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SUMMARY OF PERSONNEL MONITORING (BIOASSAY) OF PEOPLE LIVING AT BIKINI ATOLL 1969 - 1975

[Note: The bioassay data in the handout at the September (1975) Department of Interior meeting on the Bikini people has been updated in this report to include the recently completed 1975 urine data. It should be noted that in the summary table of urine analyses (Table 4 of the original handout) plutonium data have been omitted since Mr. Edward Hardy at the ERDA Health and Safety Laboratory (who did the analyses) advises that because of the large error in counting plutonium at near background levels, the results should not have been averaged. However, the individual urine plutonium data are now reported separately (Table 7)].

In 1969 a group of about 30 Marshallese people settled in a work camp on Enue Island at Bikini Atoll to carry out the rehabilitation program. Many of the group commuted to Bikini Island about 7 miles away where they worked during the day. By early 1972 three Bikini families (about 50 people) plus 20-30 workmen moved to Bikini Island and lived on the southern end of the Island in frame buildings remaining from the earlier weapon testing program. The three Bikini families later moved into several of the completed concrete houses in the southern sector near the lagoon. The size of the population living on Bikini has not changed much as of 1975.

Radiological monitoring of personnel on Bikini Atoll has been done annually by the Brookhaven National Laboratory (BNL) medical team as specified by the 1968 Ad Hoc Committee recommendation. The monitoring procedures are not medical examinations and were performed by experts

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from BNL accompanying the team. Medical examinations have not been done, since they were not indicated in view of the low levels of radiation to which the people are exposed. However, when physicians from the BNL medical team are at Bikini they have, for humanitarian reasons, examined and treated many individuals at the request of the individuals or health aide. No health problem or sickness has been noted which could be related to radiation exposure. The results of bioassay procedures have been most important in forming a basis for reassurance of the people living at Bikini regarding their radiological safety.

In order to assess the radiological hazard the following bioassay procedures have been carried out:

1. Radiochemical analyses on urine samples: (individual 24 hour and pooled samples). These analyses require sophisticated chemical procedures and are performed by the ERDA Health and Safety Laboratory in New York City. Such radiochemical analyses have also been carried out on water and indigenous food products. Analyses were made for ^{90}Sr, ^{137}Cs and Pu. On one occasion nasal swabs taken on Bikini workmen were taken to the U.S. to be analyzed for Pu.

2. Direct measurement of radiation in the people by gamma spectrographic analysis: To perform this analysis tons of radiation-free lead bricks were shipped to the Marshalls and a shielded counting facility set up in one of our air-conditioned trailers and transported to Bikini on our vessel (LCU-Liktanur). The measurement of body radiation by such analysis is very sensitive and requires complex electronic equipment and scientific personnel from BNL who are experts in this technique.

3. Personnel exposure to gamma radiation: Gamma levels on the island were derived from data furnished by radiological survey groups from the University of Washington, Lawrence Livermore Laboratory (University of California), BNL etc.

RESULTS

Urine analyses for ^{90}Sr and ^{137}Cs for personnel living at Bikini Rongelap and Utirik for 1970-1975 are summarized in Table I and individual data are presented in Table 6. The average ^{90}Sr levels over the past 5 years in the Bikini people, based on radiochemical urine analyses, were about the same as the people living on Rongelap. The average urinary ^{137}Cs level was about 1/2 to 1/3 that of the Rongelap group over the same period. Gamma spectrographic data from whole body counting on several Marshall Island groups are summarized in Table 2 and individual data for the Bikini people, whole body counted in 1974, are presented in Table 8. Based on this direct counting technique ^{137}Cs levels of the Bikini inhabitants were about 1/4 the levels of the Rongelap people (also counted at that time). These values are well below the maximum permissible levels as stated by the ICRP*. The graphs in figures 1 and 2 show that the estimated body burdens of ^{90}Sr (derived indirectly from urine) and the ^{137}Cs (by whole body counting) for the Bikini people are well below the peak values noted in the Rongelap people. The latter group had reached a peak of 6-11% of the maximum permissible ^{90}Sr level (for general populations) in 1961-1965 and about 22% of the

* Report of Committee II on Permissible Dose for Internal Radiation (1959). International Commission on Radiological Protection.

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^{137}Cs level in about 1965. These low levels of internally absorbed radionuclides in the Bikini people are in accord with the fact that they have been subsisting mainly on imported foods.

Analyses for plutonium 239, and 240 were carried out also on many of the urine samples. No statistically significant levels of plutonium were measured (Table 7). In 1971 nasal swabs from 10 men working on Bikini (2 samples each, one from each naris) were found to have no measureable plutonium.

The total estimated bone marrow doses (the critical organ for somatic radiation effects) from all radiation sources for people living at Bikini, Rongelap, Utirik, Long Island, New York and Denver, Colorado are shown in (Table 3). Since the people living at Denver have a considerably higher natural radiation contribution (due to cosmic radiation) their mean exposure is substantially higher than the people living on Bikini. The mean estimated dose to people on Long Island is about half that of the people of Denver. It might be noted that many thousands of people living in areas of South American and India are exposed to much higher levels than indicated for Bikini due to the naturally high thorium content of the soil*. There have been no reports of increased cancer or other ill effects in Denver or these other populations that might be related to their increased radiation exposure.

Table 4 shows results of analyses of water samples from Bikini. Based on these findings the well water is in the permissible range of intake for each radionuclide as stated in ICRP Publication 2 (ref. pg. 3). Catchment

* Eisenbud, M. International Symposium on Areas of High Natural Radioactivity. Summary Report, Pocos de Coldas, Brazil, 1975.

(rain) water is very low in activity. Consumption of marine life offers no radiation problem. Coconut crabs (see Table 5) appear to contain high enough levels of activity to be banned from the diet. They are quite scarce in any event and represent a minor portion of their diet. Further analyses of indigenous foods (pigs, chickens, vegetables, etc.) have not been completed. However, the estimated body burdens of radionuclides resulting from the present consumption of these available local foods and including possibly some well water have been below the ICRP limits.

Table 1

RADIOCHEMICAL ANALYSES OF URINE (DATA IN AVERAGE pCi/liter)*

Year	No. in group	Av. vol. ml	Av. Ca, mg/liter	^{90}Sr	^{137}Cs
Rongelap					
1970	20	895	152	3.5	2700
1971	15	534	336	3.7	2400
1972	18	460	120	2.4	2600
1973	11	249	247	6.5	4600
1974	14	557	706	2.8	4500
1975	14	753		4.6	2100
				$\bar{X}$ 3.9	$\bar{X}$ 3150
Utirik					
1974	11	542	734	1.3	1300
Bikini					
1970	Pooled		120	1.2	1150
	Urine G	1100		2.2	
	Urine M	930		1.9	
	HASL* control	3000	160	1.0	120
	HASL control	1000		1.6	
1971	Pooled	2670	84	1.7	1830
1972	Pooled	2700	204	4.2	0910
1973	13	304	173	6.7	1300
1974	8	165	350	2.3	1300
(Spring)	10	649			
1975	8	360		7.3	1800
(April)					
				$\bar{X}$ 3.9	$\bar{X}$ 1382

*Analytical error terms associated with ^{90}Sr and ^{137}Cs analyses were usually less than 10 percent.

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TABLE 2

Mean Cesium-137 Levels Obtained by Whole Body Counting - 1974

	Male			Female		
	No.	nCi	nCi/kg body wt.*	No.	nCi	nCi/kg body wt.*
Bikini	8	128	1.84 (0.43-5.11)	13	73	1.15 (0.22-3.26)
Utirik	9	262	4.05 (2.64-6.84)	13	133	2.13 (0.96-3.85)
Rongelap	22	475	7.76 (4.37-16.3)	24	304	5.13 (2.71-13.46)
BNL med. team	4	2.93	0.0352(0.0134-.0791)			

* MPC 43 nCi/kg

TABLE 3

Estimated Dose to Bone Marrow (mrem/yr)*

					USA	
SOURCE	BIKINI	ENUE	RONGELAP	UTIRIK	DENVER	LONG ISLAND
Natural	80	80	80	80	325	190
Medical Dental	0	0	10	10	70	70
Contamination Gamma	165	7	20	7		
Internal	21	21	68	31		
TOTAL	266	108	178	128	395	260

* Dose on Marshall Islands based on personnel and environmental data.

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TABLE 4

Radiochemical Analyses of Well Water From Bikini (Data in pCi/liter)

YEAR	SAMPLE	Vol.,ml	^{90}Sr *	^{137}Cs **	^{3}H	$^{239,240}Pu$ ***
1971	"good well"	1830	6.0 ± 17%	600 ± 1%	770 ± 40%	0.04 ± 25%
	"bad well"	1830	25 ± 3%	850 ± 1%	1040 ± 30%	0.05 ± 20%
	"good well"(closed)	1810	103 ± 2%	1044 ± 1%		0.058 ± 15%
	"good well"(opened)	1980	125 ± 3%	818 ± 1%		5.76 ± 6%
	drinking water (camp area)	3580	0.46± 4%	1.53± 8%		0.004 ±100%
1972	well water	1000	15.4 ± 9%	800 ± 1%		
	drinking water	1960	0.61± 6%	1.8 ± 8%		
1973	new well	60	52	600		0.38 ± 40%
	B-1 well	225	11	724		0.08 ± 50%

* MPC 4×10^{3} pCi/l
** MPC 2×10^{5} " "
*** MPC 3×10^{5} " "

TABLE 5

Radiochemical Analyses of Coconut Crabs From Bikini (Data in pCi wet weight)

Year	Wet wt.,g	% Ash	g Ca per kg wet wt.	^{90}Sr	^{137}Cs	^{238}Pu	^{239}Pu
1970	1164	23.3	81	23,300	11,800	0.06 ± 50%	1.5 ± 10%
	1930	18.5	61	24,800	14,800	0.001 ±100%	0.07 ± 37%
1971	1812	17.8	60	132,000	11,400		
	1827	21.5	72	412,000	8,600		
1973	1190		63.5	45,700	9,290		
				$\bar{X}$= 123,360	11,178		

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Table 6

Individual ^{90}Se and ^{137}Cs levels in urine of Bikini people 1970-1975

(Radiochemical Analyses Done By ERDA Health and Safety Laboratory, New York, N.Y.)

Year	Sample	Vol.(ml)*	mg Ca/l	pCi ^{90}Sr/l**	nCi ^{137}Cs/l**
1970	Pooled	3640	120	1.2	0.10
	"	3365	120	1.3	0.13
	G	1100		2.2 ± 11%	
	M	930		1.9 ± 13%	
	HASL Control	3000	160	1.0	0.012
	"	1000		1.6 ± 14%	
1971	Pooled	3920	54	0.96 ± 4%	0.217 ± 1%
	"	2960	74	0.89 ±13%	0.194 ± 1%
	"	3300	110	1.22 ± 2%	0.211 ± 1%
	"	500	100	3.9	0.110
1972	Pooled	2700	204	4.2 ± 7%	0.910 ± 1%
1973		260	120	8.9	2.1
		280	100	5.7	1.1
		250	240	5.5	2.6
		150	230	6.2	0.9
		115	360	11.6	2.1
		350	80	4.8	1.2
		485	120	2.2	0.6
	Distad Rep.family	300	210	5.6	1.5
		380	300	5.4	0.5
		460	79	2.0	0.4
		220	130	18.9	1.3
		410	100	1.9	0.4
		390	200	7.8	2.0
1974 (Spring)		275			
		220			
		350	For Pu Analysis		
		370			
		350			
		1050			

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Table 6 (Continued)

Year	Sample	Vol. (ml)*	mg Ca/l	pCi ^{90}Sr/l**	nCi ^{137}Cs/l**
1974 (Spring)		1380			
		1230			
		780	For Pu Analysis		
		490			
		155	290	1.2	1.0
		105	440	3.0	0.6
		140	220	2.4	0.8
		200	360	3.2	1.7
		160	320	4.6	1.2
		300	380	3.8	3.2
		150	490	≤ 0.1	0.5
		110	290	≤ 0.2	1.5
1975 (April)		350		2.6	0.8
		240		7.8	3.0
		430		12.0	2.1
		270		4.7	1.9
		270		6.6	1.5
		105		4.5	2.1
		830		2.4	0.4
		390		18.0	3.0

* Volumes less than 600 ml are almost certainly incomplete collections. Extrapolated values for small samples may be falsely higher due to exaggeration of background counting error.

** Analytical error terms associated with ^{90}Sr and ^{137}Cs analyses were usually less than 10 percent.

TABLE 7

ANALYSIS FOR PLUTONIUM ON BIKINI URINE SAMPLES (pCi/l)

YEAR	SAMPLE	VOL (ml) *	$^{239-240}Pu$ **
1970		1100	0.013 ± 100%
		930	0.015 ± "
	HASL Control	1000	0.014 "
	" "	3000	0.003 "
1971	Pooled	3920	0.004 "
	"	2960	0.004 "
	"	3300	0.004 "
1974		275	0.02 "
		220	0.06 "
		350	0.01 "
		370	0.01 "
		350	0.01 "
		1050	0.01 ± " ***
		1380	0.02 ± "
		1230	0.004 "
		780	0.01 ± " ***
		490	0.009 ± "
		350	0.02 "
1975 (April)		240	0.04 "
		430	0.02 "
		270	0.03 "
		270	0.03 "
		1050	0.08 "
		830	0.02 "
		390	0.02 "

* Volumes less than 600 ml are almost certainly incomplete collections. Extrapolated values for small samples may be falsely higher due to exaggeration of background counting error

** The error in the measurement of the plutonium samples was ± 100% which means that no statistically significant levels could be found.

*** An earlier count on these samples reported an error of ± 40 & ±60%. However, a recoun of these samples at a later date showed the error was ± 100%.

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TABLE 8

GAMMA SPECTROGRAPHIC DATA - 1974

BIKINI - MALES

NAME	Time on Bikini (mon)	Age	Wt.(kg)	Ht.(cm)	Potassium (g)	^{137}Cesium (nCi)	nCi/kg Body Wt.
	60	42	77	158	170	168	2.18
	60	49	67	168	149	71	1.06
	48	30	59	167	158	103	1.73
	48	30	75	165	156	124	1.65
	36	25	82	168	169	93	1.13
	24	47	78	165	172	402	5.11
	24	43	56	161	140	55	0.98
	24	31	78	170	(197)	222	(2.82)
	24	60	83	162	142	77	0.93
	24	39	63	166	160	122	1.92
	26	30	60	155	129	80	1.33
	24	55	76	161	165	50	0.66
	14	22	70	161	147	94	1.35
	9	17	50	165	125	77	1.55
	8	44	60	157	133	155	2.59
	6*	49	85	165	162	290	3.40
	4	16	70	172	168	75	1.08
	13	54	100	170	158	42	0.43
						128	1.84 (.43 - 5.11)

* From Rongelap

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TABLE 8 (cont'd)

GAMMA SPECTROGRAPHIC DATA - 1974

BIKINI - FEMALES

NAME	Time on Bikini (mon)	Age	Wt.(kg)	Ht.(cm)	Potassium (g)	^{137}Cesium (nCi)	nCi/kg Body Wt
	60	54	54	149	88	30	0.55
	36	23	96	155	124	73	0.76
	36	29	64	151	110	108	1.68
	36	15	46	146	85	36	0.78
	24	45	70	149	101	116	1.65
	24	27	57	142	106	25	0.44
	24	28	46	145	85	92	1.96
	18	44	50	146	94	58	1.16
	12	13	49	145	106	77	1.74
	7	31	77	149	91	252	3.26
	4	45	82	150	59	18	0.22
	4	60	73	152	93	33	0.44
	4	20	62	156	94	29	0.47
					95	73	1.15

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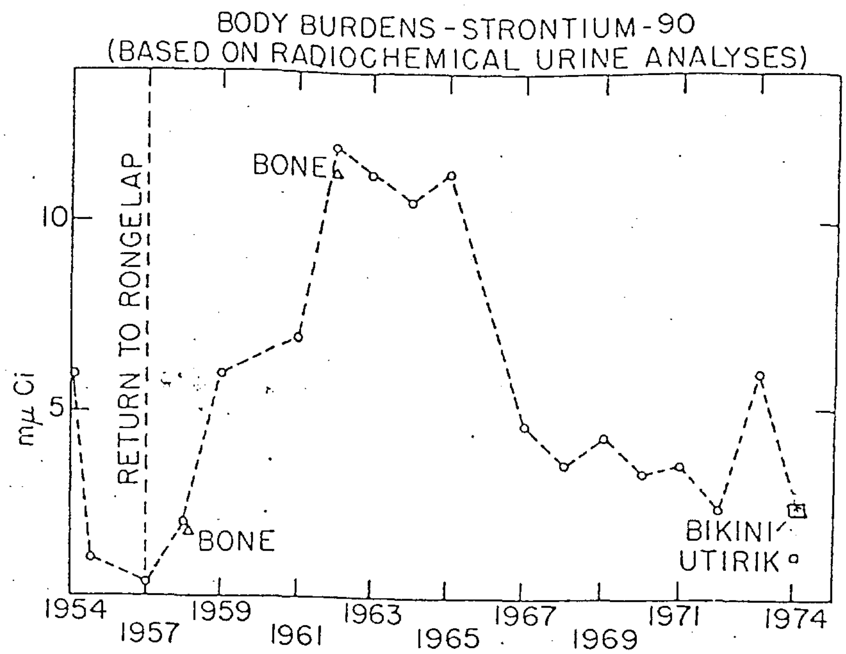

Fig. 1

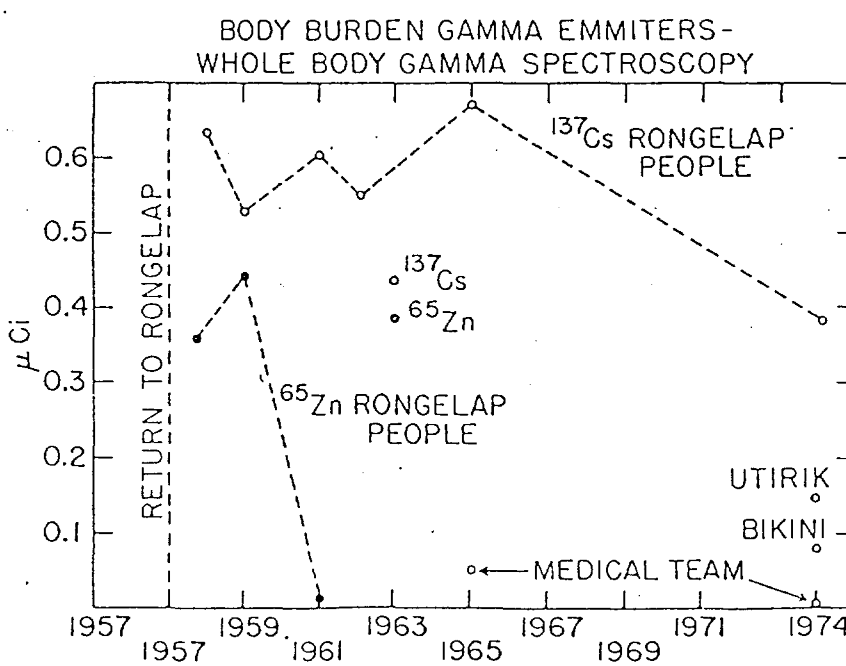

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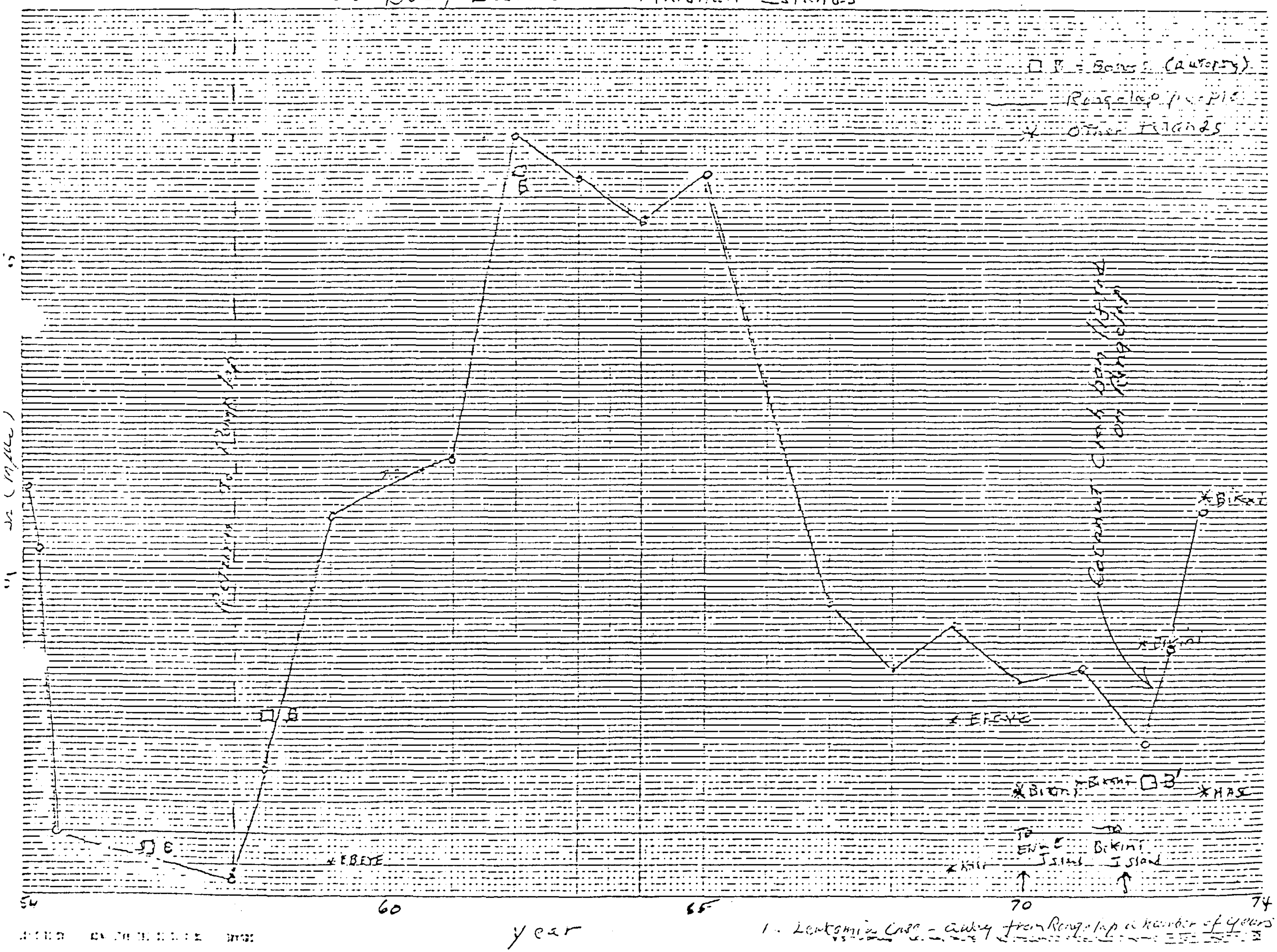
Fig. 2

Sr Body BURDENS - Marshall Islands



1. Leukemia case - away from Rongelap a number of years.

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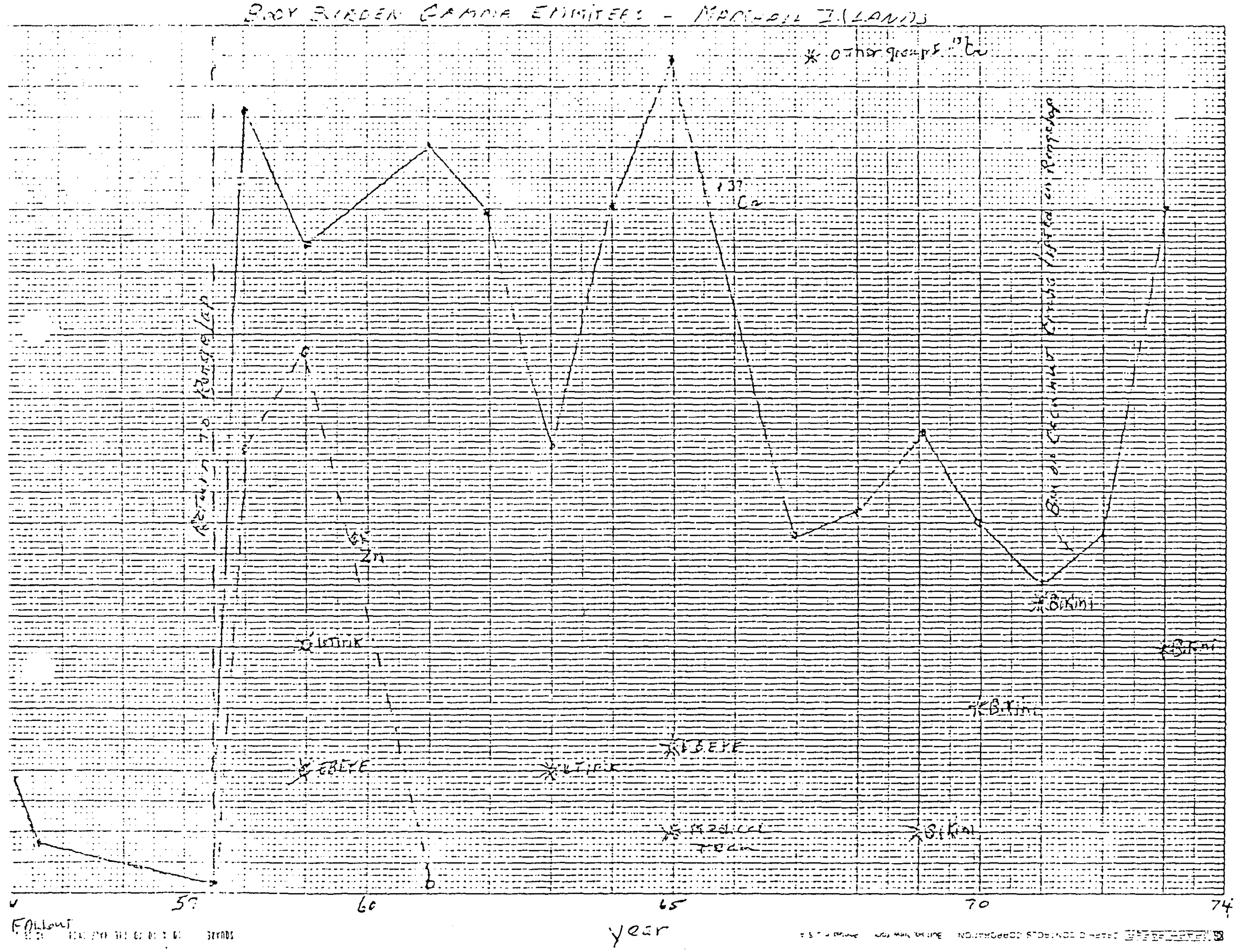

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