78

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AUTHORITY: DOE/SA-20

BY MARA SCHOLDT, DATE: 6-16-94 D.R. GILSON ARK.

Frank Cluff, Safety Mylecry Group, W

### MIKIMI EXPOSERE CALCULATIONS

Following our discussions on the plane and in Ecoclulu I agreed to make a quick check of the predictions of exposures that may be associated with the diet on Mkini. Sustafoon's enlewlations which develops the long-range exposure potential for the Dikinians, begin to produce the key results when he sums the contribution of various items of the diet for several important radiomyclides and makes comparisons with standards for the individual and for the seneral public. See Table VI of his May 1968 report.

In Attachment 1 I have gone through a portion of this exercise for 137Cs, with which I am more familiar, and then with 90Rr and 55Rs. As you will see, the values shock with Gustafson's permissible intake numbers for 1370s and for 90kr (depending on the saleium intake) but I get a much higher allowable daily intake for 55Fe. Also I obtained a somewhat lower 5 year 157Cs dose for adults, 230 mred versus 536 mrad, and about the same 5 year 1370s dose for the worst case for children, 276 med versus 268 med.

There is one additional summary report that was an appendix to the material going to the Commission that you may not have seen. See Attachment 2. You will find that Table 3 of this appendix is similar to Table VI except certain items have been emitted from the table much as Pandamus and grabs. This makes a significant reduction in the 90m and 137Cs levels in the diet but changes the 55Fe intake not at all. This is why I had more econoura for 55 Fe predictions. since I could see no vey of reducing that exposure short of placing restrictions on intake of fish.

The sample computations in the Attachment for 137Cs and 55Pe indicate that Gustafson's predicted five year total whole body dose mamber may be a little high. For example, the 5 year contribution to whole body dose from 55% of 27 mild White 1830 mind from 1370s plus 750 med external is about 1 red instead of 1.4 red as in Table VIII. As to the spleen dose of 30 med/yr from 55Fe, I'll say more later.

Bed LEB A bill pandamis will be out of There is one additional conside the dist when the natives first return since the surveys have indicated no edible variety of this Mach is symilable much less a sufficient quantity of the edible type to meet meeds of the returning matives.

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The Ad Boe Committee has recommended certain presentions in planting pendamus, namely removal of contaminated soil from the area of the plants, which should significantly reduce the radiomulide content of the fruit. However, there must be follows studies when these locally produced foods do become available since the levels will not be zero.

As to dose to children, I have taken what may be a worst case situation for 137Cs to see how the dose compares with the value for adults. I have used as a reference, "The Half-Time of Cosium-137 in Man" (Attachment 3) and have considered the improbable case where the daily "37Cs intake of the 2 year old is as high as for the adult. The resultant 5 year dose of 276 mrad for the child is not significantly different from the 230 mrad 5 year dose obtained for adults. I did not correct the child's 5 year dose for changes in biological half-time or body weight that occur over that period since the curve in Figure 4 of the cesium reference indicates that for a given intake the dose rate does not change much over this range of ages. Using this worst case assumption, I get a total 5 year dose (external plus internal) of about 1 rad for the child which agrees with the value in Table VIII.

One comment on the general subject of whole body and organ dose determinations (such as spleen) and ecoperisons with standards for small groups such as this Bikini population. The proper standard for use as a comparison is the value for the <u>individual</u> in the Bikini population. The followup studies by Comment and others will establish a basis for determining the range of individual exposures so that there should not be any surprises. Thus Gustafson's "Acceptable Entake for Individuals" in Table VI is the proper column for comparison with diet levels and the dose standard for comparison purposes for whole body, blood forming organs, etc. would be 500 mrad per year.

While I don't expect we will learn anything during the eleanup operations that will change dustafoon's predictions regarding external exposures, it may be worthwhile to again review the internal exposure question at the end of eleanup operation, particularly if additional samples of items of the diet are taken and analyzed and base-line body burden data become available. I recommend that review of such data be a consideration in the ABC determination that the cleanup project is completed and that the stell is ready for return of the population.

The conclusion to be drawn from this exercise and from working with available data is that the estimates of internal exposures I have made are not significantly different from Dr. Gustafson's. If anything,



7238/3108/PO252



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-3-

his estimates are elightly higher than my own. Additionally, it is highly desirable to obtain more information on the levels of radio-activity in foods through the radiological support activities for the eleanup project just starting at Bikimi. Also, base-line determinations of internal emitters and determinations of biological half-times must be made in order to confirm the estimates of future long term exposures for the returning Bikimi people.

Original shorts by

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## Attachment 1

Daily Radionuclide Intake Associated With The Maximum Permissible Body Burden\*

permissible burden, occupational exposure, 30 μCi (5 rad/yr) individuals in pop., 3 μCi (.5 rad/yr) suitable semple, 1 μCi (.17 rad/yr)

Electic half-life is 100 days (See FRC Report No. 7, page 25).

For conditions of continuous intake, the daily intake associated with a viven equilibrium organ burden can be determined from the following:

where  $B_E = Equilibrium$  organ burden

R = Daily intake

 $T_m$  = Mean time in reference organ

= 1.44 x Teff

I = Fraction of intake reaching reference organ through ingestion

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BY H.R. SCHMIDT, DATE: 6-16-94

D.R. GILSON

\*References are, (1) Report of ICRP Committee II as published in Health Physics, June 1960, and (2) AEC 0524, June 1967.

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$$R_0 = B_E / 1.44 \times T_{eff} \times 1$$

- = 1,000 nCi/1.44 x 100 days
- = 6.9 nCi/or about 7,000 pCi/day

This agrees with Gustafson's value in Table VI

50<sub>Sr</sub>

The value for comparison in Table VI' can be obtained from FRC Report No.2, the lc. The value 200 pCi/day comes from an arbitrary reduction by a first of three (see para 4.24, page 17) of the value 600 pCi/day that is retually equivalent to the RFG. It is assumed, however, that there is the gram of calcium intake per day which, short of some dietary supplement, the Bikinians don't have. With a calcium intake of 0.42 grams per day, the guides would be about 250 and 750 pCi/day. The Ad Hoc Committee has recommended adding calcium to the Bikini diet.

# 55**Fe**

Max. permissible whole body burden, occupational exposure,  $3 \times 10^3 \mu Ci$  " " individual in pop.,  $5 \times 10^2 \mu Ci$  " " suitable sample,  $1 \times 10^2 \mu Ci$ 

Effective half-life is 463 days. Fraction reaching organ is 0.1

#### Therefore:

$$R_0 = 1 \times 10^5 \text{ nCi/1.44} \times 463 \text{ days} \times 0.1$$
  
=  $1 \times 10^5/66.7$   
=  $1.5 \times 10^3 \text{ nCi/day}$ 

= 1.5 x 10<sup>6</sup> pCi/day

This differs considerably from Gustafson's 87,000 pCi/day.



-3-

The IGP reference lists spleen rather than whole body as the critical organ. Gustafson probably used whole body so that the doses would be addition.

For spleen, the following is obtained:

AEC Manual Chapter 0524 which treats the case for the critical organ gives an uncontrolled area MPC for  $^{55}$ Fe for water of 8 x 10 $^{-4}$  µCi/ml (for individuals). The value for the general public would be  $\frac{3}{3}$  x 10 $^{-4}$  µCi/ml. Assuming an intake on a per day basis we have:

$$\frac{8}{3}$$
 x 10<sup>-4</sup>  $\mu$ Ci/ml x 1,200 ml/day = .3  $\mu$ Ci/day = 3 x 10<sup>5</sup> pCi/day

Thus, even for the spleen, the dietary value of 59,500 pCi/day in Table VI: is only about 1/5 of the MPC.

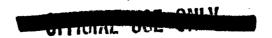
# 137Cs dose (adults)

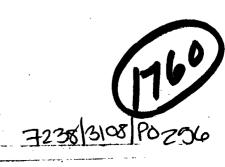
At equilibrium the initial body burden would be:

$$B_E = 2,290 \text{ pCi/day x 1.44 x 100 days x 1}$$
  
= 330 nCi

Initial dose rate would be:

This is about one half of the Table VII' five year dose for 137Cs.





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# 55 Fe dose to whole body\*

Dose = 
$$\frac{0.06 \, \mu\text{Ci/day} \times 0.5 \, \text{rad/yr}}{2.4 \cdot \mu\text{Ci/day}}$$

= 0.01 rad/yr

Dose = 
$$.01$$
  
5 yr  $.693/3$  1 - e  $-.693 \times 5$ 

= .027 rad

This is about one fifth of the Table VII' five year dose for 55Fe.

## 55 Fe dose to spleen\*\*

Dose = 
$$0.06 \, \mu \text{Ci/day} \times 0.5 \, \text{rad/yr}$$
  
.96  $\mu \text{Ci/day}$ 

= 0.03 rad/yr

# 137Cs dose (child)

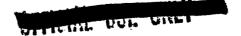
The diet of the young child, 1 to 2 years of age, will be different irom that of adults, but if the intake were as high as 2,290 pCi/day, the following body burden would be obtained:

$$B = 0.018 R (x^{1/2} + e^{-x})$$
 (See equation 9, the Half-Time of Cesium-137 in Man)

= 
$$0.018 \times 2,290 \left(2^{1/2} + e^{-2}\right)$$

= 61.4 nCi

\* MPC taken from ICRP Committee II
\*\* MPC taken from AEC 0524





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-5-

The whole body dose would be:

$$D_{2} = B/W = 85.7$$

(See equation 5, The Half-Time of Cesium-137 in Man)

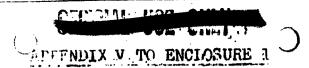
- $= \frac{61.4/12}{85.7}$
- = .06 rad/yr

Thus the 5 year dose would be about 276 mrad which is not significantly greater than the dose to the adults from  $^{137}\text{Cs}$ .





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Brief Summary of the Radiotogical Status of the Bikini Atoll

Pages 32 thm 38 only confirmed to be unclassified

Philip F. Gustafson Fallout Studies Branch Division of Biology and Medicine

BY HE SCHMIDT, DATE: 6-16-94

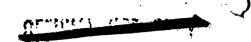
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A number of radiological surveys of Bikini Atoll have been made since 1946. The most recent survey was conducted in April and May 1967. The main effort was devoted to the measurement of ambient radiation levels using several types of detectors. The external radiation field was mapped in considerable detail on Bikini and Eneu Islands, and less thoroughly on the remainder of the atoll. The various radionuclides and their concentrations which have rise to the observed radiation field were determined from field gamma-ray spectrometry. Representative samples of local plants and animals which might be eaten by the returning natives were collected and have been analyzed for radioactivity.

The results of the 1967 survey provide a basis for making reasonable estimates of the total (external plus internal) radiation exposure which the Bikinians might receive over the coming years, if they return to the atol. Background radiation on the atoll is due almost exclusively to cosmic radiation, and there are only trace amounts of the naturally occurring radioelements in the area. Except in the immediate vicinity of nuclear detonations, the composition of the residual gamma-ray radioactivity was similar throughout the atoll, consisting of about 70% 137Cs, 20% 60Co, and 10% 125Sb. Variations in intensity were observed from place to place; Eneu was the least contaminated, followed by Bikini Island itself. A dose gradient existed across Bikini, with lowest levels on the beach area and highest values in the heavily overgrown interior.

32-

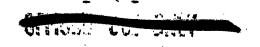
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The external dose received by the returned Bikinians will depend upon where various people are located, and for what periods of time, within the island complex. Location in turn depends upon whether they are men, women, a. children. The returnees (see Age Distribution table) will probably consist of about equal numbers of men and women. The amount of time likely to be spent in the four radiation domains (village area, beach, interior, and lag on) by the various groups within the population are shown in Table 1 choosibly the most time will be spent in the village area, where the dose rate intermediate between beach and interior levels. The dose rate may be duced one half by covering the ground with an inch of clean sand or soil has in essence will be done in the village area through the custom of covering the dirt floor and the yard with several inches of polished coral pabbles. The expected integral dose to the population over various time intervals starting in 1970 is shown in Table 2.

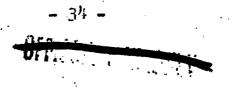
The actual internal dose derived from eating native foods is somewhat more difficult to assess. However, three points should be borne in mind.

As in the past, the natives will doubtless take much of their sustantine from the lagoon and ocean. (2) Edible land plants will be section fruited, at least at first, due to the sparcity of fruit-bearing occonditional mandanus, etc. (3) The Bikinians have become accustomed to eating new modes, and will probably continue to eat such things as rice, flour, canned meat, and powdered milk. The only radionuclides of biological importance found in roodstuffs collected at Bikini were 90Sr, 137Cs and 55Fe. Other



medical species were either lacking or present in very low concentration. A notion of the possible daily intake of the above three radionuclides may be obtained by taking the diet caten by the Rongelapese as a guide, and using the observed concentrations of radioactivity in the same food items collected on Bikini. The resultant daily intakes are shown in Table 3, and are compared with the daily intakes which will lead to acceptable body burdens for individuals and a suitable sample of the population. Special procedures which will greatly reduce the <sup>90</sup>Sr content of the fruit can be undertaken at planting when edible pandanus is re-introduced to the Atoll. Edible fruit would be available about five years after planting. The fact that edible pandanus fruit will not be available for several years removes what wight have been the major source of <sup>90</sup>Sr intake and materially reduces the <sup>157</sup>Cs intake as well. Removal also of land crab meat from the diet seems advisable, and such restrictions bring the <sup>90</sup>Sr intake down to 115 pCi/day or 270 pCi/g Ca. The corresponding <sup>137</sup>Cs intake is 2290 pCi/day.

Doses to the whole body from <sup>137</sup>Cs and <sup>55</sup>Fe were calculated assuming that the reduction of radioactivity in the diet occurs only from radioactive decay. Coses to bone from <sup>90</sup>Sr were also computed. Because of marked differences in metabolism, adults and children were considered separately for internal dose purposes. The total doses to whole body and to bone for children and adults from internal and external radiation over 5-, 30- and 70-year intervals starting in 1970 are indicated in Table 4. The doses acceptable for individuals and for a suitable sample of the population during the same time intervals are also indicated.



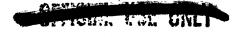
Appendix 60 Enclosure 1

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The estimated  $^{90}$ Sr dose to bone is maximal because additions of calcium to the dict could readily reduce  $^{90}$ Sr uptake.

'It appears unlikely that, with moderate restrictions on living and eating nabits, the dose to the whole body or to bone will reach 2 rads in 5 years, 10 rads in 30 years or 16 rads in 70 years.





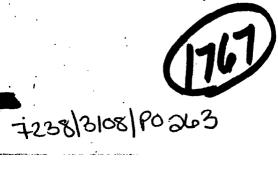


TAPLE 1 Population and Time Breakdowns

Pepulation		Breakdown (%)		Estimated Time Breakdown (4)				
		•		.i/	Village	Beach	Interior	Lagoon
Children	(0-15	yrs)	56 .		70	20	10	
k men	•		25		65	15	20	**
76.2		<i>:</i>	25.		60	10	20	10

Integral External Doses Starting in 1970

Time Interval	(years)	Integral Dose (mrade)
. 5		752
10)	• •	1391
. 20		2455
30	****	3332
- 50		4711
70		5743



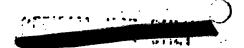


TABLE 3

# Estimated Daily Intake of 90 Sr, 137 Cs, and 55 Fe from Bikini Foods, (pCi/day)

*** Acceptable inc.viduals		1,800 pCi/g	Ca 21,000	200,000
Acceptable intake for sultable sample		600 pCi/g	87,000	
Total**	782**** 	115	2,290	59,500
imports	32	.5	1.0	, ••
Clams	45	1.8	1.0	••
Coconut	9	1.7	.1,030	
Arrowroot*	41			••
Lirds	41	5.3	1,080	4,100
Fish	554	105	178	55,400
Food Item	weight consumed per day (g)	90 <sub>Sr</sub>	137 <sub>Cs</sub>	55 <sub>Fe</sub>

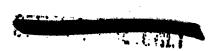
<sup>\* 90</sup> Sr and 137 Cs are removed in the processing of arrowroot to make flour

\*\*\* Calculated in the following way:

Daily intake = 
$$\frac{MPL}{1.44 \times T_{1/2} \text{ (biological)}}$$

where the value of the MPL for individuals is 1/10, and for suitable sample is 1/30 of the value for radiation workers

\*\*\*\*Other foodstuffs, (free from radioisotopic contamination) necessarily will supplement this diet.





This diet contains 0.42 g calcium per day



TABLE 4

Summary of Radiation Exposure (rads)

## Adults

. *		Internal Whole body (137 Cs & Fe)	External Whole Body	Total		Reference Values***	
Years	Bone ( <sup>90</sup> Sr)*			Whole Body	Bone	At .17 rad/year	At .5 rad/year
5	.09	.68	.75	1.43	1.52	.85	2.5
30	1:37	2.68	3.33	6.01	7.38	5.1 .	15.0
70	3.10	4.20	5.74	9.94	13.04	11.9	35.0

## Children

	.98	.41	.75	1.16	2.14	.85	2.5
30	4.06	1.99	3.33	5.32	9.38	5.1	15.0
70	. 16	4.00	5.74	9.74	15.90	11.9	35.0

\* Initial 90 Sr intake of 115 pCi/day or 270 pCi/g Ca by both children and adults.

\*\* Acceptable exposure for individuals is .5rad/year. Acceptable exposure for suitable sample of the population is .17rad/year.

