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SUMMARY REPORT OF THE 1969 AND 1970 BIKINI SURVEYS

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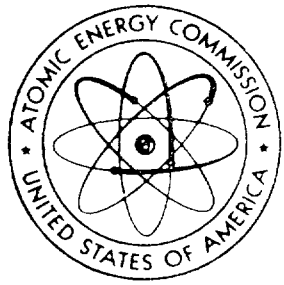

FEBRUARY 1971

UNITED STATES ATOMIC ENERGY COMMISSION
NEVADA OPERATIONS OFFICE
LAS VEGAS, NEVADA

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Resurvey of Animals, Soils and Groundwater at Bikini Atoll, 1969". (These reports should be published by Spring 1971.) This summary also includes results of selected samples from the 1967 survey as reported by P. F. Gustafson in "Radiological Report on Bikini Atoll".

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scarce.

The results of a radiological resurvey of Bikini in 1964 by the University of Washington's Laboratory of Radiation Biology indicated that Bikini might be radiologically safe for permanent habitation. A request from the High Commissioner of the Trust Territories of the Pacific to the Atomic Energy Commission (AEC) in 1966, to rehabilitate Bikini, resulted in an extensive survey of the atoll in the spring of 1967. This survey emphasized external radiation measurements, including in situ gamma-ray spectrometry, although some food items were collected to supplement data from the 1964 survey. The 1967 survey party included personnel from the AEC's Health and Safety Laboratory, the Division of Biology and Medicine (DBM), the U.S. Naval Radiological Defense Laboratory, the Trust Territory, and the University of Washington. The data were summarized by DBM and were presented to a panel of experts (referred to as the Ad Hoc Committee in this report) assembled by DBM for evaluation of potential radiological hazards. Most of the participants in the 1967 survey attended the presentation to provide details not included in the summary.

The Committee concluded that Bikini could be safely reoccupied, but recommended some simple measures that should be instituted to reduce exposure to radiation. These included reduction of the coconut crab population (because they contain high concentrations of ^{90}Sr) and covering the village area at Bikini Island with coral gravel from the beaches. The latter is consistent with local custom. The Committee also recommended that old structures and other such debris from the tests be removed from the islands and beaches and that Bikini Island be further monitored during the clean-up. Additional monitoring was necessary because dense vegetation on Bikini and Eneu Islands, especially, made it impractical to survey more than a few transects across the islands in 1967.

The Committee's recommendations were made to the Chairman of the AEC who informed the Secretary of the Interior, the Administrator for the Trust Territory of the Pacific.

2. CLEAN-UP OF BIKINI ATOLL

The clean-up phase of the rehabilitation of Bikini Atoll, a cooperative effort by AEC and Department of Defense, was begun in February 1969,

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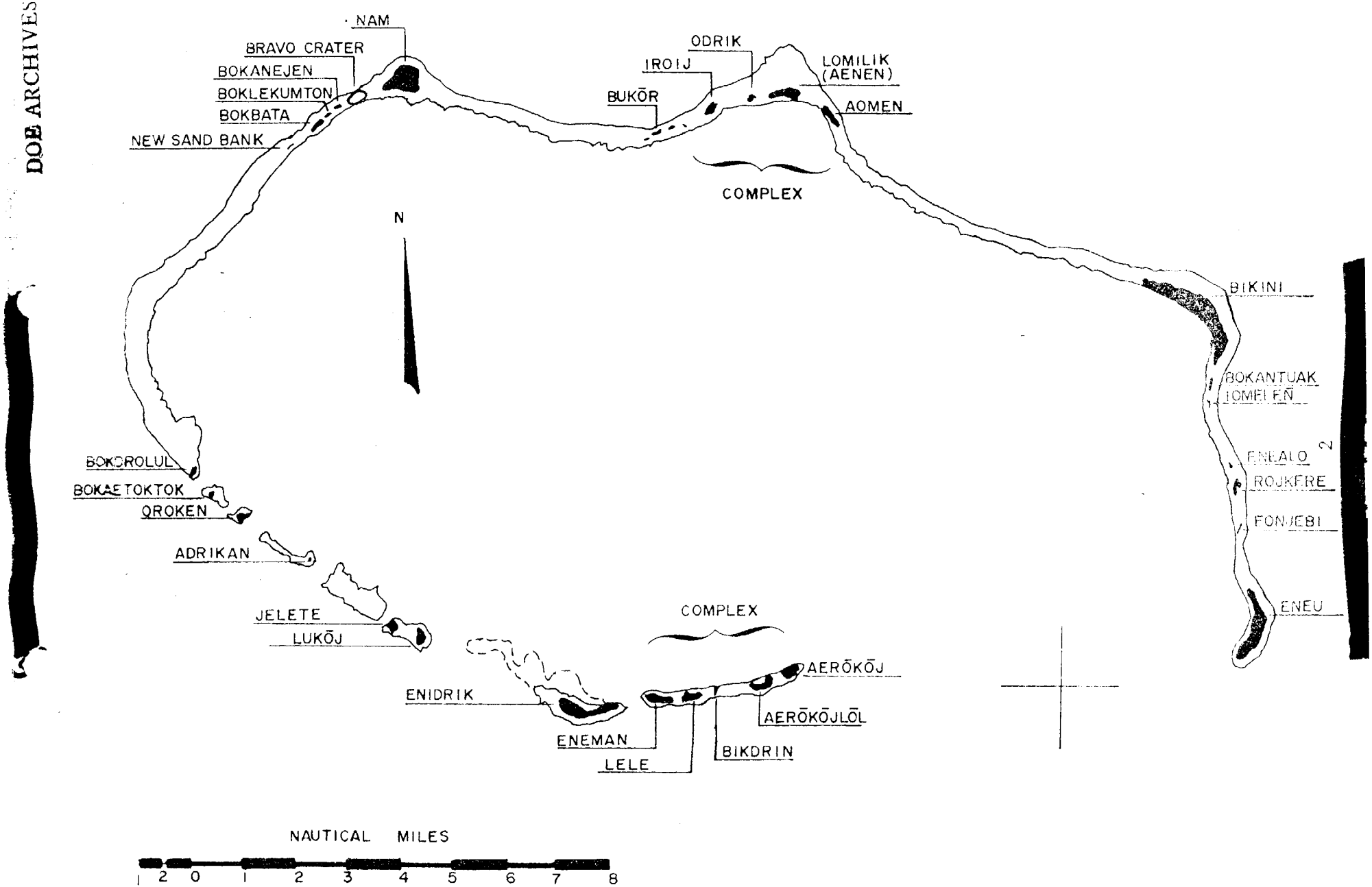

FIGURE 1 BIKINI ATOLL

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complex of islands could be used for continuous occupancy and agricultural development sufficient to support the returning population. Recommended clean-up of these islands require:

1. The removal of all test-related debris with disposal at sea of all radioactive debris.

2. Stripping of the vegetation to permit planting of coconuts, pandanus, breadfruit, etc.

3. Determination of external background radiation levels at each step of the clearing and stripping operations.

4. Obtaining additional samples of available food items for laboratory analysis for comparison with previously collected data.

Although permanent occupancy was to be limited to the islands of Bikini and Eneu, the Ad Hoc Committee further concluded that "radioactive scrap should be removed from the islands adjacent to former shot sites." This removal of radioactive debris would make the scrap unavailable for collection by the natives during food collection trips to these islands.

The final objectives of the clean-up program, therefore, included the elimination of all physical hazards and the disposal of all radioactive scrap from each island of the atoll in addition to the specific measures cited for Bikini and Eneu.

2.2 CRITERIA

Rather than establish firm, restrictive criteria for the removal of radioactive artifacts, or the elimination of high background areas from the islands of the atoll, each situation was viewed in terms of the potential exposure versus benefit. All debris or artifacts having little or no useful value were removed. Scrap metal or concrete with contact gamma readings greater than 100 micro-Roentgen per hour (uR/hr) was treated as radioactive waste and buried at sea. Three specific locations were selected for this burial. In some cases, scrap with contact gamma readings less than 100 uR/hr was buried on land together with nonradioactive debris. This was only done on islands where areas exhibiting background levels in

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present in Cs/Co ratios of approximately 25/1, 50/1, and 30/1 respectively for the three samples, and thus the projected exposure rate decay will very closely approximate the decay of ^{137}Cs. In addition, ^{90}Sr was present in amounts ranging from 10 to 50 percent of the ^{137}Cs concentrations.

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camp for the clean up operation, was found to have external radiation levels considerably lower than Bikini (Figure 3). Although an exposure rate of 50 uR/hr was obtained at one depressed location during the early stages of clean-up, filling of this "borrow pit" area reduced the level to approximately 10 uR/hr. The exposure rate generally ranged from less than 10 to 20 uR/hr.

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FIGURE 2. BIKINI ISLAND-BACKGROUND RADIATION SURVEY RESULTS

FIGURE 3. ENEU ISLAND-BACKGROUND RADIATION SURVEY RESULTS

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from those air samples will be tabulated in the SWRHL/EPA forthcoming report.

Bikini No. 5 and Eneu No. 1 are considered to be background stations since they were located on the windward side of the respective islands, overhanging the beach.

Values for radionuclide concentrations in air were obtained by analyzing one half of the filter for each day composited by the station over the total 14 day sampling period. For Bikini, the ^{239}Pu air concentrations ranged from 0.6×10^{-4} to 5.4×10^{-4} pCi/m^3. All results for Eneu were 0.4×10^{-4} pCi/m^3. For comparison, the average value for ^{239}Pu background in the U.S. during 1968 was 0.4×10^{-4} pCi/m^3 and the maximum permissible concentrations for the general public for $^{239, 240}Pu$ is 2×10^{-2}. The analytical error associated with these results is approximately $\pm$ 25 percent at the 2 sigma confidence level.

In order to assess the variation in air concentration, the remaining half of the daily samples from Bikini No. 1 were analyzed individually. The range was from less than 0.7×10^{-4} to 7.9×10^{-4} pCi/m^3 for ^{239}Pu. The average for all samples at station No. 1 was approximately 4×10^{-4} pCi/m^3 which compares quite favorably with 5.4×10^{-4} pCi/m^3, the highest value for Bikini. Although some variation in daily levels is evident from these data, the distribution of results appear to be about what one might expect. In any event, it is extremely doubtful that significantly higher concentrations would be encountered under any weather conditions expected to occur in that area.

The results for Bikini No. 1 may be somewhat representative of highest levels to be expected when the island is reoccupied since this air sampler was located adjacent to and downwind of the road and was subjected to frequent dust clouds stirred up by jeep traffic.

3.2 SOIL SAMPLES

Composite soil samples (15 to 22 individual collections) were taken in 1970 to a depth of 1 inch from disturbed and undisturbed areas along rows on Bikini (shown in Figure 4). On Eneu, soil samples were collected from the Camp Blandy and North Central areas (shown in Figure 5). Soil profile samples were taken at well points as shown in Figure 4.

The principal radionuclides in the soils are ^{137}Cs and ^{90}Sr. Average values of ^{137}Cs on Bikini ranged from less than 1 to 470 pCi/g dry soil

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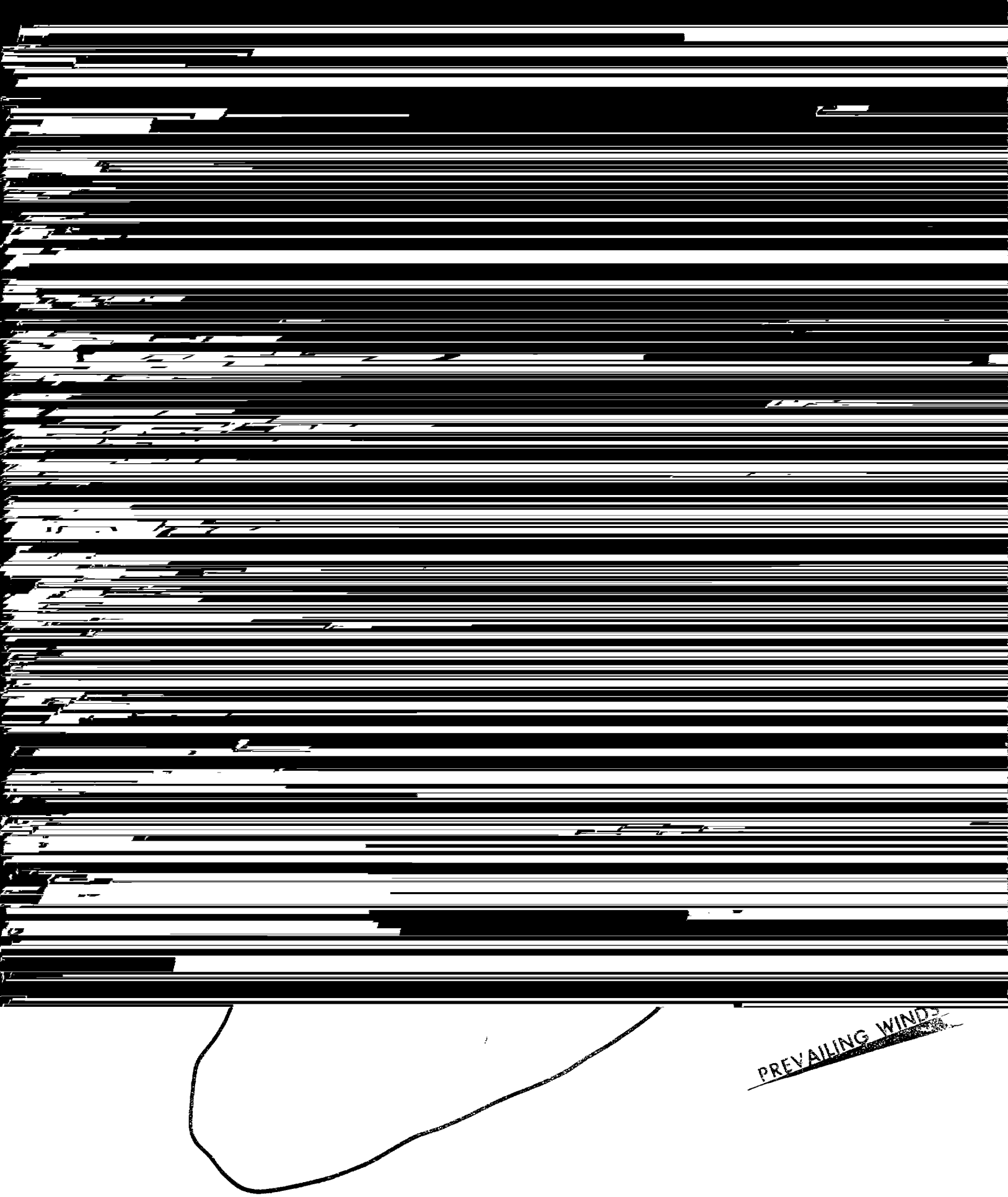
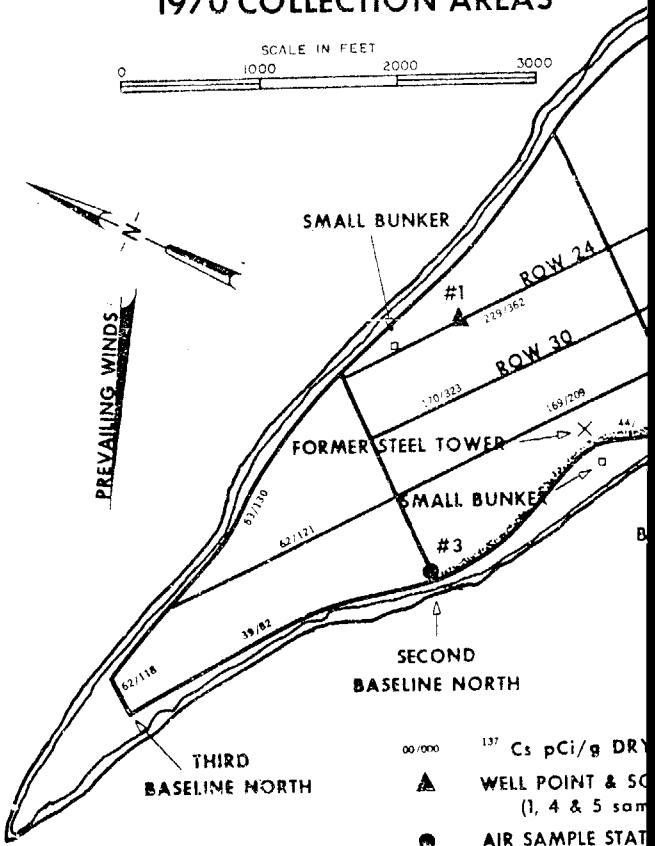


FIGURE 5.

BIKINI ISLAND

1970 COLLECTION AREAS



found was 14 pCi/ml, or 4300 tritium units (at Nam Island) whereas at Bikini and Eneu Islands, the concentration was 2 pCi/ml, or approximately 600 tritium units. (See Figure 3 for well point locations on Bikini.) These values fall within the range of tritium concentrations in surface waters of the United States in 1966. It has been shown that there is approximately 10,000 times more tritium in "bound" water than in "free" water in soils at Eniwetok Atoll, however, there is little exchange of the bound water with the free water. (Free water is that released or extracted by freeze drying. Bound water represents additional water which could be released upon combustion of the sample.) Hence it is probable that there will be no major changes in the tritium concentration of well water at Bikini Atoll.

4. RADIONUCLIDES IN FOOD

The values of radionuclides observed in food items other than land plants are presented in Table 3.

4.1 EDIBLE PLANTS

Coconut, arrowroot, and pandanus samples were collected in 1967 and 1969 and analyzed (Table 4). Coconut samples were collected from 13 different locations on Bikini in 1969. Green coconuts were used for almost all samples and the meat and milk were analyzed separately. Only ^{137}Cs and ^{90}Sr were detectable in any of the samples. Tritium analyses were performed on the milk from selected coconuts but all results were below the lower limit of detection (0.4 pCi/ml).

4.2 FISH

The fish collected and analyzed are in two main categories: reef fish and pelagic fish. The reef fish, an important item in the Marshallese diet, are caught by throw net while the pelagic fish are caught by trolling.

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Row 30	Undisturbed	20	65	± 8	*	323	± 5
	Disturbed	21	56	± 8	*	170	± 3
1st BL S to 2nd BL S							
Row 36	Undisturbed	18	87	± 14	*	470	± 9
	Disturbed	18	28	± 4	*	228	± 3
Camp area to Lagoon Rd.							
Row 66	Undisturbed	14	16	± 2	*	175	± 2
	Disturbed	14	6.2	± 0.9	*	90	± 1
Base Camp Random							

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TABLE 1 (Con't)

	N	pCi/g dry $^{239,240}Pu$	^{238}Pu	^{137}Cs
Eneu Island				
1969				
Camp Blandy		.71 ± 0.1	*	6.0 ± 0.3
1970				
North Central				
Undisturbed	5	35 ± 4	*	156 ± 2
Disturbed	4	3.0 ± 0.4	*	21 ± 0.5
Eneman Island				
1969				
SW Corner 0-1" depth		79 ± 3	49 ± 2	19 ± 6
8-9" depth		9.3 ± 0.4	4.1 ± 0.2	3.4 ± 0.5
Bravo Crater				
1969		60 ± 2	4.0 ± 1	

N Number of subsamples in composite sample
* Not detectable
** BL = Baseline
*** Bulldozed planting strip

NOTE: Multiplication of the above values by 3×10^4 will give an approximate value in units of pCi/m^2.

TABLE 2

PLUTONIUM - 239, 240 IN THE SURFACE ONE INCH
OF BIKINI SOILS COLLECTED IN 1967 AND 1969

Collection Site	Date	pCi/g dry SWRHL Analyses	pCi/g dry UW Analyses
Bikini Island			
Pit 1	1967	5.1	5.1
Pit 5	1967	130	117
Pit 6	1967	40	34
Well Point 1	1969	190	129
Well Point 2	1969	30	27
Well Point 3	1969	150	111
Eneu Island Camp Blandy	1969	0.39	0.71

TABLE 3

AVERAGE VALUES OF RADIONUCLIDES IN FOOD ITEMS OTHER THAN LAND PLANTS AT BIKINI ATOLL, 1967(1) AND 1969

pCi/g wet

Diet Item	^{55}Fe		^{60}Co		^{90}Sr		^{137}Cs	
	1967	1969	1967	1969	1967	1969	1967	1969
Fish, muscle	100		3.7		.19		.32	
Fish, eviscerated whole(2)		18		2.6		.08		.13
Fish, liver	9200*	382*	44.7				nd	
Fish, viscera(2)		120		13				nd
Tuna, yellowfin								
light muscle		7.8		.02		<.03		.06
dark muscle		88		.26		<.03		.03
liver		120		.41				.02
Tuna, Dogtooth								
light muscle	484	31	.66	.30			.20	.19
dark muscle		241		1.1				.13
liver		478	15	7.1			.06	.17
Spiny lobster(3,4)		2.5	.11	.12	.04		.02	nd
Giant clams(5)		5.9		24				nd
Coconut crabs, muscle			10		19		72	
Coconut crabs, muscle (Bikini)		1.2		.65		12		181
Coconut crabs, muscle (Eneu)		.8		.14		.05		16
Coconut crabs, "liver" (Bikini)		41		7.8		62		170
Coconut crabs, "liver" (Eneu)		16		1.5		5.1		16

TABLE 3 (Con't)

pCi/g wet

Diet Item	^{55}Fe 1967	^{55}Fe 1969	^{60}Co 1967	^{60}Co 1969	^{90}Sr 1967	^{90}Sr 1969	^{137}Cs 1967	^{137}Cs 1969
Birds, muscle, all species	100	110	3.5		.13		26.5	
Birds, muscle, curlew		24	.94			nd		380
Birds, muscle, turnstone		105	7.7			.nd		56
Birds, muscle, terns		155	1.1			nd		.05

(1) Radiological Report on Bikini Atoll. Philip F. Gustafson, Division of Biology and Medicine, USAEC, Washington, D. C., April 1968.
(2) Reef fish only.
(3) The heading, "Clams or Lobster" was used in the 1968 table, but it has been established that the values given are for spiny lobsters from Bikini Island only.
(4) The 1969 value includes spiny lobsters from Nam Island. The average values for ^{60}Co for lobsters from Bikini Island is .07 pCi/g wet.
(5) Clams from near Bikini Island only. Only small clams, not usually eaten, were found off Nam. The maximum value for ^{60}Co was 29 pCi/g wet.
* Jacks (Ulua) only.
nd not detectable

TABLE 4

MEAN ^{137}Cs AND ^{90}Sr CONCENTRATION IN EDIBLE PLANTS COLLECTED IN 1967 AND 1969

		pCi/g wet			
		^{137}Cs		^{90}Sr	
Location	Sample	1967	1969	1967	1969
Bikini	Coconut Meat	200	120	37	0.31
	Coconut Milk		130		
	Pandanus		130	33	28
	Arrowroot*		0.6		2.4
Eneu	Coconut Meat	28	21	.02	.08
	Coconut Milk		23		
	Pandanus	14	87	3.9	
	Arrowroot*		0.7		0.4
Aerōkōj	Coconut Meat		2.6		0.009
	Coconut Milk		3.0		

*Prepared by grinding, rinsing three times with salt water and once with fresh water (Marshallese method of preparation).

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A single urine specimen (24 hours) was obtained from the Trust Territory resident at Bikini. Another specimen was obtained from a member of the 1970 radiological survey team who had been on Bikini for 15 days and who probably had not reached equilibrium. Analyses of these samples indicated no detectable plutonium activity.

6. SIMULATED HOUSE EXPERIMENT

During the 1970 survey, a simple experiment was conducted on Bikini Island to determine how concrete living quarters made of aggregate obtained from the Eneman, Lele, Bikdrin, Aerokojloi, and Aerokoj complex reduces the exposure rate.

A concrete house was simulated by constructing a large, square container with hollow walls 6-inches thick. The walls and the bottom 6 inches were

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Nam - 500 uR/hr
Lomilik - 500 uR/hr

Analyses of soil samples taken on Bikini indicated that more than 95 percent of the exposure rate was due to ^{137}Cs. Thus, the reduction in exposure rate can be assumed to closely follow the decay of ^{137}Cs. Mixing

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range from slightly higher than Eneu to approximately an order of magnitude higher (for the station exposed to the dust from the jeep traffic on the lagoon road).

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