for convenience in Perth and Melbourne, several smaller processing facilities are excluded and representation is 70 per cent and 79 per cent, respectively. The weekly specimens are compounded into monthly samples which are evaporated and ashed before further preparation for analysis. Results of measurements by CRL on quarterly samples from January 1970 to June 1971 are presented in Table 4.

Grain products in the Australian diet are represented most satisfactorily by wheaten flour. Therefore, following each harvest in Western Australia, South Australia, Victoria, New South Wales and Queensland, samples of wheat are obtained by courtesy of the Australian Wheat Board. Fair-average-quality samples are prepared by the Board by collecting specimens from all depots receiving wheat from a harvest and combining these in proportion to the total wheat handled at the depots. In each State, through co-operation of the Department of Agriculture, the grain samples are milled by a standard procedure; after ashing, the flour samples are submitted to CRL for strontium 90 analysis. Results on samples from the 1969-70 harvests are given in Table 5.

Total diet in Australia, for purposes of deriving a mean level of strontium 90 in the total supply of foodstuffs for consumption by the population, is divided into four groups as discussed by Bonnyman et al. (1971a). The mean strontium 90 content of the total diet is then calculated from measured and estimated values for the groups and from the analysis of calcium intake published by the Commonwealth Bureau of Census and Statistics. For 1970, the per capita mean daily intake of strontium 90 was 5.5 picocuries and the ratio of strontium 90 to calcium in average diet was 6.4 picocuries per gramme.

(c) *Human Bone Tissue*

Most attention in the survey of strontium 90 in the Australian environment is devoted to monitoring the concentration of the radioisotope in human bone tissue of all ages up to 40 years. From these data, radiation doses to skeletal tissue may be estimated, so allowing assessments to be made of likely effects on the population.

Specimens of bone tissue of all ages up to 40 years are provided by pathologists in Perth, Adelaide, Melbourne, Sydney and Brisbane. Two sets of representative samples for strontium 90 analysis are prepared from all specimens collected during each six-month period

- the first set of samples is designed to provide information for each of the five cities in broad age groups, 0-1 month, 1-5 months, 5-19 years and 20-39 years.
- the second set of samples is chosen to provide information for the combined population of the five cities in narrower age groups, 0-1 month, 6-monthly intervals to 5 years, 5-yearly intervals to 20 years, and 10-yearly intervals to 39 years.

In compounding the specimens into representative samples for analysis, the bone tissue ashes are arranged into the groups defined above for the first set. A sample is prepared from the specimens in a group by taking an equal mass of bone ash from each specimen in the group. The procedure is then repeated for the second set.

For the two periods, January-June and July-December, 1970, the first set comprised 37 samples; they were analysed by CRL and results are given in Tables 6 and 7.

For the second set, data are available for the three periods, January-June and July-December, 1970, and January-June, 1971, and they are given in Table 8; the 48 samples were analysed by HASL.

These data reflect the expected age dependence of the ratio of strontium 90 to calcium in Australian bone tissue, discussed elsewhere (Gibbs et al., 1965). The highest values continue to occur at ages from 6 to 29 months, when growth and remodelling of the skeleton proceed rapidly. Thus a mean value for this age group will reflect generally higher levels of strontium 90 in the population, and data derived on that basis are adopted for computation of radiation dose to bone tissue. The mean value for 1970 is 1.6 picocuries per gramme of calcium and, for the first six months of 1971, 1.8 picocuries per gramme of calcium.

2. RADIATION DOSES TO THE AUSTRALIAN POPULATION

As stated in chapter 1, strontium 90 in fallout from nuclear weapons tests can affect the Australian population only as a consequence of radiation doses delivered to bone and bone marrow after the radioisotope has become incorporated in skeletal tissue. Mean dose-rates to bone marrow and endosteal tissue, following contamination of the skeleton with strontium 90, derived by Spiers and others (Spiers, 1966; International Commission on Radiological Protection (ICRP), 1968; UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1969), were accepted for previous estimates of radiation dose to bone tissue (Bonnyman et al., 1971a). Recent evaluations have yielded revised dose-rate factors (Spiers et al., 1971; UNSCEAR, 1972) and these new values are adopted for the present estimates. For uniform contamination of the skeleton, the new dose-rates for the whole population, for each picocurie of strontium 90 per gramme of calcium in bone, are

- 1.4 millirad per annum to bone marrow
- 1.9 millirad per annum to endosteal tissue.

Therefore, for those members of the Australian population aged between 6 and 29 months, for whom the mean ratio of strontium 90 to calcium in bone is generally higher than for other ages, the measurements in the 1970, and early 1971, monitoring indicate radiation doses to bone marrow of 2.6 millirad per annum and to endosteal tissue of 3.6 millirad per annum.

3. CONCLUSIONS

During 1970, and early 1971, contamination of the Australian environment with strontium 90 from nuclear weapons tests was responsible for radiation doses to the Australian population of up to 2.6 millirad per annum to bone marrow and 3.6 millirad per annum to endosteal tissue. These radiation doses are the only source of hazard to the population as a consequence of the strontium 90 contamination. The doses are small compared with, for example, 100 millirads, the average annual background radiation to bone tissue to which the whole population is continuously exposed.

Data on strontium 90 in the Australian environment during 1970 and 1971 confirm the prediction of the AWTSC (Gibbs et al., 1971b) that the programmes of megaton weapons testing by France in Polynesia will sustain the contamination of the Australian environment at about the levels observed during 1969.

Chapter 3:

MEASUREMENTS OF CAESIUM 137

J. Bonnyman[1], J. C. Duggleby[1], L. H. Kotler[1] and J. Molina-Ramos[1]

1. INTRODUCTION

This chapter reports the results of measurements of caesium 137 in precipitation and in milk during 1971 as part of the continuing programme established by the AWTSC, for the monitoring of fallout radionuclides in the Australian environment. Results of corresponding measurements for 1970 have already been published by Bonnyman et al., (1971b), but are included here to enable comparisons to be made with strontium 90 data for the same period.

The sampling programmes for precipitation and milk are described in chapter 2 while the radiochemical analysis methods remained unchanged from those described earlier (Alsop et al., 1966).

2. RESULTS AND DISCUSSION

(a) *Caesium 137 in Rainwater*

The monthly results obtained for the deposition of caesium 137 during 1970 and 1971, expressed in millicuries per square kilometre, together with the recorded rainfall, are given in Table 9. The monthly deposition at each station, averaged over quarterly periods from 1964 to 1971, is shown in Figure 3. The average annual concentration of caesium 137 in the rainfall of the six State capitals and their respective dairying areas is shown in Figure 4 for the period 1964 to 1971.

Examination of these results shows that at 15 of the 16 stations, deposition of caesium 137 was higher in 1971 than in the previous year, while the average concentration in rainwater was higher at 11 stations. Overall, the annual deposition rose by 23 per cent from 1970 to 1971, while the average annual concentration in rainwater at the six State capitals and their respective dairying areas rose by 21 per cent (Figure 4).

This rise in the annual deposition of caesium 137 is attributed to an increased contribution from the stratospheric reservoir of the radioisotope which had been augmented by the high yield tests carried out in Polynesia during 1970 and 1971. Deposition levels during 1971 are close to those prevailing in 1967 but are less than a half of those of 1965.

(b) *Caesium 137 in Milk*

Results obtained for the concentrations of caesium 137 in whole milk sampled during 1970 and 1971 are presented in Table 10. The average annual concentrations for each station, since measurement of caesium 137 began in 1963, are presented in Table 11, while the mean monthly concentration of caesium 137 in milk, for each quarter since 1963, is shown in histogram form in Figure 5. Inspection of Table 11 indicates that the average annual concentration of caesium 137 in milk reached a minimum in 1968 and since then has shown small rises each year, the concentration in 1971 being about 10 per cent higher than in 1970. This latest rise is common to all sampling centres and is consistent with the increased annual deposition of caesium 137 in rainwater, discussed above.

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3. RADIATION DOSE TO THE POPULATION FROM CAESIUM 137

(a) *Radiation Dose from Caesium 137 in Man*

UNSCEAR (1972) reports that, for man, a body burden of one picocurie of caesium 137 per gramme of potassium would give an internal dose-rate to gonads and to bone marrow of 0.018 millirad per annum. Body burdens of caesium 137 for Australians were not determined by CRL during 1971. However, the internal dose-rates can be estimated from the comprehensive data on caesium 137 in milk supplies by assuming the same proportionality as observed in 1970 between the average caesium 137 body burden and the content of the radioisotope in milk (Bonnyman et al., 1971b). Thus, in 1971, internal dose-rates to gonads and to bone marrow are estimated to have ranged from 0.2 millirad per annum for Brisbane to 0.8 millirad per annum for Perth, with a mean for the six State capitals of about 0.4 millirad per annum.

(b) *Radiation Dose from Caesium 137 in Soil*

As caesium 137 emits gamma-radiation its presence in soil results in an external contribution to the dose-rate to gonads and to bone marrow of the population. This external dose-rate may be calculated using the expression

$$C = A.S.T$$

where C is the dose-rate in millirad per annum to gonads and to bone marrow arising from one millicurie per square kilometre of caesium 137 accumulated in soil.

A is the dose-rate in air at a height of 1 metre above the surface of soil: that is, 0.033 millirad per annum per millicurie per square kilometre.

S is the effective shielding factor of buildings, assuming 17 hours each day are spent indoors, and has the value 0.4.

T is a factor for converting air dose to tissue dose allowing for screening by intervening tissues, and has the value 0.8 for the dose to gonads and to bone marrow.

These values of A and T, derived by using more refined methods, replace previously accepted values and lead to a revised dose-rate factor, C, of 0.011. (UNSCEAR, 1972).

Using this revised factor, the average external dose-rate to Australians, due to the accumulated deposits of caesium 137 in soil at the end of 1969 and 1970 (Bonnyman et al., 1971b), were 0.165 and 0.172 millirad per annum, respectively.

During 1971 an average of 1.09 millicurie per square kilometre of caesium 137 was deposited in fallout over Australia, leading to a further 0.012 millirad per annum in external dose-rate. However, during the year, radioactive decay of the accumulated deposit of caesium 137 in soil resulted in a reduction in the dose-rate by about 0.004 millirad per annum. Thus, the net increase for the year was 0.008 millirad per annum and the external dose-rate at the end of 1971 was 0.18 millirad per annum.

4. CONCLUSIONS

The average dose-rate to gonads and to bone marrow due to ingested caesium 137 in Australia during 1971 was about 0.4 millirad per annum, while the external dose-rate due to caesium 137 accumulated in soil was about 0.2 millirad per annum. Thus, the average dose-rate to Australians during 1971, due to all caesium 137 fallout in the environment, totalled about 0.6 millirad per annum. If megaton weapons testing in Polynesia continues over the next few years then these dose-rates may show some further increase. However, they would be expected to remain small in comparison with the average dose-rate contribution from natural background radiation of 100 millirad per annum.

ACKNOWLEDGEMENTS

These investigations were greatly facilitated by the generous co-operation of those in many fields who provided the specimens for analysis. We wish to record our appreciation, in particular, of the contributions of members of the Bureau of Meteorology and of the State Departments of Agriculture in operating the equipment for collecting the precipitation samples, of members of the CSIRO Division of Soils for their help with the soil sampling, of those in the dairying industry for the milk specimens, of the Australian Wheat Board and State Departments of Agriculture for the flour samples and especially of pathologists throughout Australia for their help with the bone specimens.

We are also indebted to the Health and Safety Laboratory of the US Atomic Energy Commission for measurements of strontium 90 in the samples and to the Commonwealth Radiation Laboratory for the remaining strontium 90 analyses and for all caesium 137 measurements.

The preparation of all samples prior to strontium 90 and caesium 137 analysis was carried out by Mr S. E. M. Thomas and Mrs Serena Moscato, Defence Standards Laboratories.

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TABLE 1

STRONTIUM 90 IN AUSTRALIAN SOIL, DECEMBER 1970

SITE	Density gramme per cubic centimetre	Calcium gramme per kilogramme	Strontium 90 millicuries per square kilometre	Estimated cumulative rainfall from November 1954 to date of sampling, centimetre
Wokalup	1.3	1.4	24.8	1670
Meadows	1.1	0.8	15.6	1347
Warragul	0.9	2.8	21.2	1730
Hadspen	1.1	1.0	14.3	1171
Berry	1.0	1.5	19.1	2365
Samford	1.3	0.6	16.5	1925
Townsville	1.3	0.4	6.3	1727
Darwin	1.7	0.6	8.1	2637
Alice Springs	1.4	1.5	10.2	340
Port Hedland	2.0	0.4	3.7	536

TABLE 3a

STRONTIUM 90 IN PRECIPITATION IN MAJOR DAIRYING AREAS OF AUSTRALIA

STATION		1970												1971											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
BERRY	Strontium 90 millicuries per square kilometre	0.36	0.16	0.19	0.02	0.02	0.04	0.01	0.04	0.07	0.09	0.10	0.26	0.31	0.57	0.17	0.10	0.03	0.01	0.02	0.08	0.74	0.06	0.10	0.35
	Rainfall in centimetre	11.86	3.43	12.19	4.67	3.56	2.13	0.00	3.10	13.28	7.54	8.03	30.86	21.67	72.64	9.70	5.56	1.14	1.02	1.63	6.12	4.06	2.46	5.26	17.12
	Strontium 90 picocuries per litre of rain	3.03	4.58	1.56	0.45	0.62	1.69	–	1.26	0.55	1.23	1.22	0.85	1.42	0.79	1.13	0.65	2.54	0.49	1.48	1.26	1.82	2.40	1.92	2.02
WARRAGUL	Strontium 90 millicuries per square kilometre	0.06	0.02	0.16	0.05	0.07	0.06	0.11	0.10	0.08	0.10	0.07	0.08	0.08	0.04	0.02	0.06	0.07	0.08	0.06	0.09	0.15	0.21	0.15	0.13
	Rainfall in centimetre	7.44	1.45	26.01	10.03	15.60	5.36	12.22	15.27	8.92	8.43	9.86	9.22	7.82	1.70	3.28	7.90	17.04	12.85	5.44	5.33	13.77	15.80	9.75	7.95
	Strontium 90 picocuries per litre of rain	0.75	1.11	0.63	0.52	0.46	1.14	0.88	0.63	0.93	1.20	0.75	0.86	1.06	2.17	0.61	0.70	0.42	0.62	1.07	1.67	1.01	1.31	1.50	1.59
MEADOWS	Strontium 90 millicuries per square kilometre	0.03	0.01	0.04	0.06	0.06	0.08	0.07	0.10	0.07	0.07	0.08	0.13	0.03	0.04	0.03	0.15	0.09	0.08	0.07	0.16	0.23	0.27	0.12	0.13
	Rainfall in centimetre	4.57	0.36	3.68	10.29	8.13	11.94	10.16	12.83	8.26	1.63	4.45	8.66	1.12	1.42	4.32	24.61	16.76	10.29	5.46	18.29	11.94	7.52	6.20	6.10
	Strontium 90 picocuries per litre of rain	0.55	2.53	1.14	0.55	0.75	0.64	0.72	0.76	0.86	4.00	1.80	1.50	2.95	2.46	0.72	0.61	0.54	0.80	1.30	0.89	1.92	3.53	1.87	2.12
HADSPEN	Strontium 90 millicuries per square kilometre	0.11	0.05	0.02	0.04	0.01	0.05	0.05	0.05	0.04	0.04	0.08	0.13	0.15	0.02	0.02	0.07	0.04	0.03	0.02	0.07	0.12	0.12	0.12	0.11
	Rainfall in centimetre	7.16	3.89	5.69	5.26	4.37	6.93	11.84	11.25	6.27	5.03	5.36	14.33	7.16	0.61	3.28	13.08	9.04	11.81	3.53	10.97	9.02	12.98	9.86	9.93
	Strontium 90 picocuries per litre of rain	1.48	1.34	0.39	0.67	0.30	0.66	0.40	0.47	0.57	0.72	1.42	0.89	2.07	3.12	0.61	0.50	0.42	0.22	0.68	0.62	1.35	0.94	1.20	1.07
WOKALUP	Strontium 90 millicuries per square kilometre	0.01	0.02	0.02	0.00	0.07	0.20	0.00	0.08	0.07	0.06	0.02	0.02	0.04	0.04	0.02	0.01	0.49	0.08	0.19	0.11	0.18	0.09	0.03	0.03
	Rainfall in centimetre	0.10	6.93	0.99	7.57	16.71	26.39	15.77	8.61	12.22	7.75	1.40	1.40	2.36	2.59	11.18	0.81	15.44	13.13	16.31	7.65	18.64	0.92	2.54	0.43
	Strontium 90 picocuries per litre of rain	3.94	0.32	2.12	–	0.44	0.76	0.01	0.89	0.53	0.76	1.22	1.15	1.86	1.62	0.22	1.11	0.05	0.60	1.18	1.45	0.94	1.00	1.14	6.02
SAMFORD	Strontium 90 millicuries per square kilometre	0.09	0.07	0.11	0.03	0.02	0.02	0.01	0.02	0.04	0.20	0.14	0.38	0.27	0.18	0.12	0.03	0.01	0.00	0.03	0.01	0.05	0.14	0.17	0.07
	Rainfall in centimetre	14.81	10.97	15.16	4.14	1.30	1.70	1.32	1.52	3.78	20.04	14.68	45.47	31.88	31.90	10.08	4.37	2.59	0.25	3.00	3.73	2.62	6.55	12.27	9.93
	Strontium 90 picocuries per litre of rain	0.60	0.67	0.73	0.70	1.50	0.82	0.61	1.51	1.11	0.98	0.96	0.84	0.80	0.56	1.15	0.62	0.43	0.39	0.93	0.35	1.76	2.17	1.40	0.71

TABLE 3b

STRONTIUM 90 IN PRECIPITATION AT ALICE SPRINGS AND PORT HEDLAND

STATION		1970												1971											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ALICE SPRINGS	Strontium 90 millicuries per square kilometre	0.01	0.01	0.02	0.00	0.01	0.00	0.01	0.01	0.03	0.03	0.03	0.04	0.00	0.01	0.02	0.02	0.00	0.00	0.01	0.08	0.04	0.04	0.09	0.09
	Rainfall in centimetre	0.00	1.42	0.86	5.13	1.09	0.00	0.00	0.03	1.19	0.43	1.80	5.59	0.05	0.84	1.96	0.03	0.03	1.14	0.79	1.25	0.36	0.00	3.94	1.98
	Strontium 90 picocuries per litre of rain	–	0.35	2.32	0.04	1.30	–	–	15.8	2.85	6.26	1.44	0.66	7.87	0.00	0.77	70.9	3.94	0.18	1.52	6.27	10.69	0.00	2.16	4.29
PORT HEDLAND	Strontium 90 millicuries per square kilometre	0.00	0.01	0.00	0.05	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.02	0.01	0.01
	Rainfall in centimetre	2.49	4.90	0.10	0.43	14.05	0.00	0.00	0.00	0.00	0.00	0.00	0.86	21.49	0.00	4.89	0.05	5.13	3.84	0.46	0.03	0.05	0.00	0.08	0.10
	Strontium 90 picocuries per litre of rain	0.00	0.29	0.00	11.12	0.11	–	–	–	–	–	–	0.35	0.10	0.00	0.00	1.97	0.18	0.00	2.41	0.00	13.8	0.00	14.4	10.8

TABLE 4

STRONTIUM 90 IN AUSTRALIAN LIQUID MILK JANUARY 1970 – JUNE 1971

Each quarterly sample was derived from specimens taken weekly throughout the period

ORIGIN	January to March 1970		April to June 1970		July to September 1970		October to December 1970		January to March 1971		April to June 1971	
	Strontium 90●	Stable Strontium*	Strontium 90●	Stable Strontium*	Strontium 90●	Stable Strontium*	Strontium 90●	Stable Strontium*	Strontium 90●	Stable Strontium*	Strontium 90●	Stable Strontium*
Perth	5.0	0.39	6.0	0.44	7.1	0.40	6.4	0.55	5.1	0.49	5.8	0.52
Adelaide	5.3	0.45	6.1	0.68	7.4	0.51	7.0	0.67	4.7	0.59	5.8	0.60
Melbourne	7.1	0.54	8.0	0.55	8.4	0.63	7.4	0.64	5.9	0.67	7.3	0.68
Hobart-Launceston	4.7	0.37	4.5	0.41	5.6	0.46	5.2	0.42	4.5	0.48	4.5	0.47
Sydney	5.9	0.52	5.9	0.75	5.4	0.62	5.9	0.68	6.0	0.67	6.4	0.67
Brisbane	4.8	0.53	4.6	0.78	4.0	0.67	5.2	0.76	5.2	0.76	4.6	0.74

● Strontium 90 in picocuries per gramme of calcium in the milk.

* Non-radioactive strontium in milligramme per gramme of calcium in the milk.

TABLE 5

STRONTIUM 90 IN AUSTRALIAN FLOUR

1969-70 HARVEST

Origin	Strontium 90 picocuries per gramme of calcium	Stable Strontium milligramme per gramme of calcium
Western Australia	17.2	7.5
South Australia	9.1	7.3
Victoria	16.5	6.8
New South Wales	20.4	5.9
Queensland	9.4	8.0

TABLE 6

STRONTIUM 90 IN AUSTRALIAN HUMAN BONE, ALL AGES TO 5 MONTHS
JANUARY – DECEMBER 1970

An asterisk indicates that no specimen was available in the age group. With the 1–5 month samples, the figure in brackets gives the number of specimens of a particular age contributing to the sample. The analyses were performed by CRL.

Origin	January–June 1970				July-December 1970			
	Age in months	Number of Specimens	Strontium 90●	Stable Strontium+	Age in months	Number of Specimens	Strontium 90●	Stable Strontium+
0–1 month								
Perth	0	49	0.90	0.23	0	47	0.92	0.29
Adelaide	0	29	0.77	0.31	0	23	1.03	0.25
Melbourne	0	109	0.72	0.26	0	109	1.80	0.26
Sydney	0	33	0.71	0.25	0	30	1.05	0.29
Brisbane	0	27	0.57	0.29	0	30	0.94	0.29
1–5 months								
Perth	1(8), 2(4), 3(2), 4(2)	16	0.93	0.23	1, 2(3), 3(2), 4(2)	8	1.43	0.30
Adelaide	1(2), 2(2), 3(4), 4	9	1.75	0.33	1(5), 2(7), 3(2), 4(3), 5(3)	20	1.84	0.32
Melbourne	1(9), 2(8), 3(2), 4(2)	21	1.02	0.26	1(9), 3(3), 4	13	1.14	0.26
Sydney	1(3), 2, 3(4), 4, 5	10	1.26	0.28	1(4), 2, 3(3), 4(2), 5	11	1.43	0.29
Brisbane	1(6), 2(4), 3(3), 5	14	1.02	0.35	1(4), 3(4), 4(2), 5(2)	12	1.58	0.36

● Strontium 90 picocuries per gramme of calcium in bone.
\+ Non-radioactive strontium milligramme per gramme of calcium in bone.

TABLE 7

STRONTIUM 90 IN AUSTRALIAN HUMAN BONE, ALL AGES BETWEEN 5 AND 39 YEARS
JANUARY – DECEMBER 1970

The figure in brackets gives the number of specimens from which the sample was derived. The analyses were performed by CRL. An asterisk indicates that no specimen was available in the age group.

Origin	January-June			July-December		
	Strontium 90●	Stable Strontium +	Bone	Strontium 90●	Stable Strontium +	Bone
5–19 years						
Perth	1.41 (15)	0.38	vertebra and femur	1.39 (18)	0.32	vertebra and femur
Adelaide	0.97 (21)	0.34	vertebra and rib	1.82 (16)	0.32	femur and rib
Melbourne	*	*	–	*	*	–
Sydney	1.28 (13)	0.32	vertebra and rib	1.52 (14)	0.42	vertebra and rib
Brisbane	0.76 (38)	0.38	vertebra	0.92 (42)	0.32	vertebra
20–39 years						
Perth	1.20 (13)	0.31	vertebra	1.22 (18)	0.46	vertebra
Adelaide	0.75 (27)	0.35	vertebra	1.19 (29)	0.39	vertebra
Melbourne	1.22 (2)	0.29	vertebra	*	*	–
Sydney	0.85 (10)	0.33	vertebra	1.03 (24)	0.33	vertebra
Brisbane	0.60 (81)	0.34	vertebra	0.94 (45)	0.47	vertebra

● Strontium 90 picocuries per gramme of calcium in bone.
\+ Non-radioactive strontium milligramme per gramme of calcium in bone

TABLE 2

STRONTIUM 90 IN PRECIPITATION IN MAJOR POPULATION CENTRES IN AUSTRALIA

STATION		1970 Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
SYDNEY	Strontium 90 millicuries per square kilometre	0.12	0.06	0.12	0.03	0.02	0.01	0.01	0.09	0.05	0.04	0.15	0.16
	Rainfall in centimetre	9.63	8.26	17.60	4.52	1.78	1.68	0.00	10.77	5.89	2.06	15.09	25.43
	Strontium 90 picocuries per litre of rain	1.28	0.76	0.67	0.60	0.90	0.41	0.00	0.85	0.87	1.74	1.00	0.63
MELBOURNE	Strontium 90 millicuries per square kilometre	0.13	0.05	0.12	0.04	0.05	0.06	0.02	0.06	0.06	0.06	0.15	0.18
	Rainfall in centimetre	9.91	1.55	13.71	8.00	6.93	5.16	2.49	6.81	3.78	3.48	6.65	12.34
	Strontium 90 picocuries per litre of rain	1.27	2.99	0.86	0.50	0.73	1.07	0.75	0.85	1.60	1.85	2.25	1.43
ADELAIDE	Strontium 90 millicuries per square kilometre	0.03	0.01	0.02	0.05	0.04	0.05	0.04	0.07	0.06	0.06	0.07	0.05
	Rainfall in centimetre	1.57	0.03	0.81	5.74	6.25	6.32	5.69	7.37	5.79	0.79	3.81	3.12
	Strontium 90 picocuries per litre of rain	1.81	41.31	2.70	0.85	0.67	0.80	0.65	0.96	1.07	7.54	1.92	1.62
HOBART	Strontium 90 millicuries per square kilometre	0.14	0.03	0.04	0.03	0.01	0.02	0.03	0.02	0.02	0.08	0.06	0.09
	Rainfall in centimetre	12.09	3.66	5.10	2.92	3.20	4.72	5.08	10.59	2.29	10.62	6.91	14.99
	Strontium 90 picocuries per litre of rain	1.13	0.88	0.78	0.93	0.43	0.38	0.53	0.20	0.84	0.75	0.90	0.61
PERTH	Strontium 90 millicuries per square kilometre	0.03	0.03	0.01	0.05	0.09	0.11	0.12	0.05	0.10	0.08	0.02	0.04
	Rainfall in centimetre	0.30	4.55	0.07	8.10	19.69	20.27	16.64	7.39	8.69	4.37	1.19	0.61
	Strontium 90 picocuries per litre of rain	10.96	0.75	8.11	0.67	0.45	0.55	0.73	0.66	1.20	1.90	1.66	6.39
BRISBANE	Strontium 90 millicuries per square kilometre	0.10	0.07	0.12	0.03	0.01	0.01	0.02	0.02	0.06	0.07	0.13	0.28
	Rainfall in centimetre	15.24	8.86	19.66	5.68	1.30	1.27	2.67	0.79	4.83	19.79	23.98	39.90
	Strontium 90 picocuries per litre of rain	0.64	0.79	0.64	0.52	0.95	0.73	0.77	2.21	1.32	0.35	0.53	0.69
TOWNSVILLE	Strontium 90 millicuries per square kilometre	0.04	0.03	0.04	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.08	0.04
	Rainfall in centimetre	6.38	7.19	27.48	2.01	0.03	0.36	0.03	5.33	0.30	0.48	7.62	14.91
	Strontium 90 picocuries per litre of rain	0.54	0.42	0.14	0.52	9.74	2.96	9.70	0.61	6.09	2.69	1.06	0.27
DARWIN	Strontium 90 millicuries per square kilometre	0.05	0.05	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.06	0.06
	Rainfall in centimetre	22.02	31.24	12.44	3.32	1.42	0.00	0.00	0.00	2.46	16.64	12.57	19.79
	Strontium 90 picocuries per litre of rain	0.21	0.15	0.25	0.13	0.83	0.00	0.00	0.00	0.48	0.43	0.49	0.30

STATION		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
SYDNEY	Strontium 90 millicuries per square kilometre	0.15	0.08	0.08	0.07	0.04	0.04	0.03	0.14	0.08	0.02	0.08	0.14
	Rainfall in centimetre	22.23	12.09	5.97	8.13	7.16	6.76	2.51	11.20	5.13	0.18	6.73	10.95
	Strontium 90 picocuries per litre of rain	0.67	0.62	1.33	0.83	0.48	0.53	1.33	1.23	1.57	10.4	1.23	1.25
MELBOURNE	Strontium 90 millicuries per square kilometre	0.10	0.12	0.04	0.04	0.04	0.04	0.04	0.05	0.06	0.08	0.10	0.09
	Rainfall in centimetre	10.31	8.36	2.59	4.88	6.15	4.95	2.79	3.35	7.59	5.79	13.92	6.81
	Strontium 90 picocuries per litre of rain	0.92	1.39	1.43	0.76	0.67	0.70	1.35	1.59	0.81	1.36	0.68	1.38
ADELAIDE	Strontium 90 millicuries per square kilometre	0.04	0.02	0.03	0.18	0.06	0.04	0.07	0.07	0.13	0.06	0.07	0.05
	Rainfall in centimetre	0.38	0.51	3.25	17.93	7.98	5.23	4.60	8.59	7.09	3.00	5.82	2.49
	Strontium 90 picocuries per litre of rain	10.1	4.38	0.95	0.99	0.80	0.78	1.57	0.81	1.80	1.84	1.24	2.00
HOBART	Strontium 90 millicuries per square kilometre	0.15	0.06	0.06	0.03	0.04	0.02	0.01	0.03	0.03	0.08	0.10	0.07
	Rainfall in centimetre	11.58	10.24	3.78	3.58	8.15	3.28	1.55	5.77	7.37	6.96	7.70	5.16
	Strontium 90 picocuries per litre of rain	1.33	0.63	1.52	0.88	0.47	0.70	0.88	0.59	0.40	1.11	1.26	1.28
PERTH	Strontium 90 millicuries per square kilometre	0.08	0.03	0.07	0.02	0.05	0.07	0.15	0.12	0.16	0.13	0.02	0.01
	Rainfall in centimetre	0.66	0.81	7.16	0.79	8.48	10.85	11.89	7.92	18.62	10.24	1.83	0.38
	Strontium 90 picocuries per litre of rain	12.6	3.35	1.00	2.44	0.61	0.59	1.25	1.48	0.84	1.25	1.34	2.93
BRISBANE	Strontium 90 millicuries per square kilometre	0.29	0.17	0.10	0.03	0.02	0.01	0.03	0.07	0.04	0.17	0.22	0.08
	Rainfall in centimetre	49.53	27.86	8.84	2.62	1.52	0.20	3.68	4.95	2.79	9.47	14.91	11.02
	Strontium 90 picocuries per litre of rain	0.59	0.62	1.15	1.25	1.26	3.35	0.89	1.49	1.57	1.82	1.46	0.71
TOWNSVILLE	Strontium 90 millicuries per square kilometre	0.08	0.06	0.06	0.03	0.01	0.01	0.02	0.02	0.00	0.02	0.02	0.09
	Rainfall in centimetre	10.29	19.94	24.87	3.58	2.87	4.22	0.97	4.32	0.00	2.03	2.74	34.72
	Strontium 90 picocuries per litre of rain	0.77	0.30	0.23	0.69	0.45	0.19	1.67	0.53	0.00	1.08	0.85	0.25
DARWIN	Strontium 90 millicuries per square kilometre	0.14	0.06	0.03	0.02	0.01	0.00	0.00	0.00	0.01	0.04	0.05	0.04
	Rainfall in centimetre	40.87	33.43	41.55	18.67	2.87	0.00	0.00	0.00	2.08	10.69	16.43	30.58
	Strontium 90 picocuries per litre of rain	0.33	0.19	0.06	0.11	0.30	0.00	0.00	0.00	0.44	0.34	0.30	0.14

TABLE 8

STRONTIUM 90 IN AUSTRALIAN HUMAN BONE
ALL AGES TO 39 YEARS
JANUARY 1970 to JUNE 1971

Bracketed figure gives the number of specimens from which the sample was derived for analysis. The analyses were performed by HASL.

Age Group		January–June 1970●		July–December 1970●		January–June 1971●	
0–1	month	0.68	(208)	0.74	(240)	0.73	(214)
1–5	"	1.20	(70)	1.18	(70)	1.26	(70)
6–11	"	1.59	(16)	1.72	(25)	2.02	(22)
12–17	"	1.58	(14)	1.89	(12)	1.74	(10)
18–23	"	1.55	(9)	1.26	(7)	1.92	(4)
24–29	"	1.61	(10)	1.67	(15)	1.66	(11)
30–35	"	1.40	(2)	1.50	(7)	1.36	(7)
36–41	"	1.39	(5)	1.40	(7)	1.34	(6)
42–47	"	1.04	(4)	1.02	(4)	1.14	(3)
48–53	"	1.35	(5)	0.96	(4)	1.17	(2)
54–59	"	1.30	(2)	1.18	(2)	1.26	(5)
5–9	year	1.10	(23)	1.28	(26)	1.08	(18)
10–14	"	1.30	(20)	1.16	(20)	0.84	(11)
15–19	"	1.01	(42)	0.98	(44)	1.09	(36)
20–29	year	0.86	(79)	0.91	(71)	0.89	(72)
30–39	"	0.87	(51)	0.80	(45)	0.97	(52)

● Strontium 90 picocuries per gramme of calcium in bone.

CAESIUM 137 IN PRECIPITATION IN AUSTRALIA, 1970 AND 1971

TABLE 9

1970

STATION		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Concentration ●
SYDNEY	Caesium 137 millicuries per square kilometre	0.14	0.06	0.12	0.06	0.07	0.01	0.01	0.08	0.03	0.01	0.17	0.27	1.03	1.00
	Rainfall in centimetre	9.63	8.26	17.60	4.52	1.78	1.68	0.00	10.77	5.89	2.06	15.09	25.43	102.71	
BERRY	Caesium 137 millicuries per square kilometre	0.36	0.19	0.08	0.06	0.05	0.03	0.01	0.03	0.11	0.14	0.09	0.29	1.44	1.43
	Rainfall in centimetre	11.86	3.43	12.19	4.67	3.56	2.13	0.00	3.10	13.28	7.54	8.03	30.86	100.65	
MELBOURNE	Caesium 137 millicuries per square kilometre	0.11	0.08	0.03	0.07	0.05	0.05	0.05	0.07	0.07	0.07	0.18	0.22	1.05	1.30
	Rainfall in centimetre	9.91	1.55	13.71	8.00	6.93	5.16	2.49	6.81	3.78	3.48	6.60	12.34	80.76	
WARRAGUL	Caesium 137 millicuries per square kilometre	0.09	0.03	0.18	0.07	0.08	0.04	0.13	0.11	0.06	0.12	0.19	0.12	1.22	0.94
	Rainfall in centimetre	7.44	1.45	26.01	10.03	15.60	5.36	12.22	15.27	8.92	8.43	9.86	9.22	129.81	
ADELAIDE	Caesium 137 millicuries per square kilometre	0.04	0.01	0.03	0.05	0.05	0.06	0.09	0.11	0.08	0.08	0.06	0.09	0.75	1.57
	Rainfall in centimetre	2.87	0.03	0.81	5.74	6.25	6.32	4.98	7.34	5.79	0.79	3.81	3.12	47.85	
MEADOWS	Caesium 137 millicuries per square kilometre	0.04	0.03	0.03	0.08	0.04	0.11	0.06	0.13	0.08	0.06	0.09	0.12	0.87	1.02
	Rainfall in centimetre	4.57	0.36	3.68	10.29	8.13	11.94	10.16	12.83	8.26	1.63	4.45	8.66	84.96	
HOBART	Caesium 137 millicuries per square kilometre	0.18	0.06	0.08	0.02	0.04	0.03	0.02	0.05	0.04	0.09	0.10	0.14	0.85	1.03
	Rainfall in centimetre	12.09	3.66	5.10	2.92	3.20	4.72	5.08	10.59	2.29	10.62	6.91	14.99	82.17	
HADSPEN	Caesium 137 millicuries per square kilometre	0.13	0.06	0.04	0.04	0.02	0.05	0.12	0.08	0.05	0.07	0.10	0.16	0.92	1.05
	Rainfall in centimetre	7.16	3.89	5.69	5.26	4.37	6.93	11.84	11.25	6.27	5.03	5.36	14.33	87.38	
PERTH	Caesium 137 millicuries per square kilometre	0.05	0.05	0.00	0.06	0.12	0.17	0.15	0.13	0.16	0.08	0.04	0.05	1.06	1.15
	Rainfall in centimetre	0.30	4.55	0.07	8.10	19.69	20.27	16.64	7.39	8.69	4.37	1.19	0.61	91.87	
WOKALUP	Caesium 137 millicuries per square kilometre	0.02	0.04	0.03	0.00	0.08	0.17	0.15	0.12	0.14	0.06	0.04	0.04	0.89	0.86
	Rainfall in centimetre	0.10	6.93	0.99	5.26	16.71	26.39	15.77	8.61	12.22	7.75	1.40	1.85	103.98	
PORT HEDLAND	Caesium 137 millicuries per square kilometre	0.02	0.01	0.00	0.05	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.02	0.12	0.53
	Rainfall in centimetre	2.49	4.90	0.10	0.43	14.05	0.00	0.00	0.00	0.00	0.00	0.00	0.86	22.83	
BRISBANE	Caesium 137 millicuries per square kilometre	0.15	0.09	0.18	0.05	0.02	0.02	0.02	0.03	0.05	0.26	0.24	0.40	1.51	1.05
	Rainfall in centimetre	15.24	8.86	19.66	5.68	1.30	1.27	2.67	0.79	4.83	19.79	23.98	39.90	143.97	
SAMFORD	Caesium 137 millicuries per square kilometre	0.10	0.09	0.15	0.05	0.02	0.01	0.01	0.02	0.07	0.16	0.17	0.41	1.26	0.90
	Rainfall in centimetre	14.81	10.97	15.16	7.57	1.30	1.70	1.32	1.52	3.78	20.04	14.68	46.84	139.69	
TOWNSVILLE	Caesium 137 millicuries per square kilometre	0.02	0.04	0.04	0.02	0.00	0.02	0.00	0.03	0.02	0.03	0.09	0.08	0.39	0.54
	Rainfall in centimetre	6.38	7.19	27.48	2.01	0.03	0.36	0.03	5.33	0.30	0.48	7.62	14.91	72.12	
DARWIN	Caesium 137 millicuries per square kilometre	0.07	0.10	0.03	0.01	0.01	0.02	0.02	0.02	0.02	0.11	0.05	0.06	0.52	0.43
	Rainfall in centimetre	22.02	31.24	12.44	3.32	1.42	0.00	0.00	0.00	2.46	16.64	12.57	19.79	121.90	
ALICE SPRINGS	Caesium 137 millicuries per square kilometre	0.02	0.01	0.02	0.01	0.01	0.02	0.00	0.01	0.03	0.04	0.07	0.07	0.31	1.77
	Rainfall in centimetre	0.00	1.42	0.86	5.13	1.09	0.00	0.00	0.03	1.19	0.43	1.80	5.59	17.54	

1971

STATION		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Concentration ●
SYDNEY	Caesium 137 millicuries per square kilometre	0.16	0.08	0.08	0.08	0.05	0.03	0.04	0.19	0.13	0.06	0.09	0.22	1.21	1.23
	Rainfall in centimetre	21.31	12.09	5.97	8.13	7.16	6.78	2.51	11.20	5.13	0.18	6.73	10.95	98.14	
BERRY	Caesium 137 millicuries per square kilometre	0.37	0.76	0.23	0.13	0.05	0.03	0.05	0.10	0.09	0.10	0.10	0.31	2.32	1.56
	Rainfall in centimetre	21.67	72.64	9.70	5.57	1.14	1.02	1.53	6.12	4.06	2.46	5.26	17.12	148.39	
MELBOURNE	Caesium 137 millicuries per square kilometre	0.10	0.05	0.05	0.04	0.07	0.02	0.04	0.05	0.10	0.09	0.04	0.11	0.76	0.98
	Rainfall in centimetre	10.31	8.36	2.59	4.88	6.15	4.95	2.82	3.35	7.59	5.79	13.92	6.81	77.52	
WARRAGUL	Caesium 137 millicuries per square kilometre	0.08	0.02	0.03	0.05	0.06	0.08	0.05	0.09	0.17	0.28	0.18	0.13	1.22	1.12
	Rainfall in centimetre	7.82	1.70	3.28	7.90	17.04	12.85	5.44	5.33	13.77	15.80	9.75	7.95	108.63	
ADELAIDE	Caesium 137 millicuries per square kilometre	0.05	0.02	0.04	0.16	0.11	0.07	0.06	0.08	0.10	0.27	0.20	0.07	1.23	1.83
	Rainfall in centimetre	0.38	0.51	3.25	17.93	7.98	5.23	4.60	8.59	7.09	3.00	5.82	2.49	66.87	
MEADOWS	Caesium 137 millicuries per square kilometre	0.07	0.06	0.09	0.17	0.15	0.09	0.08	0.17	0.23	0.27	0.16	0.15	1.69	1.48
	Rainfall in centimetre	1.12	1.42	4.32	24.61	16.76	10.29	5.46	18.29	11.94	7.52	6.20	6.10	114.03	
HOBART	Caesium 137 millicuries per square kilometre	0.21	0.11	0.07	0.05	0.06	0.03	0.02	0.04	0.03	0.12	0.09	0.13	0.96	1.28
	Rainfall in centimetre	11.58	10.24	3.78	3.58	8.15	3.28	1.55	5.77	7.37	6.96	7.77	5.21	75.24	
HADSPEN	Caesium 137 millicuries per square kilometre	0.18	0.05	0.04	0.09	0.04	0.05	0.03	0.07	0.15	0.12	0.09	0.13	1.04	1.03
	Rainfall in centimetre	7.16	0.61	3.28	13.08	9.04	11.81	3.53	10.97	9.02	12.98	9.86	9.93	101.27	
PERTH	Caesium 137 millicuries per square kilometre	0.04	0.04	0.08	0.04	0.05	0.07	0.17	0.15	0.24	0.19	0.04	0.03	1.14	1.43
	Rainfall in centimetre	0.66	0.81	7.16	0.79	8.48	10.85	11.89	7.92	18.62	10.24	1.83	0.38	79.63	
WOKALUP	Caesium 137 millicuries per square kilometre	0.04	0.06	0.05	0.03	0.08	0.09	0.21	0.16	0.19	0.14	0.04	0.04	1.13	1.13
	Rainfall in centimetre	2.36	2.59	11.18	0.81	15.44	13.13	16.31	7.65	18.64	8.92	2.54	0.43	100.00	
PORT HEDLAND	Caesium 137 millicuries per square kilometre	0.02	0.02	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.02	0.02	0.01	0.12	0.33
	Rainfall in centimetre	21.49	0.00	4.88	0.05	5.13	3.84	0.46	0.03	0.05	0.00	0.08	0.10	36.11	
BRISBANE	Caesium 137 millicuries per square kilometre	0.43	0.19	0.08	0.05	0.04	0.02	0.05	0.10	0.07	0.24	0.26	0.10	1.63	1.18
	Rainfall in centimetre	49.53	27.86	8.84	2.62	1.52	0.20	3.68	4.95	2.79	9.47	14.91	11.02	137.39	
SAMFORD	Caesium 137 millicuries per square kilometre	0.33	0.27	0.18	0.05	0.02	0.01	0.03	0.01	0.05	0.14	0.17	0.08	1.34	1.12
	Rainfall in centimetre	31.88	31.90	10.08	4.37	2.59	0.25	3.00	3.73	2.62	6.55	12.27	9.93	119.17	
TOWNSVILLE	Caesium 137 millicuries per square kilometre	0.09	0.07	0.03	0.01	0.04	0.01	0.02	0.02	0.01	0.06	0.01	0.12	0.49	0.44
	Rainfall in centimetre	10.29	19.94	24.87	3.58	2.87	4.22	0.97	4.32	0.00	2.03	2.74	34.72	110.55	
DARWIN	Caesium 137 millicuries per square kilometre	0.22	0.10	0.09	0.03	0.01	0.00	0.00	0.00	0.01	0.06	0.07	0.05	0.64	0.32
	Rainfall in centimetre	40.87	33.43	41.55	18.67	2.87	0.00	0.00	0.00	2.08	10.69	16.43	30.61	197.20	
ALICE SPRINGS	Caesium 137 millicuries per square kilometre	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.04	0.05	0.10	0.09	0.40	3.24
	Rainfall in centimetre	0.05	0.84	1.96	0.03	0.03	1.14	0.79	1.24	0.36	0.00	3.94	1.98	12.36	

● Concentration of Caesium 137 in rainfall, picocuries per litre.

TABLE 10

CONCENTRATIONS OF CAESIUM 137 IN AUSTRALIAN WHOLE MILK, 1970 AND 1971 IN PICOCURIES PER LITRE

Each monthly sample was derived from specimens taken weekly throughout the period.

Centre	1970												1971											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perth	21	24	25	23	23	33	40	39	49	54	45	45	33	33	26	27	27	28	38	48	53	61	55	51
Adelaide	14	12	13	12	14	13	15	20	20	19	15	20	16	13	10	13	14	15	14	20	24	28	25	23
Melbourne	27	23	25	19	19	16	20	19	20	20	24	29	28	28	21	18	18	17	18	18	21	31	29	33
Hobart-Launceston	20	18	24	14	15	16	16	17	15	18	18	22	28	26	19	15	19	15	17	18	15	26	24	34
Sydney	11	14	16	13	9	10	10	9	11	10	10	17	16	17	18	18	12	12	10	12	12	12	11	17
Brisbane	8	11	13	13	8	8	8	7	8	10	10	15	16	14	15	13	10	10	9	9	11	11	11	9
Average	17	17	19	16	15	16	18	19	21	22	20	25	23	22	18	17	17	16	18	21	23	28	26	28

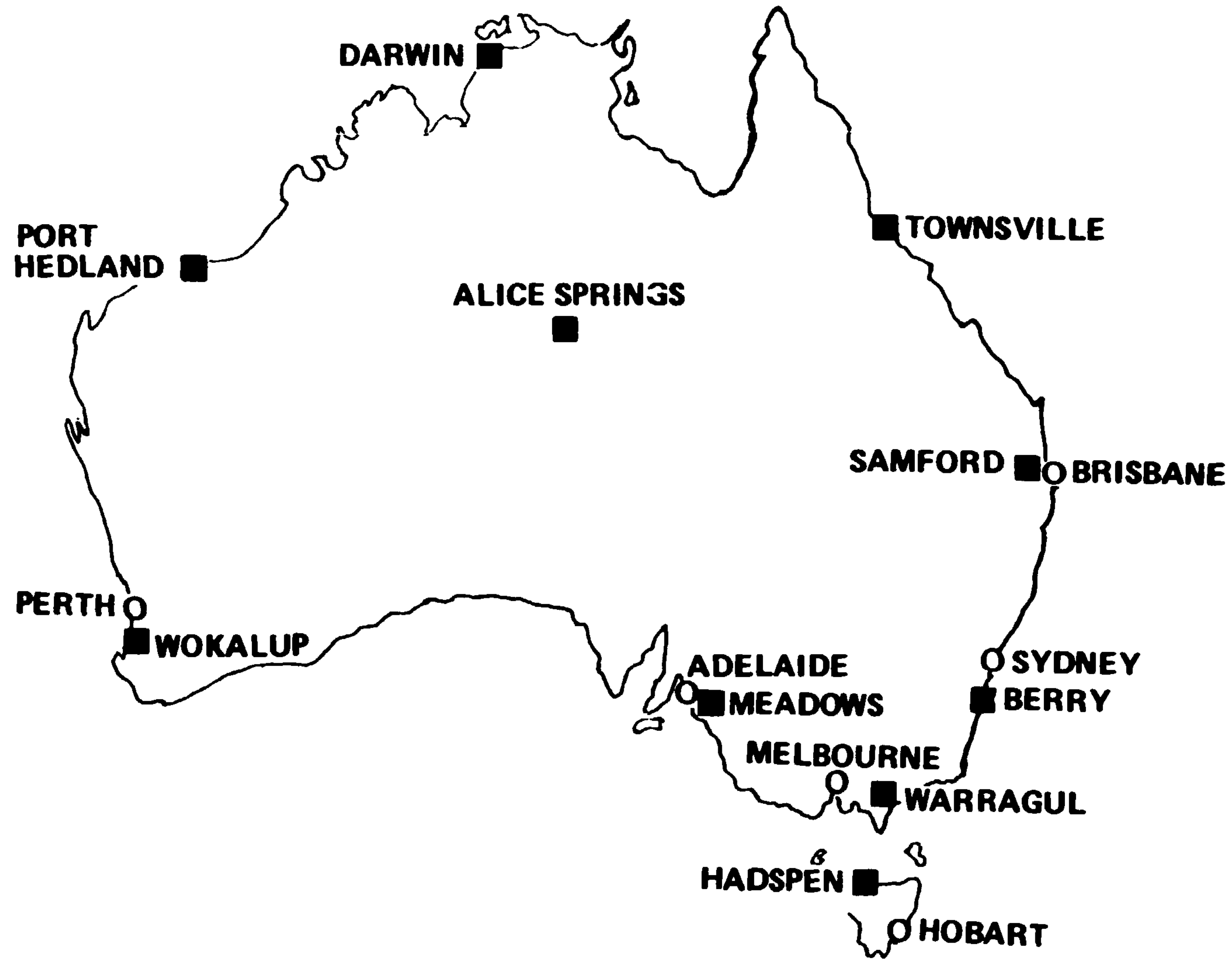
TABLE 11

AVERAGE CONCENTRATIONS OF CAESIUM 137 IN WHOLE MILK, 1963 TO 1971

PICOCURIES PER LITRE

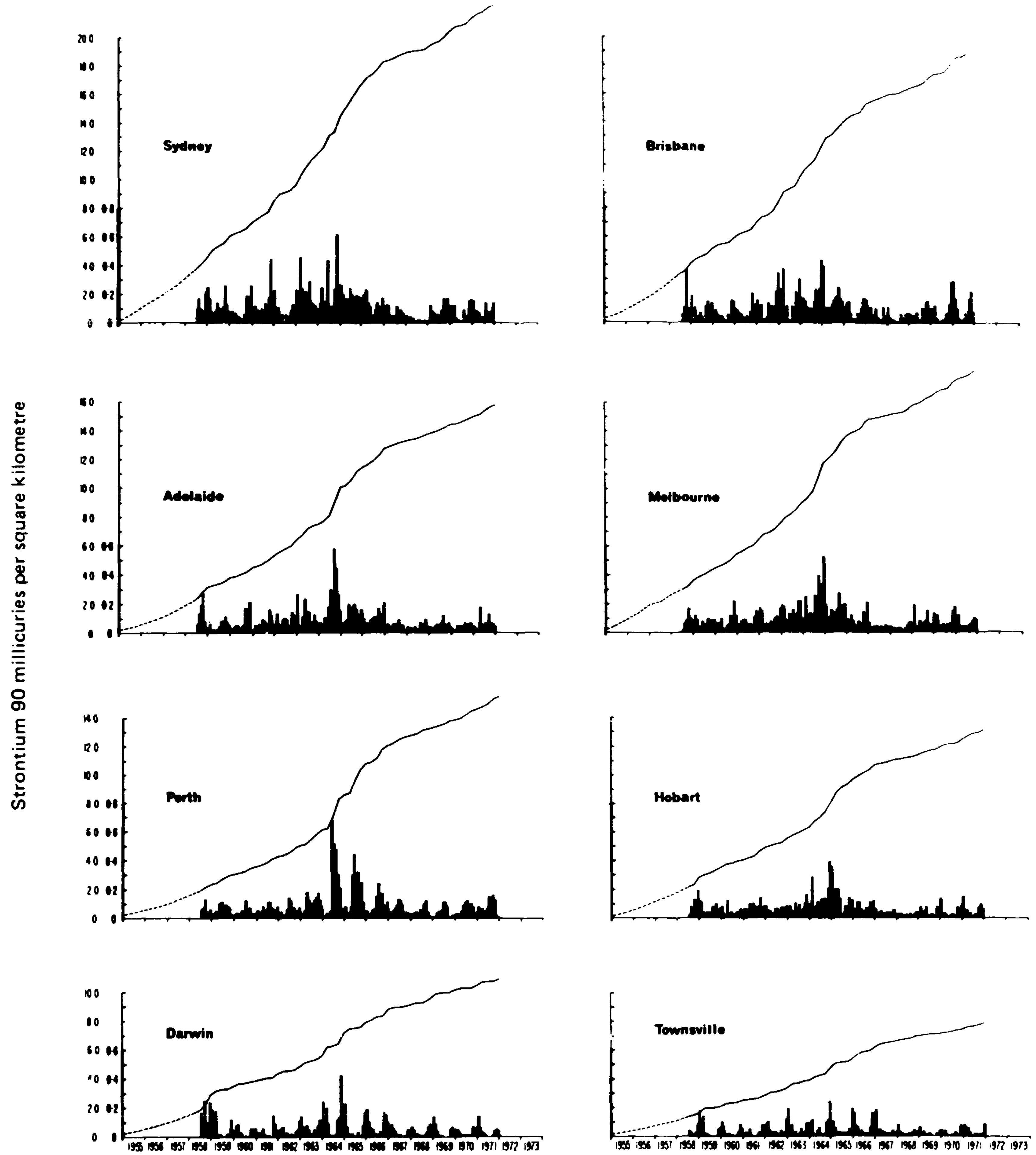
Centre	1963	1964	1965	1966	1967	1968	1969	1970	1971
Perth	63	86	93	66	50	40	34	35	40
Adelaide	27	59	49	27	16	12	18	16	18
Melbourne	34	58	58	30	19	13	22	22	23
Hobart-Launceston	28	39	39	21	13	11	16	18	21
Sydney	26	30	28	15	13	8	10	12	14
Brisbane	18	20	19	9	8	6	8	10	12
Average	33	49	47	28	20	15	18	19	21

FIGURE 1



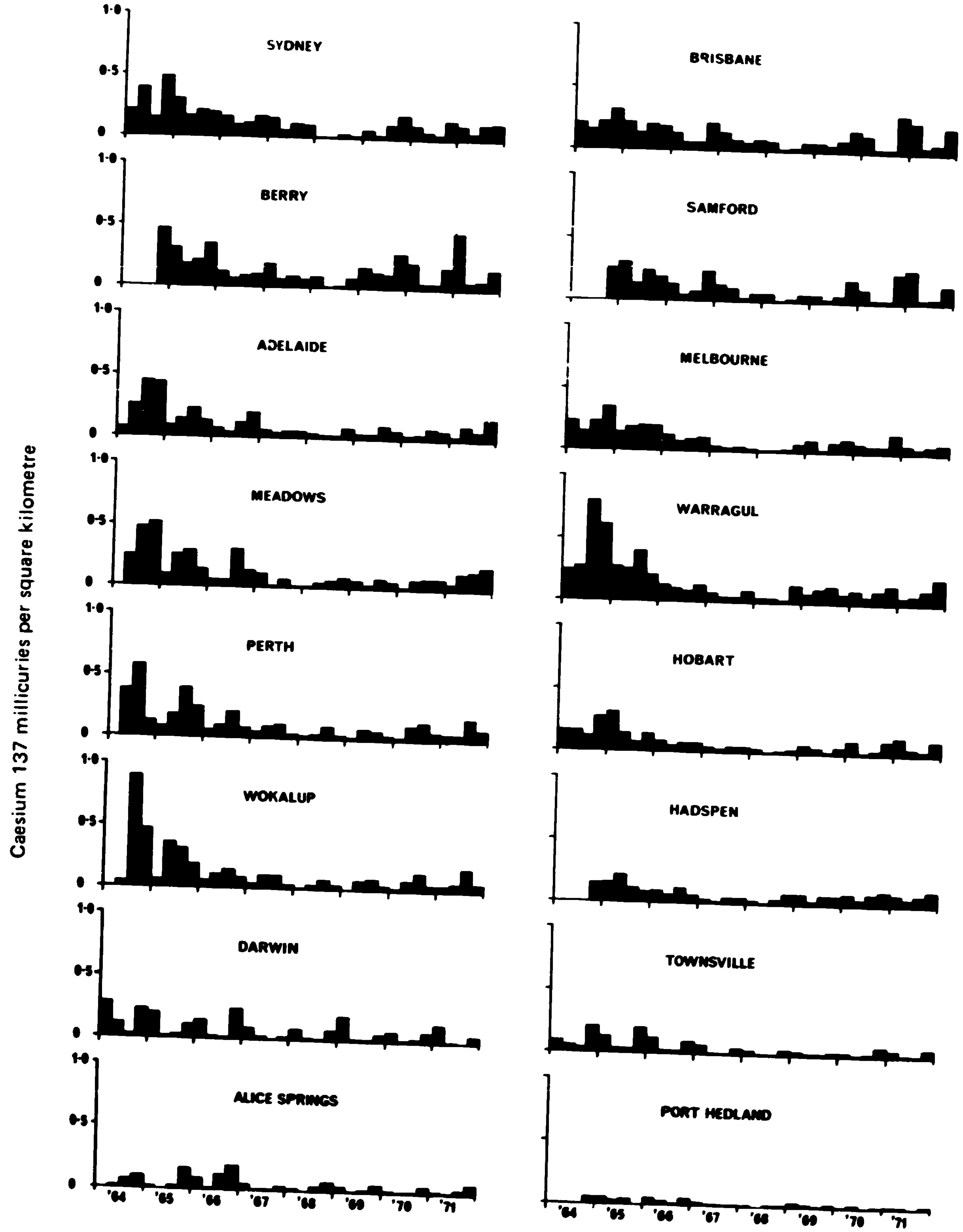
Stations in Australia for monitoring strontium 90 and caesium 137 in precipitation, and strontium 90 in soil. Sixteen stations, O and ■ take monthly precipitation samples and ten of them ■ maintain sites for annual soil sampling.

FIGURE 2



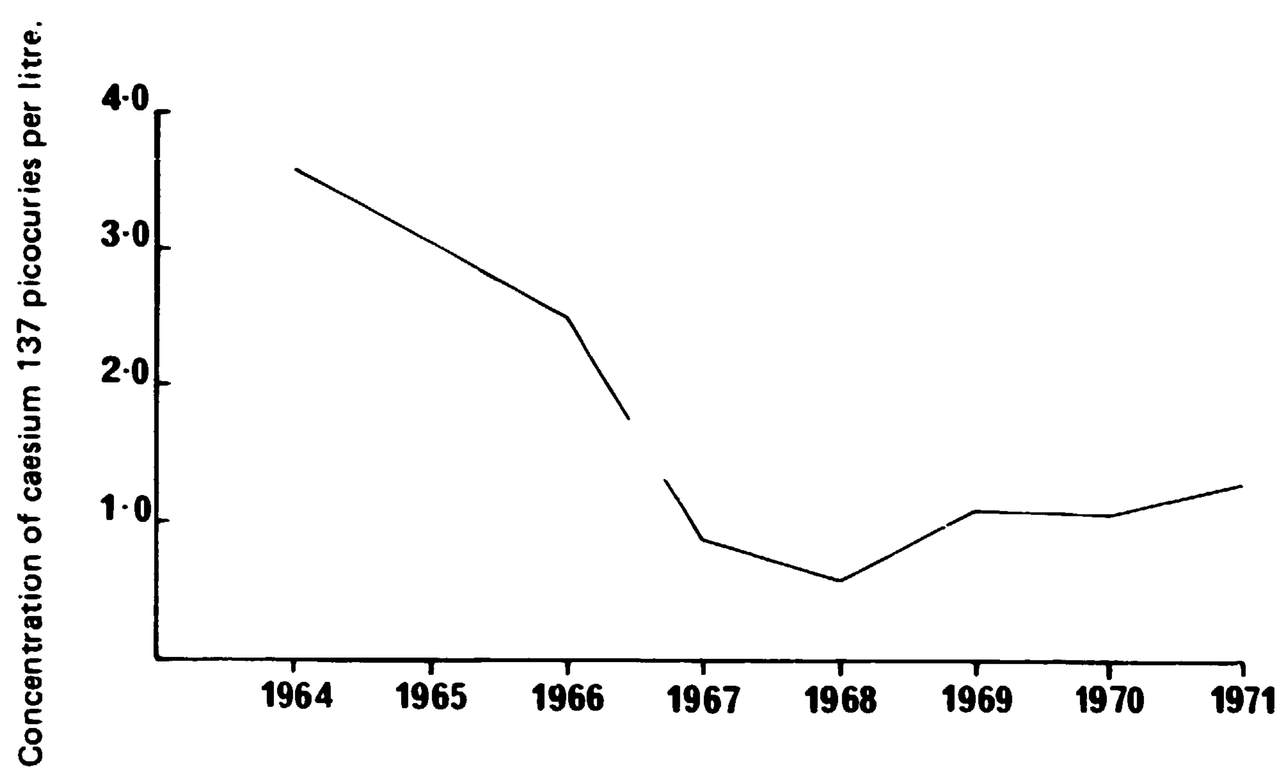
Strontium 90 in precipitation in Australia. Results of measurements of strontium 90 in monthly precipitation samples, June 1958 to December 1971, are given as the histograms. The curves present the total accumulation of strontium 90 in precipitation. The full lines correspond to the period of the measurements. The cumulative deposits of strontium 90 prior to June 1958 have been estimated (Gibbs et al., 1965); these extrapolations are represented by the broken lines. Ordinate axes are marked in units of 1.0 millicuries per square kilometre for the cumulative deposit curves, and 0.1 millicuries per square kilometre for the histograms.

FIGURE 3



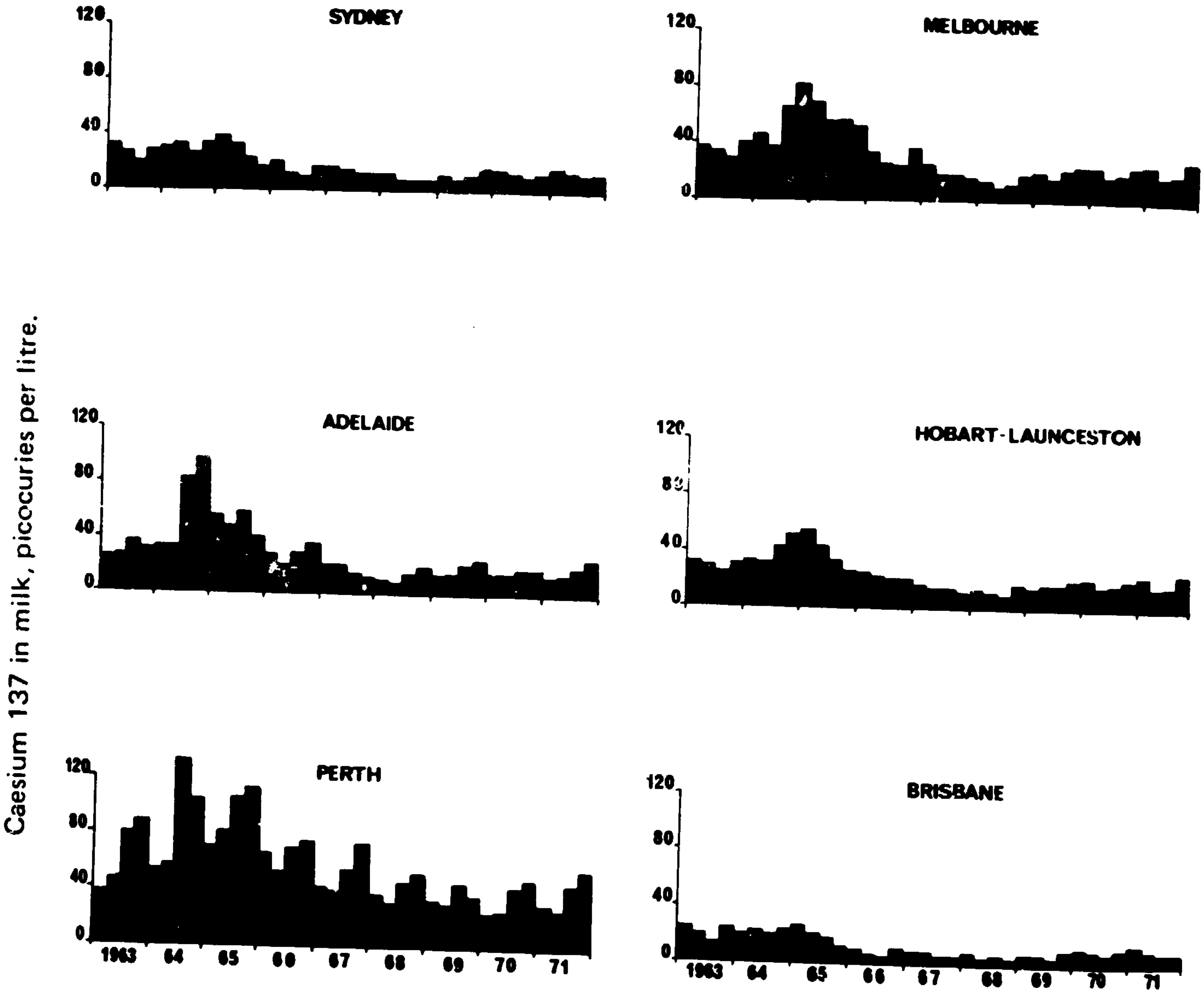
Average monthly deposition of caesium 137 in precipitation for each quarter during the period 1964 to 1971.

FIGURE 4



Average annual concentration of caesium 137 in precipitation in Australia during the period 1964 to 1971.

FIGURE 5



Quarterly averages of the concentration of caesium 137 in whole milk in Australia during the period 1963 to 1971.