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ANNUAL REPORT 1977-78

PACIFIC RADIOECOLOGICAL PROGRAM*

by

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Annual Report, 197[illegible]

Pacific Radioecological [illegible]

The annual report is an account of work completed during the 1977-78 contract year for two projects - the Amchitka Long Term Effect and Monitoring Project and the Baseline Project. The latter project included the analyses of samples collected in the Central Pacific including the Marshall Islands and the preparation of reports. The Amchitka project was supported by the Division of Military Application ([illegible]) and the Baseline project by the Division of Operational and [illegible] Safety ($50,624).

The report consists of six sections. A summary comment and a report which is attached as an appendix is provided for each section.

1. Amchitka Radiobiological Program Progress Report, January 1977 to December 1977. This is the [illegible] series of progress reports that began in 197[illegible], one year prior to the [illegible] event. This report appends the results of analyses of samples collected in September 1977 to the data in last year's report. The results of analyses of the 1977 samples leaves unchanged the conclusions of previous years, namely, that except for small quantities of tritium in the Long Shot mud pits and drainage basin there are no radionuclides of Amchitka origin in the water, plants, or animals of Amchitka [illegible]. A copy of the report is attached and the report is in the process of publication by the Nevada Operations Office, U. S. Department of Energy, as report NVO-269-34.

2. The title of the second section of the annual report is, "Results of Plutonium and Gamma Spectrum Analyses of Enewetak Plant, Rat and Soil Samples Collected in M[illegible]." This is a table of the results of analyses of [illegible] samples collected [illegible] for use by Dr. William B. Jackson and associates of Bowling Green University in the preparation of a report on the rats of Enewetak Atoll. The analyses of these samples were not a part of the 1977-78 contract [illegible] the Laboratory agreed at a meeting at Lawrence Livermore Laboratory [illegible] June 1977 to do this work as a replacement of [illegible] 1977 [illegible] that was cancelled.

3. A report "Radiological Survey of [illegible], Animals, and Soil in Micronesia, November 1975" was prepared by [illegible] Nelson. Dr. Nelson was a former employee of the Laboratory [illegible] as a consultant to prepare this report of the results [illegible] of samples he had collected while he was an employee of the [illegible]. The report has been submitted to the Nevada Operations Office of the U. S. Department of Energy and is expected to be published as report NVO-269-35.

4. Dr. Nelson [illegible] a second report "[illegible] Radiological Survey of Plants, Animals and Soil at Five Atolls in the Marshall Islands, September-October 1976." He had collected [illegible] while an employee of the Laboratory. This report has been [illegible] the Nevada Operations Office as well and is expected to be published as report NVO-269-36.

5. Although the spring 1977 trip to Bikini was cancelled, some of the samples scheduled for collection at that time were collected in Ocotober 1977 when the Laboratory had a field program at Bikini Atoll for another research contract. From this collection 14 coconut samples, 10 pandanus, [illegible] breadfruit and [illegible] papaya samples were analyzed for ^{137}Cs and 23 soil samples for [illegible] Pu and ^{241}Am. Some samples were collected from the same areas in either 1974, 1975 or 1976 and the results of analysis of these samples are presented for the purpose of comparison. Usually the 1977 values were as great as or greater than values for earlier years and hence there is no strong evidence of a decrease in radionuclide concentration with time. For this period this observation indicates a [illegible] ecological half-life value for these radionuclides at [illegible].

6. The quality of our analytical work has been evaluated in two ways - first, by an interlaboratory comparison program and secondly by duplicate or replicate analyses of samples [illegible] our own collection. The interlaboratory comparison program, methods of analysis, and the limits of detection are reviewed in section [illegible].

APPENDIX I

APPENDIX I

AMCHITKA RADIOBIOLOGICAL PROGRAM

PROGRESS REPORT

JANUARY 197[illegible] TO DECEMBER 197[illegible]

By

Allyn H. Seymour and Arthur F. [illegible]

NVO-269-34

Environmental
and Earth Sciences

AMCHITKA RADIOBIOLOGICAL PROGRAM
PROGRESS REPORT
JANUARY 1977 TO DECEMBER 1977

BY

Allyn H. Seymour and [illegible] Nelson

JULY 1978

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Prepared for the U. S. Department of Energy
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ABSTRACT

The [illegible] the Radioecological Program began in 1970 and is a continuing program of [illegible] biological and environmental samples for radiometric analyses. [illegible] of the program from July 1970, to [illegible] 1976, has been [illegible] previous [illegible] reports from the Laboratory of Radiation Ecology [illegible] Operations Office of the U. S. Energy Research and Development Administration. This report is an account of the program for calendar [illegible] 1977.

[illegible] of analyses for samples collected [illegible] September 1977 have been [illegible] in Nelson and Seymour (1977) that summarize the results of analyses of samples collected from 1970 to 1976, and include [illegible] from (1) gamma-emitting radionuclides in soil, [illegible] freshwater, birds, [illegible] marine invertebrates, fish, [illegible] and freshwater moss and plants; (2) strontium-90 (^{90}Sr) in [illegible] birds, and soil; (3) [illegible] in [illegible] marine algae, and fish; and (4) tritium (^{3}H) in seawater, freshwater, and biological organisms. Monitoring of background radiation with [illegible] instruments was added to the Laboratory's program in 1974, and the results of the [illegible] annual surveys [illegible] are included in this report.

Conclusions from the results of the recent analyses are a reiteration of the results stated in Nelson and Seymour (1976a), namely, (1) [illegible] (2) the most abundant radionuclides that are naturally occurring [illegible] beryllium-7 (^{7}Be) and potassium-40 (^{40}K); (3) the trace quantities of [illegible] products and induced radionuclides are from world fallout; and (4) a [illegible] contamination [illegible] previously reported. It is concluded from the results of analyses of samples collected between [illegible] 1970, and September 1977, as reported in this and the [illegible] previous reports, that there were no radionuclides of [illegible] in the water, [illegible] of Amchitka Island.

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1. INTRODUCTION

The present Amchitka radiobiological program begun in 1970 has been preceded by [illegible] radiobiological programs [illegible]. A description of the present program is given in the 1972 Progress Report ([illegible] et al., 1973), and the following portion from that report follows.

"The present Amchitka radiobiological program was initiated in July, 1970, by the University of Washington's Laboratory of Radiation Ecology at the request of the U.S. Atomic Energy Commission, Nevada Operations Office. The program is designed to provide a means for determination of radionuclides, both naturally occurring and [illegible], in selected environmental samples from Amchitka [illegible]. [illegible] and [illegible] potentially [illegible] through the [illegible] organisms [illegible] food organisms are also collected and analyzed. The indicator organisms [illegible] significantly concentrate one [illegible] radionuclides. Concentrations of radionuclides other than those potentially hazardous to man are measured as a means of providing clues to the origins of radionuclides at Amchitka. Unexpected radionuclides or concentrations of radionuclides would indicate the presence of newly added radionuclides in the environment, presumably from fresh fallout, nuclear-powered vessels, or from nuclear detonations at Amchitka Island."

The first two Amchitka Radiobiological Program Progress Reports covered the period July 1970 to February 1972. These reports have been summarized by [illegible] (1973), who concluded, "All [illegible] of the man-made radionuclides [illegible] did not originate at Amchitka except for tritium, which [illegible] previously been reported to be present in pond water and [illegible] from the [illegible]."

The third to seventh progress reports reiterated the above conclusion and extended the record of the program through August 1976. Major conclusions of the seventh report, as stated by Nelson and Seymour (1977) were as follows:

a. "Naturally occurring ^{7}Be and ^{40}K are the most abundant radionuclides in all sample types."

b. "Trace quantities of fission products, induced radionuclides and plutonium have been detected in amounts that would be expected from world fallout [illegible]."

c. "No unexpected radionuclides or radionuclide ratios have been detected."

d. "Tritium values in seawater and freshwater are not significantly different than the values that would be expected at other stations at the same latitude in the northern hemisphere."

6. Some of the ponds and mud pits in the vicinity of the Long Shot [illegible] Ground Zero may be contaminated with [illegible]. The drainage [illegible] pits is also [illegible]. The concentration [illegible] than the amount of [illegible] in the rainfall in Vienna, Austria, in 1963, and about twice as great as the amount in [illegible] water [illegible]."

7. "An extensive search with sensitive instruments for radionuclides [illegible] in the terrestrial environment, [illegible] and in marine [illegible] collected during the first 20 months after the Cannikin detonation of November 6, 1971, indicates that no radionuclides from the Cannikin or Milrow events have escaped to the surface environment."

In 1977, the third progress report, the format is the same as for the [illegible] report except that new data from the analyses of [illegible] samples collected in September 1977, were added to the appropriate tables of the previous report. Figure 1 of this progress report shows the general location of Amchitka Island. Figure 2 shows general collection sites for the radiobiological program, while Figures 3 through 6 present the specific collection sites for the study areas shown in Figure 2. Peak years of [illegible] radionuclides are shown in Figure 7.

2. [illegible]

Food samples collected prior to June 1976 and fish, marine invertebrates, and birds collected through 1977 were analyzed by gamma spectrometry with systems using 4x4 inch NaI (Tl) crystals and 256-channel [illegible] analyzers. Samples (except fish, marine invertebrates, and [illegible] noted above) collected since June 1976, have been analyzed with [illegible] Ge(Li) diode detectors and 4096-channel analyzers. [illegible] the ashes of selected samples. [illegible] was chemically [illegible], collected on filter paper and counted with a [illegible] counting system. Plutonium was extracted by ion exchange, electroplated on platinum discs, and analyzed by alpha spectrometry with [illegible] barrier silicon detectors and multichannel analyzers. [illegible] which was determined by [illegible]. Tritium in [illegible] was determined by vacuum distillation of the [illegible] liquid scintillation counting of the distillate, as [illegible] (1973). Free and bound ^{3}H in [illegible] samples from fish, [illegible] plant samples was determined by azeotropic distillation [illegible] and liquid scintillation counting. A discussion of the procedure for [illegible] biological samples and analysis of ^{3}H in bound water was given in [illegible] (1975a and 1976).

Freshwater samples (4 liters or more) for analysis of radionuclides other than ^{3}H were collected from eight [illegible] sites. The water was evaporated and the residue counted for gamma-emitting radionuclides.

All data presented in the tables have been corrected to the date of collection; this correction will introduce little or no error in the [illegible] values except for [illegible] in the sample was [illegible] parent [illegible] and is not in equilibrium with its daughter. In this case, an accurate decay correction [illegible].

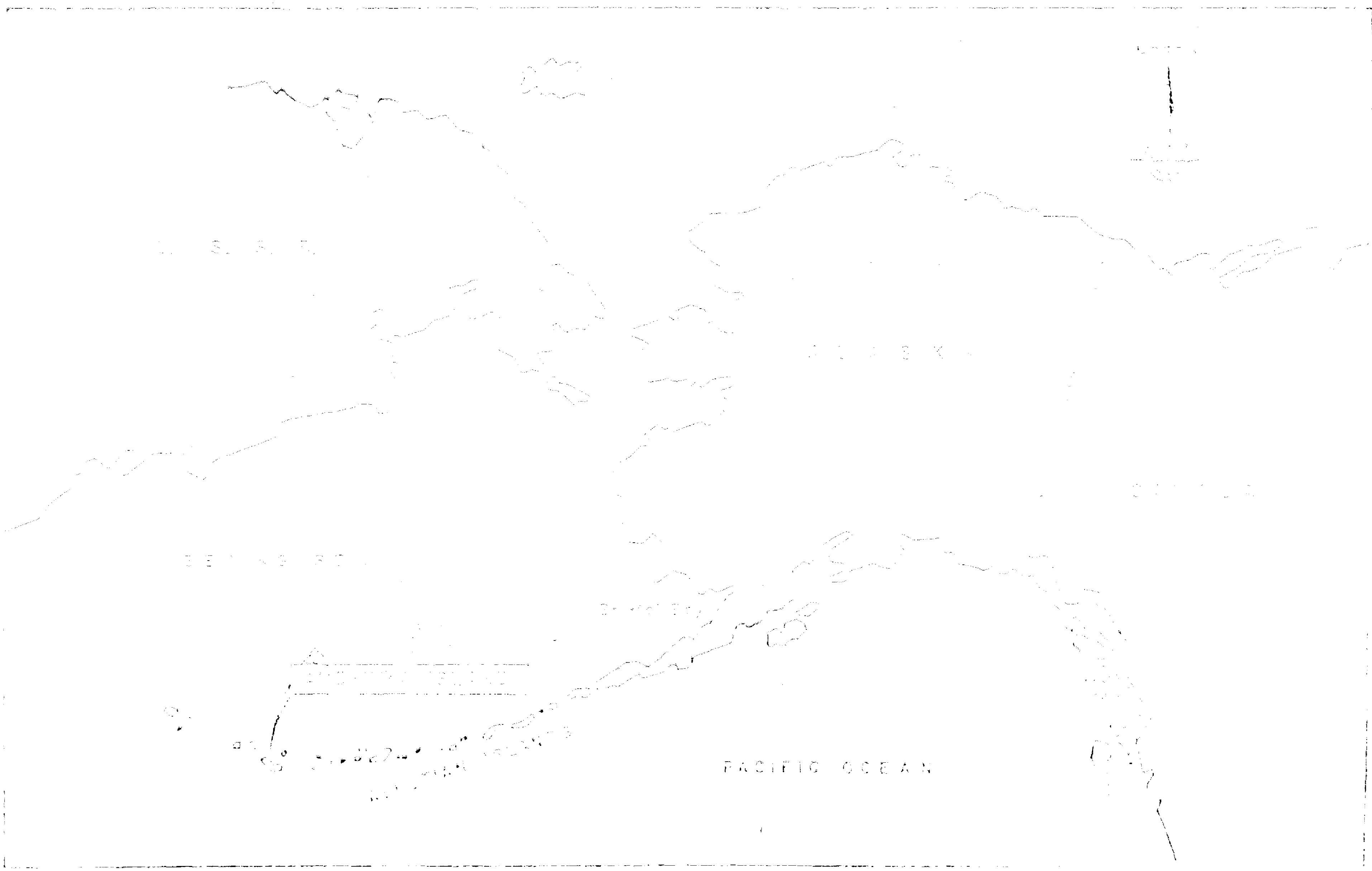
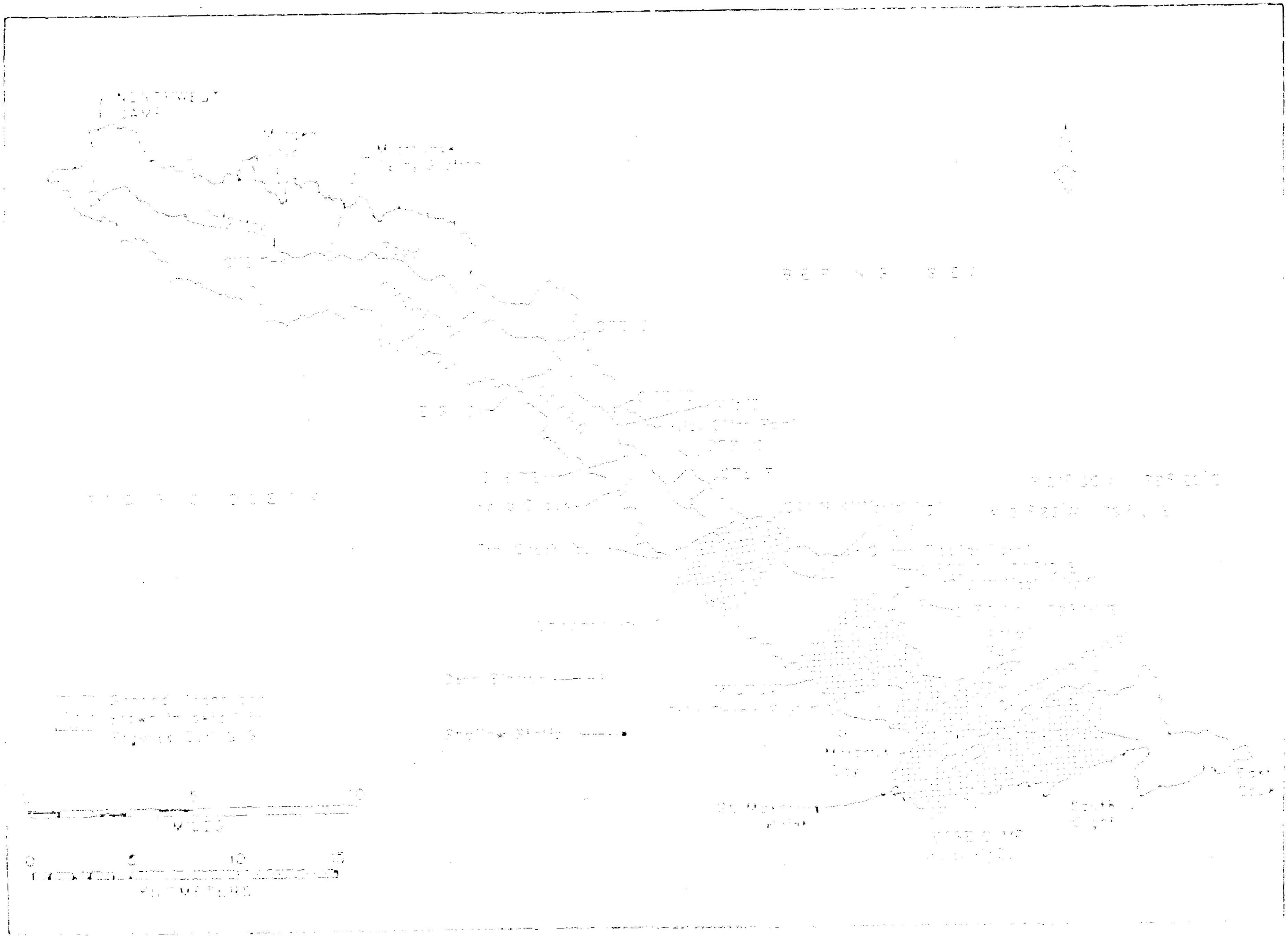
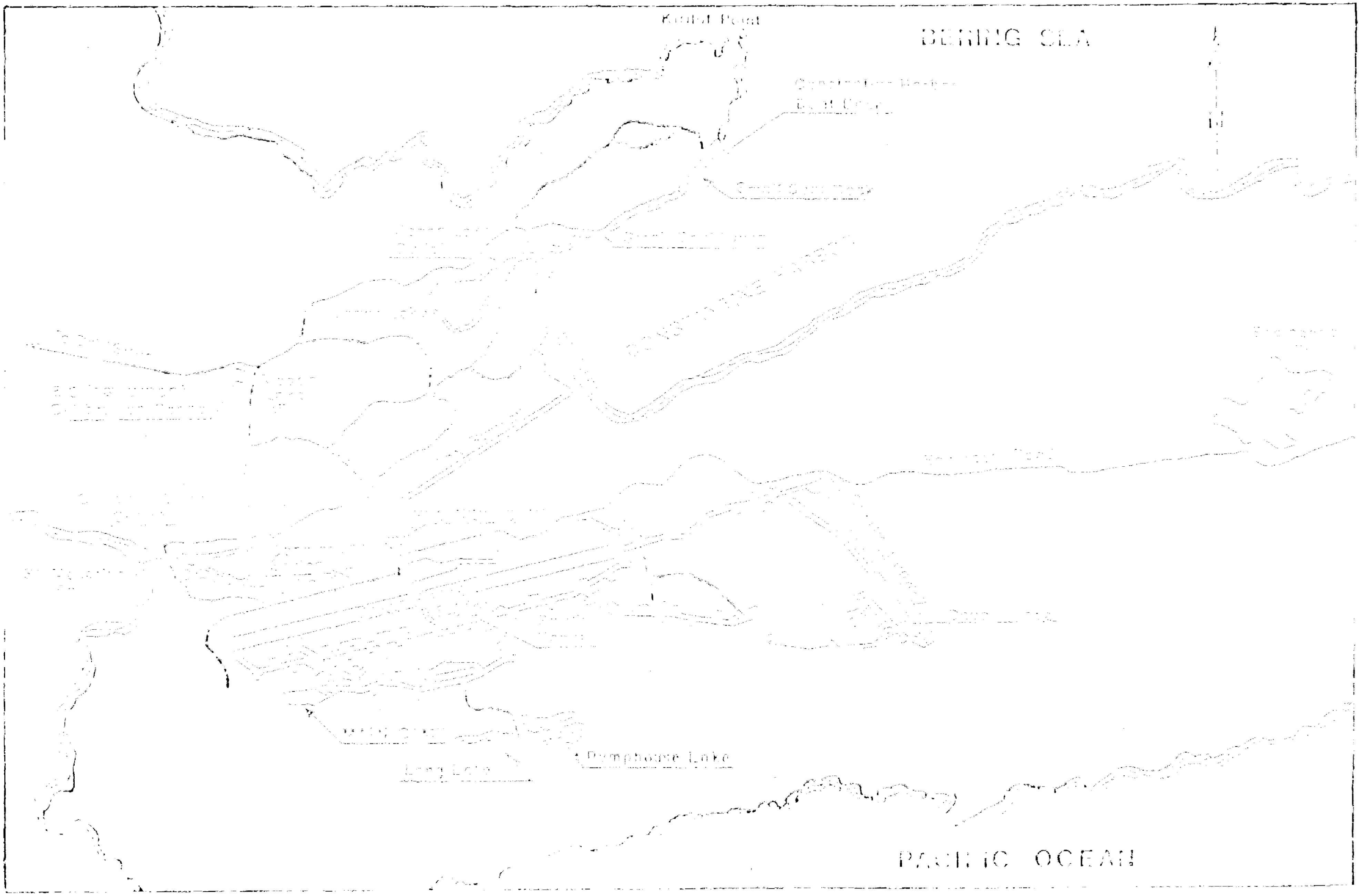
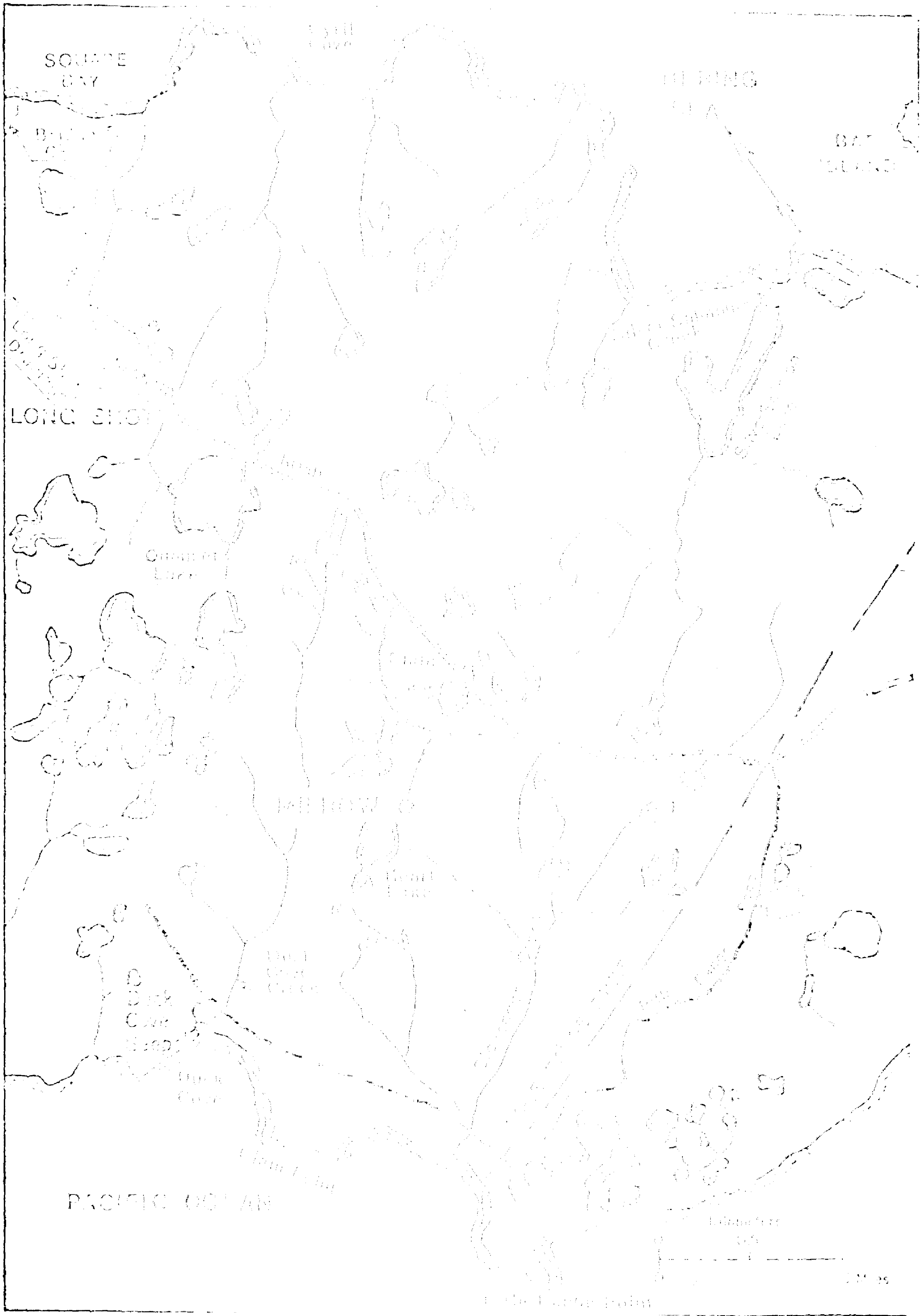


FIGURE 1. Location Map





FI. E 3. Collection Sites and Other Prominent Features in the Amchitka Island Base Camp Area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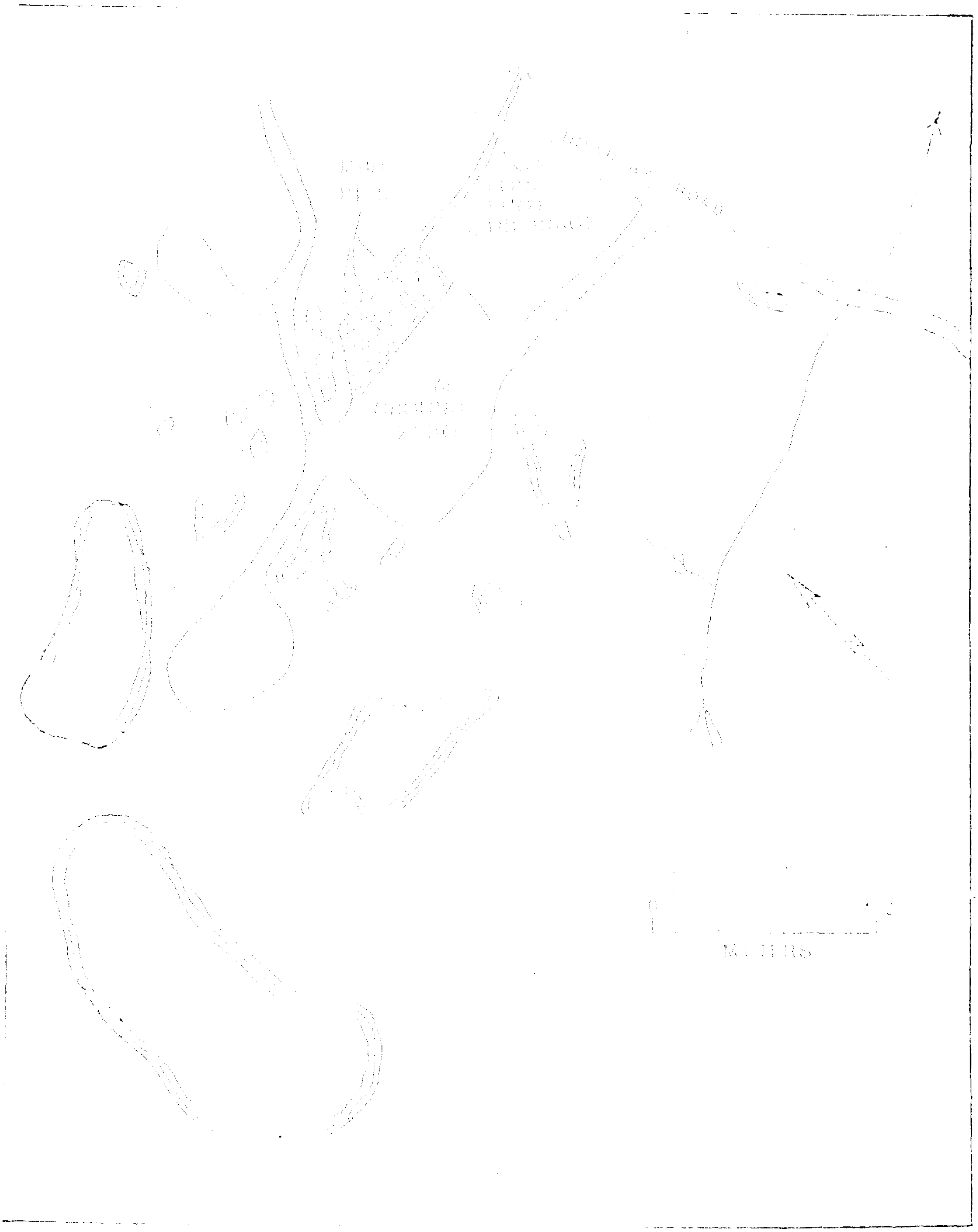
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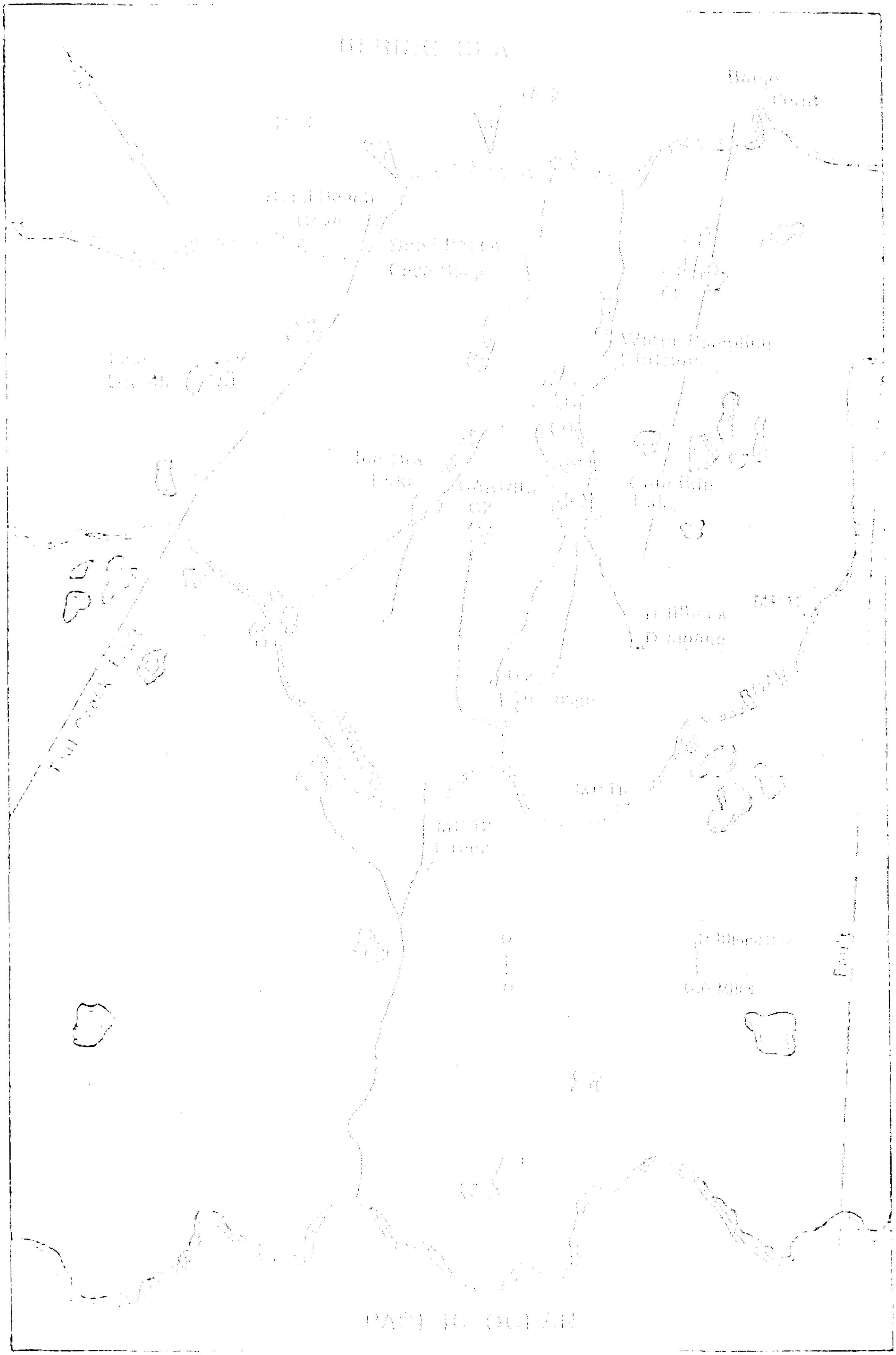


Figure 6. Collection Sites and Other Prominent Features in the [illegible] Area

[illegible] and the application of the [illegible] decay correction factor for [illegible] to the amount of [illegible] percent of the time of counting gives an estimate of the maximum possible amount of [illegible] present at the time of collection. [illegible] have been discussed in [illegible] et al. (1973).

[illegible] error term in radionuclide [illegible] for single samples [illegible] the combined counting error for [illegible] background, standard, and [illegible] [illegible] the term "[illegible]" [illegible] the error limit for the [illegible] counting techniques. [illegible] single samples are [illegible] counting errors, while the [illegible] data error limits [illegible] [illegible] errors. [illegible] for [illegible] single [illegible] collected before 1973 are one [illegible] counting errors, while [illegible] 1972, 1974, and 1975 [illegible] and [illegible] analyses [illegible] counting errors. The error term for the mean of more than one [illegible] are [illegible] deviation of the mean.

Limits of detection are important since they govern the amount of a radionuclide that can be detected [illegible] in a sample. [illegible] factors influence the limit of detection, including the type of [illegible] and [illegible], the presence of other radionuclides, the duration of counting, the [illegible] of the sample, and the [illegible] relationship of the sample and detector. Hence, the actual limits of detection can vary considerably for various radionuclides and types of samples, but can be summarized by stating that the detection limits were approximately as follows:

By gamma detection

[illegible]K	2.1 pCi/g or less
[illegible]	0.4 [illegible]
[illegible]	0.1 [illegible]

By beta detection

[illegible]	[illegible] nCi/liter or less
^{90}Sr	0.2 pCi/g or less

By X-ray detection

[illegible]	0.04 [illegible]

By alpha detection

[illegible]	0.[illegible]

In addition to the radiological analyses made on the biological and environmental samples, environmental radiation surveys of selected sites on Amchitka Island were made in August 1974, 1975, 1976, and September 1977 with a Baird-Atomic survey meter, Model [illegible], and a [illegible] probe with a 2 mg/cm^2 window.

RESULTS AND DISCUSSION

Since the completion of the 1976 Amchitka radiobiological program report, the book, "The Environment of Amchitka Island," has been published (Merritt and Fuller, ed. 1977). Chapter 24, "Radionuclides in the Water and Biota," (Seymour and Nelson, 1977) is a summary of the radiobiological studies at Amchitka from 1965 to 1976 including the studies presented in the 1970-71 to 1976 annual progress reports. Prior to 1970 there was a radiobiological project for the Long Shot program in 1965 and for the Milrow program in 1969 but the effort expended for these two projects was much less than for the Cannikin radiobiological project which began with a preshot study in 1970. Other chapters of the book provide additional information about the Amchitka environment based upon extensive studies by many investigators.

The samples collected in September 1977 were of the same type and from the same locations as in previous years and included biological species, water, soil, or sand from freshwater, terrestrial, and marine environments. The only changes in the 1977 schedule of sample collections and analyses were as follows:

1. A water sample was collected from Long Lake for the first time and was used for both ^{3}H and gamma spectrum analyses.

2. Water samples from Constantine Springs and Sand Beach Cove seep and of rainwater from [illegible] were collected for gamma spectrum and ^{3}H analyses, whereas only samples for ^{3}H analysis were collected in previous years.

3. The sampling program which has been limited to one collection a year in recent years was supplemented by collections of [illegible] and water from Bridge and Clevenger creeks and of rainwater from the Cannikin area in the spring and summer of 1977 by staff members of the U. S. Fish and Wildlife Service.*

Most of the samples were analyzed by gamma spectrometry for both neutron-induced and fission product radionuclides. In addition, selected samples were analyzed for tritium, strontium-90, and plutonium-239, 240. The results of radiological analyses are presented in Tables 1 to 10.

*The assistance of James Coffey, Glen Elison, John Martin (refuge manager) and Robert Schulmeister (biologist) of the Aleutian Islands National Wildlife Refuge program is gratefully acknowledged.

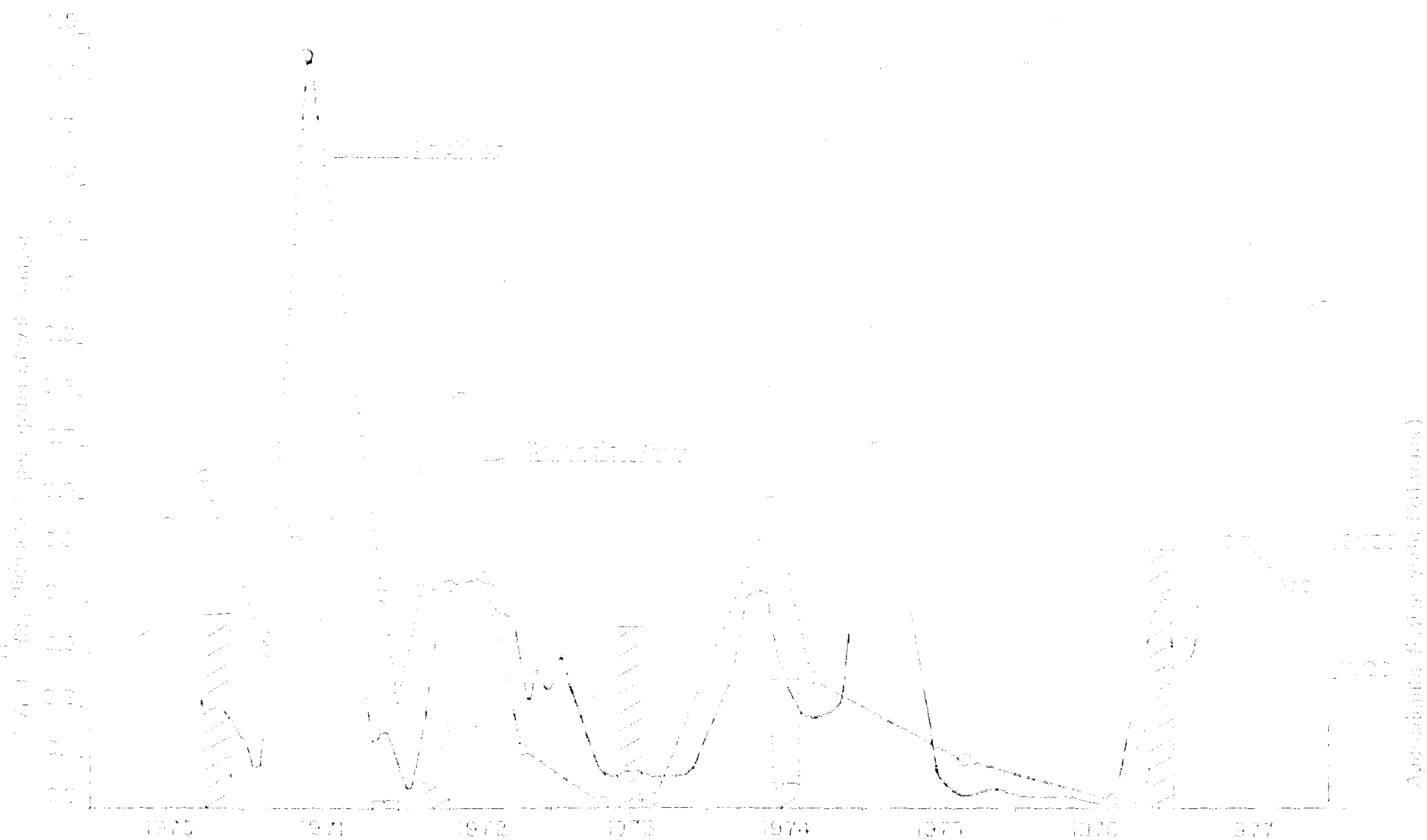
The results of gamma spectrum analysis for three types of biological samples collected in [illegible] are given in Tables 3 to 5. The samples were [illegible] (a [illegible]), Ranunculus (a plant), and Aufwuchs (bottom adhering micro organisms) with filamentous algae. Samples were collected at [illegible] stations but only [illegible] was present at all locations. Inspection of the tables reveals that the values for [illegible] generally are greater than the values for the [illegible] and that there is a distinct "year of collection" effect with peak years in 1970-71, 1974, and 1977.

To further investigate the "year of collection" effect, the values for the [illegible] of zirconium-95 (^{95}Zr) plus niobium-95 (^{95}Nb) in [illegible] from Amchitka were compared with the sum of ^{95}Zr plus ^{95}Nb in [illegible] and algae samples from the Columbia River and with the schedule of atmospheric detonation of nuclear devices of 20 kilotons or greater fission yield in China. These data are presented in Figure 7.

The variables in Figure 7 were selected for the following reasons: ^{95}Zr and ^{95}Nb are indicators of fresh fallout radionuclides [illegible] the most abundant fission products in the Amchitka samples. [illegible] was selected as an excellent biological indicator species [illegible]. [illegible] from the Columbia River were selected as comparable samples [illegible] samples from a location at approximately the same [illegible] as Amchitka and the schedule of Chinese nuclear detonations was selected for comparison with the ^{95}Zr plus ^{95}Nb values because this is the probable source of fallout radionuclides in the samples from both areas. The results of one year of the Columbia River samples ([illegible] and/or [illegible] algae, [illegible]) were reported by [illegible] (1970). The Columbia River samples were collected [illegible] and it should be noted in Figure 7 that the results [illegible] have been smoothed by a moving average of three. Also, the Columbia River samples were reported in terms of dry weight [illegible] the Amchitka samples in Figure 7 are given in terms of wet weight. The wet weight values were calculated from the wet weight-dry weight ratio of [illegible] as determined from the [illegible] of [illegible] samples [illegible].

The source of information about the Chinese nuclear detonations was [illegible] (1977). Inspection of Figure 7 provides evidence for the following conclusions: (1) the trends for the Amchitka and Columbia River values are parallel; (2) the peaks in the curves occur after Chinese nuclear detonations of 20 kilotons or greater fission yield; (3) there is a "year of collection" effect with peaks in 1970-71, 1974, and 1977; and (4) the detection and measurement systems are sensitive to small perturbations in the amounts of fallout radionuclides in the environment.

From statements (1) and (2) above, the obvious conclusion is that the source of radionuclides at Amchitka is world fallout, presumably from the Chinese nuclear detonations. Another method of determining the source of the radionuclides is to determine the date of origin of the radionuclides and/or the presence of short half-lived fallout radionuclides in the samples. The date of origin of radionuclides can be determined from the ratio of fission product radionuclides of the parent radionuclide [illegible]. If [illegible] fission of any kind occurs, [illegible] fission product radionuclide ratios can be [illegible]. For the Amchitka data, there [illegible] insufficient information to calculate date of origin by the [illegible] method. However, the presence of short half-life [illegible]


1970
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1977

[illegible] (6 and [illegible] days respectively) of [illegible] short-lived fission product [illegible] in the samples means that these radionuclides are of recent origin from the [illegible] nuclear detonation at [illegible] (Bo[illegible] 1976) and [illegible] from world fallout.

There has been no strong evidence from the radioecological data for a [illegible] or [illegible] in the radioactivity of the [illegible] related to the [illegible] test sites on Amchitka Island. However, [illegible] Table 3, the September 1977 values for lichens were two to three times greater [illegible] [illegible] area than for samples from the [illegible] Long Shot sites [illegible] less than for natural radionuclides. [illegible] observation [illegible], "Were the differences statistically significant?" To answer the question, the total radioactivity of [illegible] lichen samples collected from the Cannikin area ([illegible] [illegible] Creek) was compared with the radioactivity of the [illegible] samples from the Milrow area ([illegible] Creek, [illegible] Creek) and the [illegible] samples from the Long Shot area ([illegible] Long Shot drainage stream). The radioactivity of each sample was [illegible] determined to be the sum of the radioactivity for [illegible] most abundant fission product radionuclides: [illegible], [illegible], ^{106}Ru, ^{125}Sb, [illegible], ^{137}Cs, and ^{144}Ce. The mean values, and one standard deviation, for these [illegible] samples from the Cannikin, Long Shot, and Milrow areas, in terms of pCi/g of dry sample, were [illegible] [illegible] 1.0, 1.8 [illegible] 0.9 and 4.3 [illegible] 0.8, respectively. To determine the significance of the mean differences, the "t" test was applied and the conclusion was that the differences were not statistically significant. Hence, even though the differences were two or three fold, the differences were not statistically significant because of the [illegible] of the error term and the limited number of samples.

Radionuclide values for *Stereocaulon* are given in Table 4, for [illegible] [illegible] Table 5, and for *Cladonia* in Table 6. [illegible], a [illegible] and [illegible], yellow adhering micro-organisms, [illegible] good biological indicator species but was present in [illegible] as [illegible]. The radionuclide values for *Stereocaulon*, [illegible], and [illegible] are similar. The lichens are well known for the collection and retention of fallout radionuclides [illegible] are thus considered best indicator species for the terrestrial environment. The [illegible] values for ^{137}Cs and [illegible] are greater than for the [illegible] indicator species [illegible] otherwise [illegible].

Samples of the [illegible] algae, [illegible] (Table 7) had lower fallout radionuclides present and at lower concentrations in 1977 and [illegible] other years than the [illegible] vegetation types, [illegible] and *Stereocaulon*. The naturally occurring radionuclide, ^{40}K, was present in concentrations that [illegible] [illegible] 2 to 29 pCi/g of dry sample [illegible] 25 times or more greater than [illegible] most abundant fission product. Also, [illegible] was detected in [illegible] 1977 sample for the first time since 197[illegible].

[illegible] radionuclide values for the [illegible], a marine invertebrate, in terms of pCi/g of dry sample, as given in Table 8, were 6.2 for [illegible] and ranged from 0.41 to 1.2 for the [illegible] fission products.

Naturally occurring ^{40}K and [illegible] ^{137}Cs were the two radionuclides most commonly detected in fish (Tables 9-11). Of the [illegible] analyzed in 1977 [illegible], Dolly Varden, [illegible] [illegible] was detectable in five samples and the maximum value was 0.4 pCi/g [illegible].

[illegible]. Potassium-40 was the predominant radionuclide in all fish samples in all years and [illegible] was usually present in concentrations 10 or more times greater than [illegible].

Potassium-40 and [illegible] also were the predominant gamma-emitting radionuclides in [illegible] in previous years (Table 12) and [illegible] the [illegible] values were significantly [illegible] than the 1976 values. [illegible] values for both radionuclides in the 1977 fish samples fell within the range of values for other years.

The samples analyzed for [illegible] were [illegible] and the bones of [illegible] and [illegible] (Table 13). In samples collected since 197[illegible], the [illegible] concentrations of pCi/g of dry sample ranged from [illegible] to 27 for [illegible] and from [illegible] the limits of detection to [illegible] for [illegible] bones. The [illegible] values were [illegible] less than [illegible] values for these samples in previous years. Soil samples were collected in 1975, 1976, and [illegible] but in only one sample was the [illegible] greater than the limit of detection and this value was 0.05 pCi/g of dry sample. Soil, [illegible] and sand samples (0-2 [illegible]) collected in the last three years were analyzed for gamma-emitting radionuclides. The soil samples were [illegible] at the [illegible] and in the [illegible] Area and the sand samples from [illegible] Sand Beach Cove. [illegible] were [illegible]. There were [illegible] differences in radioactivity [illegible] year or [illegible]. The gamma-emitting fallout radionuclides present in the [illegible] were [illegible], [illegible], and [illegible] but their concentration in the samples was less than 1 pCi/g of dry sample. Similar [illegible] levels of fallout radionuclides were seen in soil samples collected in Washington [illegible] during 1974 and 1975 (Nelson and [illegible], 197[illegible]).

Precipitation samples have been collected for gamma spectrum analysis in 1974-77 at four sites — Deep Lake, [illegible] Lake, [illegible] Lake, and [illegible] Pit No. [illegible] — and in 1977 at three additional sites — [illegible], Long Lake, and Sand Beach Cove. In addition, a [illegible] sample also was collected for gamma spectrum analysis in 1977. The results of analyses on the residue from the evaporation of 10-[illegible] are presented in Table 15. The most abundant gamma-emitting fallout radionuclides in the 1977 precipitation samples were [illegible] and [illegible] the Long Shot Mud Pit No. 1 sample, the values being 0.46 and [illegible] pCi/liter respectively. These fission products also were present in the [illegible] 1977 [illegible] sample but at concentrations an order of magnitude less than the values for the Long Shot Mud Pit No. 1 sample. [illegible] was the source of [illegible] and [illegible] observed in the 1977 [illegible] at Long Shot Mud Pit No. 1 would be expected to [illegible] in the lake samples because of [illegible] in the lake. The [illegible] and [illegible] observed in the 1977 samples [illegible] relatively [illegible] because of the short half-lives of [illegible] and [illegible] ([illegible] and [illegible] respectively) and, hence, the origin [illegible] appeared to be world-wide fallout. Other significant observations from [illegible] of Table 15 is that the radioactivity for samples from the [illegible] sites in 1977 was within the range of values for samples from other locations.

The concentrations of tritium (^3H) in freshwater and seawater samples [illegible] recorded in Table 16. From 1970-71 to 1973 the ^3H values for seawater declined from 100 to 71 pCi/liter and since that time, including [illegible], the values have been at or below the limit of detection which is [illegible] 20 pCi/liter. The ^3H values for freshwater samples have been [illegible] for seawater samples, and like seawater, the values have constantly declined. The average value of 290 pCi/liter in 1970-71 [illegible] other than those from the Long Shot area, has declined to values [illegible] ranged from 95 to 140 pCi/liter in the period 1975-1977. In 1977, [illegible] average of 3H in freshwater samples (other than samples from the Long Shot area) and 11 seawater samples was 95 and 1.8 pCi/liter, respectively. [illegible] Because of the relatively low seawater concentration values, the difference between the freshwater and seawater values is not significant.

The Mud Pit surface water [illegible] Long Shot [illegible] have [illegible] been confirmed repeatedly [illegible] samples [illegible] found to be slightly contaminated with ^3H a few months after the Long Shot nuclear detonation in 1965. The extent of the contamination has been well documented in previous biological reports and in other publications (see [illegible], 1975; [illegible], 1977; and [illegible] and Nelson, 1977). In the period from 1970-71 to 1977, the average [illegible] for water samples from Long Shot Mud Pits have declined from [illegible] x 10^5 pCi per liter. These values are significantly less than [illegible] allowable concentration of ^3H in drinking water for the general [illegible] which is 10^6 pCi of ^3H per liter. This value is 1/30 the [illegible] (maximum permissible concentration in drinking water) for radionuclides [illegible] by the International [illegible] (ICRP, 1964). A more extensive discussion of this subject is given in Nelson and [illegible] (1977) and [illegible] (1977). Samples of water [illegible] from the Long Shot Mud Pits [illegible] were collected in 1975, 1976 and 1977 for ^3H analysis. [illegible] in course of the drainage [illegible] the ^3H values decreased [illegible] compared to the Mud Pit values [illegible] the mouth of the [illegible] were comparable to ^3H values in freshwater samples from other [illegible] of Amchitka Island. In 1977 the values [illegible] of pCi per liter [illegible] from [illegible] x 10^3 near the Mud Pits to 52 at [illegible]. Hence the contribution of ^3H from the Long Shot Mud Pits to the [illegible] insignificant.

Table 17 also provides some information for evaluation of the [illegible] [illegible] of one year with the [illegible] of ^3H in the samples [illegible] not [illegible] for a positive correlation. In 1977, water samples collected from [illegible] and [illegible] in May, August and September [illegible] significantly greater amount of ^3H in the May sample [illegible] however, rainwater samples were collected in [illegible] July, August and September and for these samples, no [illegible] effect is apparent although [illegible] values in [illegible] would not have been unexpected.

In Table 17, the results of ^3H analyses of free water extracted from biological samples are presented. The collections in 1977 included [illegible] from the marine environment ([illegible] and [illegible]) and [illegible] from freshwater ([illegible] and [illegible]) and from the terrestrial environment ([illegible]). The 1977 values, generally, were less than the 1976 values but the differences were not great. The concentrations were in the [illegible] and the average value for 1977 [illegible] samples from the Long Shot Area was 120 pCi per liter [illegible] were not greatly different from the average value of 93 pCi per liter.

of Amchitka freshwater samples exclusive of the Long Shot Area. [illegible] observation that the values for ^{3}H in rainfall from Cleveland [illegible] were about twice as great as ^{3}H values in water samples [illegible] the same location, was not verified by the 1977 data. However, [illegible] in previous years, the values for ^{3}H in rain results from the [illegible] have shown very several times greater than in comparison [illegible] from other areas. [illegible] the ^{3}H values [illegible] were related [illegible] in the same area which the [illegible] were collected. [illegible] in the [illegible] of [illegible] samples [illegible] results have not been obtained. [illegible] of [illegible] sampling method may resolve some of the previous problems.

Some 1975, 1976, and 1977 samples of [illegible] sand, [illegible] and [illegible] which were analyzed for $^{239,240}Pu$ and the results of these analyses are given in Table 10. The general conclusion from these [illegible] of the table are that the maximum value was 0.015 pCi per gram [illegible] of [illegible] sample and that there were no obvious differences related [illegible] collection. The $^{239,240}Pu$ values at Amchitka were compared with the data of analyses of comparable samples from the Atlantic Coast (Noshkin et al., 1975), California (Wong et al., 1977), and Washington (Nelson and [illegible], 1976b) and were found to be similar, i.e., some of the Amchitka values were slightly less, some slightly greater than the values from [illegible] areas ([illegible] and [illegible], 1977). For this reason the source of [illegible] at Amchitka is believed to be the same as for other areas of the world — fallout.

A background radiation survey program with a Geiger-Mueller detector [illegible] than 0.01 mR/hr was initiated in 1974 and the results of the survey for 1977 and the three previous years are presented in Table 11. Observations were made at 14 locations and in no instance was the [illegible] greater than 0.01 mR per hour, although occasionally pulses of radiation would momentarily deflect the needle on the dial to values [illegible] 0.01 mR per hour. The survey meter readings for all [illegible] and [illegible] were nearly the same, the background radiation [illegible] being near the lower limits of detection was insensitive to [illegible] changes in background radiation.

V. SUMMARY AND CONCLUSIONS

The objective of the program is to determine the extent of radionuclide contamination of Amchitka Island. The objective is achieved, primarily, by the collection and radiochemical analysis of biological and environmental samples, and also by background radiation measurements. If the contamination was significantly greater than would be expected from world fallout, a [illegible] leakage of radionuclides from the underground sites of the Amchitka nuclear detonations would be indicated. The results of analyses of the samples collected in September 1977 and the background radiation measurements [illegible] that [illegible] lead to the same conclusion as in previous years, i.e., there is no evidence that the radionuclide contamination at Amchitka Island is greater than would be expected from world fallout except for a slight contamination at the Long Shot GZ-HTH-[illegible] area.

Following are summary statements from which the conclusions were made [illegible] radionuclide contamination at Amchitka Island and [illegible] is there, with the exception of tritium [illegible] from the [illegible] and mud pit system, is of world-wide fallout origin.

1. Naturally occurring radionuclides, [illegible] and [illegible], were the most abundant radionuclides in most samples.

2. Some fission products, induced radionuclides, and plutonium have been detected in samples. [illegible] range from the limits of detection to a few pCi/g of dry sample.

3. Values for ^{137}Cs and ^{90}Sr in [illegible] moss and algae from Amchitka Island and the Colorado River were similar in [illegible] and peaks of abundance.

4. Peaks of abundance of fission product radionuclides occurred in 1970-71, 1974 and 1977 and follow major Chinese nuclear detonations.

5. Two fission products of short half-life, ^{95}Zr and ^{95}Nb, were the dominant fallout radionuclides in the samples and [illegible] of which [illegible] were [illegible] from the [illegible] Amchitka [illegible] detonation.

6. The radioactivity from fallout radionuclides, generally [illegible] greater for fresh water than for marine organisms.

7. There has been no increase in the [illegible] which is a potential [illegible] indicator of radionuclide leakage from underground sites.

8. The background radiation survey meter readings were at or near the lower limits of detection for the instrument.

9. The laboratory detection and measurement system for the radiological analyses of [illegible] samples was sensitive to small [illegible] in the amounts and species of radionuclides in the environment.

10. The results of analyses of the 1977 samples compared [illegible] results of analyses of samples collected previously and [illegible] reveal any unexpected information.

TABLE 1

Scientific and Common Names and Wet Weight to Dry Weight Ratios of Some Amchitka Island Organisms

Organism	Tissue	Wet/Dry Ratio	Standard Deviation
	VERTEBRATES		
Mammals			
Phoca [illegible]			
Seal	Bone		
Fish			
Salvelinus malma			
Dolly Varden	Muscle	[illegible].62	0.70
	Viscera	4.29	0.47
Oncorhynchus gorbuscha			
Pink Salmon	Gonad	4.[illegible]	
	Muscle	4.[illegible]	
	Liver	4.[illegible]	0.6[illegible]
[illegible]			
[illegible]	Muscle	4.0[illegible]	0.58
	Liver	[illegible]	0.04
Hexagrammos lagocephalus			
Rock Greenling	Liver	[illegible]	0.41
	Muscle	4.[illegible]	0.14
	Viscera	2.13	0.3[illegible]
Birds			
Lagopus mutus			
Rock Ptarmigan	Liver	3.[illegible]	0.37
	Muscle	[illegible]	0.0[illegible]
	INVERTEBRATES		
Strongylocentrotus [illegible]			
Sea urchin (green)	Entire	[illegible]	
	PHAEOPHYTA		
Laminaria digitata			
[illegible] algae	Entire	4.[illegible]	1.4
	CHLOROPHYTA [illegible]		
Cladophora sp.			
Filamentous algae	Entire	5.[illegible]	
Fontinalis sp.			
Moss	Entire	4.[illegible]	0.09
Ranunculus sp.			
Freshwater plant	Entire	12.2	[illegible]

TABLE 1 (Continued)

[illegible]	Tissue	Wet/Dry Ratio	[illegible]
[illegible]			
[illegible] & other crustaceans	Entire	7.27	2.40
[illegible]			
[illegible] sp. [illegible]	Entire	3.75	0.37

a. [illegible] from [illegible] and [illegible] Index of [illegible] from the [illegible] (Third Edition). 1970 American Fisheries Society Special [illegible] 6.

b. Value calculated from [illegible] samples in 1977 (n = 9).

Table 2

[illegible] Radionuclides on Air Filters at Ground Level

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	—	[illegible]	—	—	—	—	—	—

a. [illegible]

b. [illegible]

Table 3

[illegible]-Emitting Radionuclides in the Freshwater Moss, [illegible]

Sampling Date	n	Radionuclides [illegible]									
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	---	---	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	---
[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	---	---	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	---
[illegible]											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---
[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]											
[illegible]	3	5 ±3	5.6±2.5	1.2±1.1	[illegible]±2.3	3.5±0.6	2.0±1.3	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]±0.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	---	0.24±0.11	---	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	4.7±[illegible]	7.0±1.[illegible]	---	[illegible]	---	---	0.18±[illegible]	1.4±0.1	---	---
Sept '77	1	---	3.6±2.1	---	1.1±0.4	---	---	---	1.0±0.2	1.5±0.4	---

Table 4

[illegible]

Table 5

[illegible]

[illegible]	n	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. [illegible]

b. [illegible]

Table 6

[illegible] in Lichens Collected at [illegible] Island

[illegible]

[illegible]

a. [illegible] included in the analysis.

b. [illegible]

c. [illegible]

Table 9

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Second Day				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. Radionuclide values for a single sample (n = 1) are a single count of the sample [illegible] counting error. The radionuclide value shown for more than one sample is the [illegible]
[illegible]

Table 10

Potassium-40 and Cesium-137 in Greenling Collected off Amchitka Island

Table 1b (Continued)

[illegible]

a. [illegible]

b. [illegible]

c. [illegible]

Table 11

[illegible] -40 and Cesium-137 in Muscle of [illegible] Caught [illegible] 1976 [illegible]

Year	Collection Location	[illegible]	Radionuclides [illegible]		
			40	[illegible]	[illegible]
[illegible]	Jones Lake	3/3	15 ± 0.5	0.[illegible]	[illegible]
[illegible]	Bridge Creek	3/3	16 ± 1.0	0.7	[illegible]
[illegible]	"	3/3	16 ± 0.6	0.3	[illegible]
[illegible]	"	4/4	15 ± 1.7	0.[illegible]	[illegible]
[illegible]	"	5/5	17 ± 4.2	0.[illegible]	[illegible]
1976	Gamelin Lake	1/1	14 ± 0.5	0.[illegible]	[illegible]
	Jones Lake	1/1	15 ± 0.4	0.[illegible]	[illegible]
	Buck Cove	1/1	15 ± 1.6	0.3	[illegible]
1977	Clevenger Lake Outlet	1/1	15 ± 2.6	0.[illegible]	[illegible]
	Jones Lake	1/1	12 ± 2.[illegible]	0.[illegible]	[illegible]
	Buck Cove	1/1	16 ± 2.9	0.[illegible]	[illegible]

a. Radionuclide values for a single sample (n = 1) are a single count ± 1 [illegible] of the [illegible] propagated, [illegible] radionuclide [illegible] For more than one sample [illegible] the mean [illegible] standard deviation of the [illegible] single sample counts.

b. Number of samples/total number of [illegible] samples.

c. [illegible]

d. Jones Lake, Bridge Creek, Clevenger Lake Outlet.

e. Jones Lake, Gamelin Lake, Buck Cove.

f. Jones Lake, Gamelin Lake, Bridge Creek, Buck Cove, Clevenger Creek.

Table 17

Potassium-40 and Cesium-137 in [illegible]
collected on Amchitka Island

				Concentration (pCi/g, [illegible])	
[illegible]	Collection Site	Tissue	Number of [illegible]	^{40}K	^{137}Cs
[illegible]	South Bight	Liver	1	---	---
[illegible]	C-Site	Muscle	1	13 ± 1.2	1.6 ± [illegible]
[illegible]	South [illegible]	Muscle	[illegible]	[illegible] ± 0.5	1.0 ± [illegible]
[illegible]	[illegible]	"	[illegible]	11 ± 1.6	0.75 ± [illegible]
[illegible]	[illegible]	"	[illegible]	[illegible] ± 0.8	[illegible]
May '7[illegible]	C-Site	"	2	11 ± 1.2	0.87 ± [illegible]
[illegible]	C-Site	"	4	[illegible] ± 1.5	0.90 ± [illegible]
[illegible]	C-Site	"	7	16 ± 2	3.4 ± [illegible]
[illegible]	[illegible]	"	2	11 ± 2	1.6 ± [illegible]
[illegible]	Milrow Area	"	2	12 ± 2	1.6 ± [illegible]
[illegible]	C-Site	"	2	12 ± 0.5	1.7 ± [illegible]
[illegible]	[illegible]	"	2	18 ± 4.1	0.[illegible]
[illegible]	Camp Area	"	[illegible]	10 ± 0.6	1.5 ± [illegible]
[illegible]	[illegible]	"	1	[illegible] ± 0.6	0.76 ± [illegible]
[illegible]	C-Site	"	6	[illegible] ± 2.5	2.1 ± [illegible]
[illegible]	Long Shot	"	6	0.6[illegible] ± 1.0	0.27 ± [illegible]
[illegible]	Camp Area	"	5	[illegible] ± 2.3	0.66 ± [illegible]

a. [illegible] concentrations in samples collected from 1970 through 1972 are [illegible] the standard deviation of two or more single sample counts. [illegible] collected from 1970 to 1972 are from a single count [illegible] counting error. [illegible] of the table indicate the sample counts were not significant.

b. [illegible]

c. [illegible] from [illegible] Lake, C-Site, and [illegible] from Table 5.

[illegible] in [illegible] and [illegible] Samples Collected [illegible]

Collection Date	n[a]	Collection Location	Sample Type	pCi/g[b]	±2σ[c]
[illegible][d]	2	[illegible]	[illegible]	1.6	[illegible]
[illegible]	2	"	"	5.8	[illegible]
[illegible]	[illegible]	"	"	1.9	[illegible]
[illegible]	[illegible]	"	"	0.5	[illegible]
[illegible]	[illegible]	"	"	<1.[illegible]	
[illegible]	[illegible]	"	"	<0.[illegible]	
[illegible]	1	[illegible][e]	[illegible]	1.8	[illegible]
[illegible]	2	"	"	1.[illegible]	[illegible]
[illegible]	2	"	"	1.[illegible]	[illegible]
[illegible]	[illegible]	"	"	<1.[illegible]	
[illegible]	[illegible]	"	"	0.[illegible]	
[illegible]	1	[illegible]	[illegible], bone	31	[illegible]
[illegible]	1	"	"	[illegible]	[illegible]
[illegible]	1	"	"	[illegible]	[illegible]
[illegible]	[illegible]	"	"	17	1.[illegible]
[illegible][d]	1	[illegible]	[illegible], bone	27	1.[illegible]
[illegible]	1	"	"	11	[illegible]
[illegible]	1	"	[illegible]	17	1.4
[illegible]	1	"	"	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]
[illegible]	2	[illegible][f]	[illegible], bone	27	[illegible]
[illegible]	[illegible]	"	"	14	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	"	[illegible]	19	[illegible]
[illegible]	2	"	"	26	[illegible]
[illegible]	1	"	"	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Soil	0.0[illegible]	[illegible]
[illegible]	3	"	[illegible]	<0.[illegible]	
[illegible]	1	"	"	<0.[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Soil	<0.[illegible]	
[illegible]	3	"	"	<0.[illegible]	
[illegible]	3	"	"	<0.[illegible]	

a. [illegible] samples obtained from 2 to 4 [illegible].

b. [illegible] values for [illegible] samples ([illegible]), collected before [illegible] of a repeated count of the sample [illegible], propagated, [illegible] figures for 197[illegible], 1976, and 1977 [illegible] counts [illegible] value for more than one sample is the mean [illegible] of these individual sample values. In 1976 and 1977 a [illegible] was made for [illegible] and, in 1977, an additional [illegible] sample [illegible]. The [illegible] of these [illegible] on sample values, in terms of pCi [illegible], is about 0.5 for [illegible] ([illegible]), 0.3 for [illegible] ([illegible]) and [illegible] for soils ([illegible]).

c. [illegible].

d. [illegible]

e. [illegible]

f. [illegible] 12.

[illegible]le 14

[illegible] -Emitting Radionuclides in Sand and Soil Collected at [illegible] Island

Radionuclide, [illegible]

Type	Location	n	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I. [illegible] 1976									
Soil	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Soil	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—
Sand	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]	[illegible]	[illegible]
Sand	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
II. August 1976									
Soil	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]
Soil	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Sand	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]	[illegible]	[illegible]
Sand	[illegible]	[illegible]	[illegible]	—	—	—	[illegible]	[illegible]	[illegible]
III. [illegible] 1977									
Soil	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Soil	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	—
Sand	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]	[illegible]	—
Sand	[illegible] Beach	[illegible]	[illegible]	—	—	—	[illegible]	[illegible]	—

[illegible] count of the [illegible] [illegible] count is not significant.

Table 1? (continued)

[illegible]	[illegible]	[illegible]	[illegible]	Radionuclide ... (pCi/g)				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Entire	[illegible]	---	---	---	---	---
[illegible]	[illegible]	Entire	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Entire	[illegible]	[illegible]	[illegible]	[illegible]	---	---
[illegible]	20	Entire	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. [illegible] ^{226}Ra [illegible] for ... samples.

b. [illegible]

Table [illegible]

Tritium Concentration in Water Samples Collected at Amchitka Island, 1970-1977

Collection Date	Collection Locality	Number of Samples	Tritium Units	Range
I. [illegible]				
1970-71	d	13	32 ± 19	[illegible]
1972	d	6	20 ± 25	[illegible]
1973	d	6	22 ± 12	[illegible]
1974	d	6	<15	[illegible]
1975	d	6	<15	[illegible]
1976	d	6	<15	[illegible]
September 1977	Constantine Harbor	1	<15	[illegible]
"	Square Bay	1	<15	[illegible]
"	Sand Beach Cove	1	<15	[illegible]
"	Duck Cove	1	13 ± 11	[illegible]
II. [illegible], except [illegible] Area				
1970-71	d	17	92 ± 46	[illegible]
1972	d	62	49 ± 14	[illegible]
1973	d	46	50 ± 17	[illegible]
1974	d	44	32 ± 18	[illegible]
1975	d	29	24 ± 14	[illegible]
1976	d	35	30 ± 12	[illegible]
[illegible] 1977	Rain Gage (rainfall)	7	34 ± 6	[illegible]
[illegible] "	"	2	<24	[illegible]
[illegible] "	"	5	34 ± 3	[illegible]
August "	"	2	46 ± 20	[illegible]
Sept. "	"	3	34 ± 9	[illegible]
May	Clevenger Creek	1	17 ± 13	[illegible]
[illegible] "	"	1	23 ± 11	[illegible]
[illegible]	"	1	23 ± 11	[illegible]
May	Bridge Creek	1	32 ± 21	[illegible]
August "	"	1	13 ± 11	[illegible]
Sept.	"	1	41 ± 11	[illegible]
September 1977	[illegible] Spring	1	19 ± 12	[illegible]
"	[illegible] Lake	1	<16	[illegible]
"	Bone Lake Outlet	1	13 ± 11	[illegible]
"	Clevenger Lake Outlet	1	21 ± 12	[illegible]

Table 10 (Continued)

Collection Date	Collection Location	Number of Samples	Tritium Units[a]	[illegible]
II. [illegible] (cont.)				
September 1977	[illegible]	1	35 ± 12	[illegible]
"	[illegible]	1	29 ± 11	[illegible]
"	[illegible] Creek (Mouth)	1	28 ± 11	[illegible]
"	[illegible]	1	20 ± 11	[illegible]
"	[illegible] Creek (at road)		31 ± 10	[illegible]
"	[illegible] 12 Creek	1	29 ± 11	[illegible]
"	Conklin Lake Inlet (underground flow)		14 ± 11	[illegible]
"	Conklin Lake Inlet (near Bell Rock)	1	42 ± 12	[illegible]
"	Conklin Lake [illegible] (A Site Inlet)	1	20 ± 9	[illegible]
"	Conklin Lake Station #1 Surface	1	<15	
"	Conklin Lake Station #1 Bottom		<16	
"	Conklin Lake Station #2 Surface		46 ± 12	[illegible]
	Conklin Lake Station #2 Bottom	1	27 ± 12	[illegible]
"	Conklin Lake Station #3 Surface	1	36 ± 12	[illegible]
"	Conklin Lake Station #3 Bottom		31 ± 12	[illegible]
"	Conklin Lake Station #4 Surface		18 ± 12	[illegible]
"	Conklin Lake Station #4 Bottom	1	30 ± 9	[illegible]
"	Conklin Lake Outlet	2	20 ± 10	[illegible]
"	Ice Box Lake Inlet		25 ± 11	[illegible]
"	Ice Box Lake Outlet	1	<14	
"	DK 45 [illegible]	1	22 ± 11	[illegible]
	Soap Sand Beach Cove	2	22 ± 8	[illegible]
III. Long Shot [illegible]				
1970-1972	[illegible]	3	[illegible]	[illegible]
1973	"	1	[illegible]	[illegible]
1975	"	1	[illegible]	[illegible]

Table 15 (Continued)

Collection Date	Collection Location	Number of Samples	Tritium [illegible]	[illegible]	[illegible]
III. Long Shot Mud Pits (cont.)					
1976	Mud Pit #3	1	1150 ± 23	[illegible]	[illegible]
1977	"	1	95[illegible] ± 23	[illegible]	[illegible]
1976	Mud Pit [illegible]	1	1140 ± 23	[illegible]	[illegible]
1977	"	1	751 ± 20	[illegible]	[illegible]
1973-74[c]	Mud [illegible] #4	3	1800 ±350	[illegible]	
1974	"	4	2520 ±240	[illegible]	[illegible]
1975	"	2	1950 ±420	[illegible]	[illegible]
1976	"	2	1360 ±250	4[illegible]	
1976	"	1	192 ± 11	[illegible]	[illegible]
1976	"	2	726 ± 12	[illegible]	[illegible]
1977	"	2	651 ± 27	[illegible]	[illegible]
IV. Long Shot Mud Pit Drainage					
August 1975	3 meters below Mud Pit #1	1	872 ± 19	[illegible]	[illegible]
"	Infinity Road	1	666 ± 16	[illegible]	
"	100 meters below road	1	424 ± 15	[illegible]	[illegible]
"	500 meters below road	1	89 ± [illegible]	[illegible]	[illegible]
	200 meters above Sea Bay	1	121 ± [illegible]	[illegible]	[illegible]
"	Mouth of creek	1	197 ± 13	[illegible]	
August 1976	3 meters below Mud Pit #1	1	739 ± 19	[illegible]	
"	Infinity Road	1	592 ± 14	[illegible]	
"	100 meters below road	1	278 ± 14	[illegible]	
"	200 meters below road[d]	1	[illegible] ± 13	[illegible]	
"	400 meters below road[d]	1	100 ± 12	[illegible]	[illegible]
"	500 meters below road	1	53 ± [illegible]	[illegible]	
"	200 meters above Sea Bay	1	48 ± 11	[illegible]	[illegible]
"	20 meters above Sea Bay	1	27 ± [illegible]	[illegible]	
September 1977	Infinity Road	1	454 ± 16	[illegible]	[illegible]
"	100 meters below road	1	148 ± [illegible]	[illegible]	[illegible]
"	200 meters below road	1	84 ± 12	[illegible]	
"	300 meters below road[d]	1	57 ± 12	[illegible]	

[illegible] (Continued)

Location / Date	Collection Location	Number of Samples	[illegible]	[illegible]
[illegible] (Cont.)				
[illegible]	[illegible]	1	[illegible]	[illegible]
	[illegible]	1	[illegible]	[illegible]

a. [illegible] individual sample values.

b. [illegible]

c. [illegible]

d. [illegible]

e. A small lake formed in the north fork of [illegible] Creek after [illegible] in this site.

f. [illegible]

Table [illegible]

Tritium in Free Water from Biological
Samples Collected at Amchitka Island

[illegible] Type	Tissue	Collection Location	Collection Date	n	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Constantine Harbor	Aug '75	2	25±18		
	"	"	Aug '76	1	[illegible]		
	"	"	Sept '77	1	[illegible]		
	"	Square Bay	Aug '75	3	20±12		
	"	"	Aug '76	2	[illegible]		
		"	Sept '77	1	[illegible]		
	"	Sand Beach Cove	Aug '75	[illegible]	[illegible]		
	"	"	Aug '76	3	[illegible]		
	"	"	Sept '77	[illegible]	[illegible]		
	"	Duck Cove	Aug '76	3	[illegible]		
	"	"	Sept '77	[illegible]	[illegible]		
[illegible]	Muscle	Constantine Harbor	May '74	2	[illegible]		[illegible]
	"	"	Aug '75	1	[illegible]	[illegible]	
	"	"	Aug '76	1	[illegible]		
	"		Sept '77	2	[illegible]		
	"	Square Bay	Aug '75	[illegible]	[illegible]		[illegible]
	"		Aug '76	1	[illegible]		
	"	"	Sept '77	1	17±10		
	"	Sand Beach Cove	May '74	3	[illegible]	[illegible]	
	"		Aug '75	2	[illegible]	[illegible]	[illegible]
"	"	"	Aug '76	3	[illegible]		[illegible]
	"		Sept '77	[illegible]	[illegible]		
	"	Duck Cove	Aug '75	1	[illegible]		
	"		Sept '77	1	[illegible]		
[illegible] Varden	Muscle	Ice Box [illegible]	[illegible]	3	[illegible]		
		White Alice Creek	Aug '7[illegible]	2	[illegible]		
		Bridge Creek	Aug '73	4	[illegible]		
		"	Aug '75	2	[illegible]		
		Duck Cove	Aug '76	2	[illegible]		
	"	"	Sept '77	1	[illegible]		
		Jones Lake	May '74	[illegible]	[illegible]		
		"	Aug '75	4	[illegible]		
		"	Aug '76	1	50±13		
	"	"	Sept '77	1	[illegible]		
	"	Cannikin Lake	Aug '75	1	[illegible]		
	"	"	Aug '76	1	[illegible]		
[illegible]	Entire	Duck Cove Creek	Aug '73	[illegible]	[illegible]		
	"	White Alice Creek	Aug '75	2	69±28		
	"	Bridge Creek	Aug '75	2	[illegible]		
	"	Long Shot Pond	Aug '76	1	120±17		
[illegible]	Entire	Clevenger Creek [illegible]	Aug '75	[illegible]	105±18		
	"		Sept '77	1	27±16		
		"	Aug '76	2	97±14		
	"	White Alice Creek	Aug '75	2	35±28		
		"	Aug '76	1	72±17		
		"	Sept '77	1	[illegible]		

T[illegible] 17 (Continued)

[illegible]	[illegible]	Collection Location	Collection Date	n[a]	Tritium Unit[b]	±	[illegible][b]
[illegible]	[illegible]	[illegible] 1	Aug '76	2	[illegible]	[illegible]	[illegible]
	"	" 2	Sept '77	1	[illegible]		[illegible]
	"	" 3	Aug '76	2	56 [illegible]	[illegible]	[illegible]
	"	"	Sept '77	1	[illegible]	[illegible]	36
	"	[illegible] 4	Aug '76	1	[illegible]		
		"	Sept '77	1	77 [illegible]	[illegible]	[illegible]
	"	[illegible] 5	Aug '76	1	[illegible]	[illegible]	[illegible]
		[illegible] 6	[illegible]	1	[illegible]	[illegible]	[illegible]
	"		Sept '77	1	60 [illegible]	[illegible]	[illegible]
	"	[illegible]	Aug '76	2	[illegible]	[illegible]	[illegible]
	"	[illegible]	Sept '77	[illegible]	[illegible]	[illegible]	[illegible]
	"	[illegible]	Aug '76	[illegible]	[illegible]	[illegible]	[illegible]
	"	[illegible]	Sept '77	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Camp Area	Aug '76	2	[illegible]	[illegible]	
	"		Sept '77	[illegible]	71 10	[illegible]	32
	"	[illegible]	Aug '76	2	40 17	[illegible]	[illegible]
	"		Sept '77	2	36 [illegible]	[illegible]	[illegible]
	"	[illegible]	Aug '76	[illegible]	36 [illegible]	[illegible]	[illegible]

a. n equals the number of [illegible] samples [illegible]

b. [illegible] values for single samples [illegible] mean of [illegible] of the results [illegible] one sigma [illegible] counting errors. The [illegible] value shown for more [illegible] deviation of these individual sample values.

c. [illegible]

d. [illegible] meters below Industry Sand.

e. Site [illegible] 200 meters upstream from [illegible].

f. Site [illegible] 25 meters upstream from [illegible].

Table 18

[illegible]

[illegible]

Sample Type	Collection Location	[illegible] 1977		[illegible] 1977		[illegible] 1977	
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Sand Beach Camp	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<0.3	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	—		—	[illegible]	[illegible]
[illegible]	Sand Beach Camp	<0.007	<0.4	<0.003	<0.3	[illegible]	[illegible]
[illegible]	[illegible]	<0.003	<0.1	<0.003	<0.3	<0.003	<0.3
[illegible]	Sand Beach Camp	[illegible]	—	<0.003	—	[illegible]	—
[illegible]	[illegible]	<0.003	—	[illegible]	—	[illegible]	—
[illegible]	[illegible]	[illegible]	—	[illegible]	—	[illegible]	—
Soil, Surface	[illegible]	[illegible]		<0.003	—	[illegible]	—
Soil, Surface	[illegible]	[illegible]	—	[illegible]	—	[illegible]	—
Soil, Surface	[illegible]	[illegible]	—	<0.003	—	[illegible]	—
Soil, Surface	Camp [illegible]	[illegible]	—	[illegible]	—	[illegible]	
Soil, Surface	Camp [illegible]	[illegible]	—	[illegible]	—	[illegible]	—

a. [illegible]

b. [illegible] 2.5 cm layer.

Table 19

[illegible]

[illegible]	[illegible]				[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	<0.01	[illegible]	0.01	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	<0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	<0.01	[illegible]	0.01	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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Year	Report No.	Author
1970-71	NVO-269-11	[illegible]
1972	NVO-269-15	Held, E. E.
1972	NVO-269-19	Held, E. E., et al.
1973	NVO-269-[illegible]	Nelson, V. A., and A. H. [illegible]
1974	NVO-269-22	Nelson, V. A., and A. H. [illegible]
1975	NVO-269-27	Nelson, V. A., and A. H. [illegible]
1976	NVO-269-[illegible]	Nelson, V. A., and A. H. [illegible]

6. [illegible]

[illegible] Site	Figure No. (s)	Table No. (s)
[illegible]	[illegible]	13
[illegible]	2 [illegible] 3	2, 13, 19
[illegible]	1 [illegible] 2	9, 10
[illegible] Creek	4	3, 4, 11, 16, 17
[illegible] Lake [illegible]	6	16
[illegible]	6	6, [illegible], 16, [illegible]
[illegible] Lake [illegible]	6	[illegible], 16, 17
[illegible] Lake [illegible]	6	16
[illegible] Lake [illegible] [illegible]	6	6, 16
[illegible]	[illegible] 6	12, [illegible], 14, 18, [illegible]
[illegible] Cove [illegible]	7	[illegible]
[illegible]	4	6, 13, 16
[illegible] Creek	4	3, 4, [illegible], 13, 16
[illegible] Lake Outlet	[illegible]	7, 16
[illegible] Harbor	7 [illegible]	7, 9, 10, [illegible], 14, [illegible], [illegible], 13
[illegible] Harbor	3	16
[illegible] Spring	3	12, 14
[illegible] Point	2 [illegible]	7
[illegible]	2	19
[illegible]	3	19
[illegible] Cove [illegible]	3	7, [illegible], 10, 11, 12, 17
[illegible] Cove [illegible]	4	3, 4, 11, 16
[illegible] Cove [illegible]	4	16
[illegible]	2	19
[illegible]	3	19
[illegible] Lake	7	13, 16
[illegible] Bay [illegible]	[illegible]	19
[illegible]	6	None
[illegible]	6	[illegible]
[illegible] Lake ([illegible])	6	6, 16
[illegible] Lake [illegible]	6	2, 16, 17
[illegible] Road	2 [illegible] 6	None
[illegible] Lake	[illegible]	[illegible], 15, 16, 17, [illegible]
[illegible] Lake Outlet	[illegible]	16, 19
[illegible]	6	[illegible]
[illegible] Outlet	[illegible]	None
[illegible]	[illegible]	15, 16
[illegible]	2, 7, 8	[illegible], 15, 16, 19
[illegible] Drainage	4 [illegible]	3, 4, 16, 17
[illegible] Camp	3	12, [illegible], 14, 18, [illegible]
[illegible] Cove	2	9
[illegible]	2	12, 13
[illegible]	2	12, 13
[illegible]	2 [illegible] 4	12, 19, 13, 17
[illegible] Creek	5	3, 16
[illegible]	4	16
[illegible] Range Target Area	4	19
[illegible] Cove	6	7, 8, 10, 13, [illegible]

[illegible] (CONTINUED)

[illegible]	Figure No.(s)	Table No.(s)
[illegible]	[illegible]	16
[illegible]	2	5
[illegible] Lake	6	13
[illegible] Dock [illegible]	3	None
[illegible]	2	12
[illegible]	1	16
[illegible] Bay	4	7, 8, 9, 10, 16, 17
[illegible] Creek	6	3, 4, 5, 16, 17

[illegible]

[illegible] (16)
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] (2)
[illegible]
[illegible]
[illegible]
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[illegible]
[illegible] Dept. of the Interior, Washington, DC
[illegible], Dept. of Commerce, [illegible], DC
[illegible], Dept. of the Interior, Washington, DC
R. F. [illegible], Fish & Wildlife Service, Washington, DC
[illegible], Fish & Wildlife Service, Portland, OR
D. [illegible], Alaska Cooperative Wildlife Research Unit, College, AK
J. [illegible], Fish & Wildlife Service, Anchorage, AK [illegible]
J. [illegible], Fish & Wildlife Service, [illegible], AK (2)
[illegible], Fish & Wildlife Service, [illegible], CA
[illegible], Fish & Wildlife Service, Cold Bay, AK
[illegible], National Marine Fisheries Service, Dept of Commerce, [illegible], AK
[illegible], National Marine Fisheries Service, Dept [illegible], AK
Commissioner of Fish and Game, State of Alaska, Juneau, AK [illegible]
Commissioner of Environmental Conservation, Alaska State [illegible], [illegible], AK
[illegible], Health & Social Services, State of Alaska, [illegible], AK
[illegible], Alaska Dept of [illegible], Anchorage, AK
[illegible], Anchorage, AK
[illegible], Anchorage, AK
[illegible], Defense Nuclear Agency, Kirtland AFB, NM
J. C. [illegible] (2)
[illegible] (2)
[illegible] (2)
[illegible], Sandia Laboratories, [illegible], NM
[illegible], Sandia Laboratories, [illegible], NM
[illegible], Denver, CO (2)
[illegible] (2)
[illegible], Environmental [illegible]
[illegible]
[illegible]

[illegible], College of Veterinary Medicine, Washington State University, Pullman, WA
[illegible], [illegible], Fayetteville, AR
[illegible], [illegible], [illegible], TX
[illegible], Dept. of Zoology, Oklahoma State University, [illegible], OK
[illegible], Laboratory of Radiation Ecology, University of [illegible] (1-0)
[illegible], University of [illegible], [illegible], FL
[illegible], University of Tennessee, Knoxville, TN
[illegible], University of Arkansas, [illegible], AR
[illegible], [illegible], [illegible], OR
[illegible], University of [illegible], [illegible]
[illegible], Oregon State University, Corvallis, OR
[illegible], Columbia [illegible], Corvallis, OR
[illegible], [illegible], [illegible], NV
[illegible], Las Vegas, NV
[illegible], Desert Research Institute, University of Nevada, Reno, NV
[illegible], [illegible], Idaho Falls, ID
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[illegible], Technical Information Center, [illegible], NV (2)
[illegible], [illegible], NV
[illegible], [illegible], NV (2)
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[illegible], [illegible], NV
[illegible], [illegible] Division, NV (10)
[illegible], Corvallis, OR
[illegible] Information Center, [illegible], TN, for [illegible] distribution in Category [illegible] (Environmental and Earth Sciences) (225)

APPENDIX 2

RESULTS OF PLUTONIUM AND GAMMA SPECTRUM ANALYSES OF ENEWETAK PLANT, RAT AND SOIL SAMPLES COLLECTED IN MARCH 1976

APPENDIX 2

UNIVERSITY OF WASHINGTON

LABORATORY OF RADIATION ECOLOGY

RESEARCH RESULTS

January 26, 1978
A. Nevissi

Principle Investigator: Dr. William R. Schell
Subject: Results of Plutonium and Gamma Spectrum Analyses of Enewetak Plant, Rat, and Soil Samples Collected in March, 1976

Rat, plant, and soil samples from [illegible] were sent to our laboratory by Dr. Jack [illegible] for gamma counting and plutonium analysis. These samples had been [illegible], dried, and [illegible] by [illegible]'s group.

The soil samples [illegible] standard sample holders and counted [illegible] 400 minutes [illegible] detector system. The gamma-counting results [illegible] soil samples are given in Table 1. The quantity of the individual [illegible] samples [illegible] sufficient to fill the standard sample holder. [illegible] standard sample holder in batches of [illegible] for gamma counting. The results of analyses for gamma-emitting [illegible] are given in Table 2.

After gamma-counting, the samples [illegible] for plutonium analysis were spiked with [illegible] chemical yield [illegible]. The laboratory [illegible] standard method [illegible] for [illegible] purification of plutonium. Finally, plutonium [illegible] electroplated on [illegible] steel disc and measured with a [illegible] alpha-detector and [illegible]-height analyzer. The results of plutonium analysis are shown in Table [illegible].

cc: Seymour
Schell
Nevissi

Table [illegible]. Gamma-Emitting Radionuclides in Soil Samples Collected by Dr. William [illegible] at Enewetak in March, 1976. Values in pCi/g dry weight of sample.*

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	—	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	—	[illegible]	—	—	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	—	—	—
[illegible]	[illegible]	—	[illegible]	[illegible]	—	—	—	[illegible]	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	—	—	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	—
[illegible]	[illegible]	[illegible]	—	—	—	[illegible]	—	—	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]	—	—	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	—	—	—	—
[illegible]	[illegible]	—	0.7 ± 0.1	—	—	—	—	—	—	—	

* All counts are for single samples and the error term is the two sigma, propagated, counting errors; less than (<) values are blank. + The standard deviation divided by sample weight.

Table [illegible]. Plutonium-239,240 and Plutonium-238 in Rat, Plant, and Soil Samples Collected by Dr. [illegible] [illegible] of Enewetak in March 197[illegible]. Values in pCi/g Dry Weight of Sample.*

Sample	Sample Type	$^{239,240}Pu$	^{238}Pu
11	Rat Lung	0.10[illegible] ± 0.03[illegible]	0.057 ± [illegible]
12	Rat Bone	0.04[illegible] ± 0.016	0.043 ± 0.012
13	Rat Liver	0.[illegible] ± 0.007	0.024 ± 0.005
14	Rat Skin	0.[illegible] ± 0.06	0.[illegible] ± 0.03
15	Rat Muscle	0.084 ± 0.02[illegible]	0.049 ± 0.0[illegible]
16	Rat Lung	<0.00[illegible]	<0.007
17	Rat Bone	0.0[illegible] ± 0.03	0.06 ± 0.0[illegible]
18	Rat Liver	0.02[illegible] ± 0.006	0.012 ± 0.004
19	Rat Skin	0.8[illegible] ± 0.28	0.51 ± 0.1[illegible]
20	Rat Muscle	0.[illegible] ± 0.00[illegible]	0.051 ± 0.010
22	Rat Bone	0.1[illegible] ± 0.0[illegible]	0.052 ± 0.0[illegible]
23	Rat Liver	0.0[illegible] ± 0.006	0.015 ± 0.003
24	Rat Skin	0.[illegible] ± 0.0[illegible]	0.75 ± 0.07
25	Rat Muscle	0.0[illegible] ± 0.01[illegible]	0.032 ± 0.009
26	Rat Lung	<0.0[illegible]	<0.014
27	Rat Bone	0.00[illegible]	<0.0028
28	Rat Liver	0.00[illegible] ± 0.003	0.001
29	Rat Skin	0.2[illegible] ± 0.08	0.06 ± 0.03
30	Rat Muscle	<0.0[illegible]	0.34 ± 0.[illegible]
31	Rat Lung	0.04[illegible] ± 0.00[illegible]	<0.005
32	Rat Bone	<0.00[illegible]	<0.004
33	Rat Liver	<0.00[illegible]	<0.001
35	Rat Muscle	<0.00[illegible]	<0.003
36	Rat Lung	<0.00[illegible]	0.009
37	Rat Bone	<0.00[illegible]	0.005 ± 0.00[illegible]
38	Rat Liver	0.0[illegible] ± 0.003	0.003 ± 0.00[illegible]
39	Rat Skin	0.0[illegible] ± 0.03	0.02 ± 0.0[illegible]5
41	Rat Muscle	<0.00[illegible]	<0.002
42	Rat Ear	0.0[illegible] ± 0.0[illegible]	0.03 ± 0.01[illegible]
SS-1	Scaevola Pollen	0.[illegible] ± 0.058	0.337 ± 0.[illegible]
SS-2	"	0.[illegible] ± 0.07	0.29 ± 0.[illegible]
SS-3	"	0.0[illegible] ± 0.01	0.04 ± 0.[illegible]
SS-4	"	<0.00[illegible]	0.03 ± 0.[illegible]
SS-5	"	0.[illegible] ± 0.1[illegible]	0.47 ± 0.1[illegible]
SS-6	"	0.0[illegible]	0.21 ± 0.[illegible]

Table 3. Continued

Sample#	Sample type	[illegible]	[illegible]
DS-1	Soil 0.[illegible] from crater	214 ± 27.7	134 ± 14.0
DS-2	Soil "	134 ± [illegible]	74.1 ± [illegible]
DS-3	Soil "	130 ± [illegible].7	71.4 ± 6.45
DS-4	Soil 200' from crater	5.3[illegible] ± 0.28	0.77 ± [illegible]
DS-5	Soil "	4.00 ± 0.[illegible]7	2.89 ± [illegible]
DS-6	Soil "	2.66 ± 0.[illegible]	[illegible].84 ± [illegible].29

* All counts are for [illegible] sample [illegible] the one sigma, propagated counting error. Less than (<) values are blank values and one standard deviation divided by sample weight.

APPENDIX

APPENDIX 3

RADIOLOGICAL SURVEY OF PLANTS, ANIMALS AND SOIL IN MICRONESIA

NOVEMBER 1975

by

Victor A. Nelson

NVO-263-35

RADIOLOGICAL SURVEY OF PLANTS, ANIMALS, AND SOIL IN MICRONESIA, NOVEMBER 1975

by

Victor A. Nelson

28 April 197[illegible]

University of Washington
College of Fisheries
Laboratory of Radiation Ecology
Seattle, Washington 98195

Prepared for the U. S. Department of Energy
Nevada Operations Office under Contract No. EY-76-S-08-0269

INTRODUCTION

From 1946 to 1958 atomic devices were detonated under water, over water, on land or in the atmosphere over the waters of the central Pacific. Most of these tests took place at Bikini and Enewetak atolls in the Marshall Islands and some at Johnston, Christmas and Malden Islands further east. The distribution of radionuclides produced by these tests has been studied extensively, especially at Bikini and Enewetak atolls. The present study is part of a Laboratory of Radiation Ecology program begun in 1974 and described in a previous report (Nelson, 1977). The purpose of this study was to determine qualitatively and quantitatively radionuclides presently found in certain foods and soils in areas of Micronesia other than those areas of the local fallout during the test periods. Areas sampled were Majuro Atoll in the Marshall Islands, Truk and Ponape in the Caroline Islands, Guam in the Mariana Islands and Koror and Babelthuap in the Palau Islands. Data on samples collected in these areas will provide a comparison with the amounts and kinds of radionuclides found in similar samples from Bikini and Enewetak atolls.

SAMPLING PROGRAM

The areas mentioned above were visited in November 1975. In Figure 1 these areas are shown in relationship to the test sites at Bikini and Enewetak atolls, while in Figures 2 and 3 the collection sites within these areas are shown. The trip was a joint survey with personnel from Brookhaven National Laboratory (BNL) who took radiation survey readings with sodium iodide (NaI) scintillation detectors and a pressurized ion chamber. The results of the survey readings will be given in a separate BNL report. Personnel from

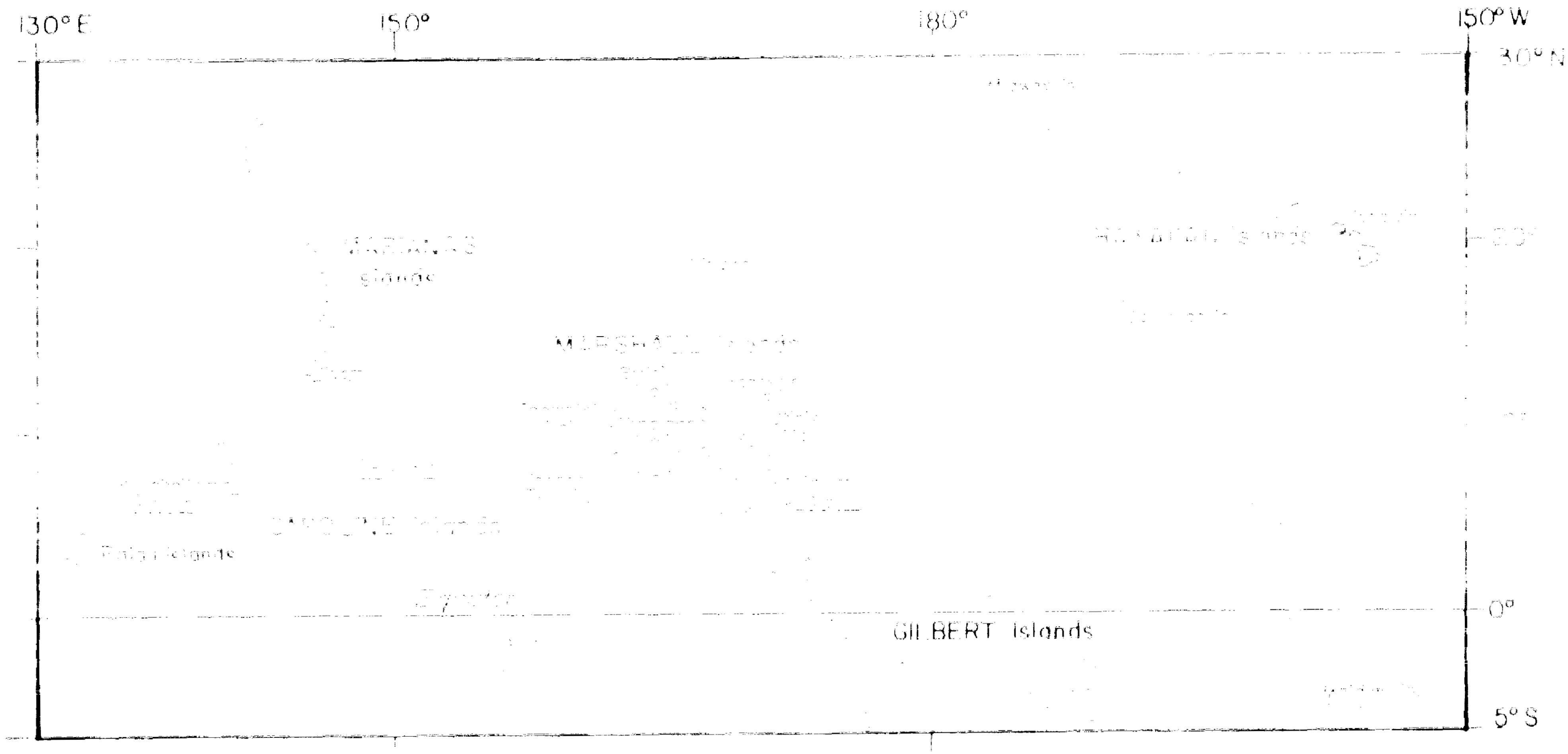

Figure 1. Sampling locations (underlined) in Micronesia, November 197[illegible]

Figure [illegible]. Locations sampled at Ponape, Truk, Guam and Palau in [illegible]

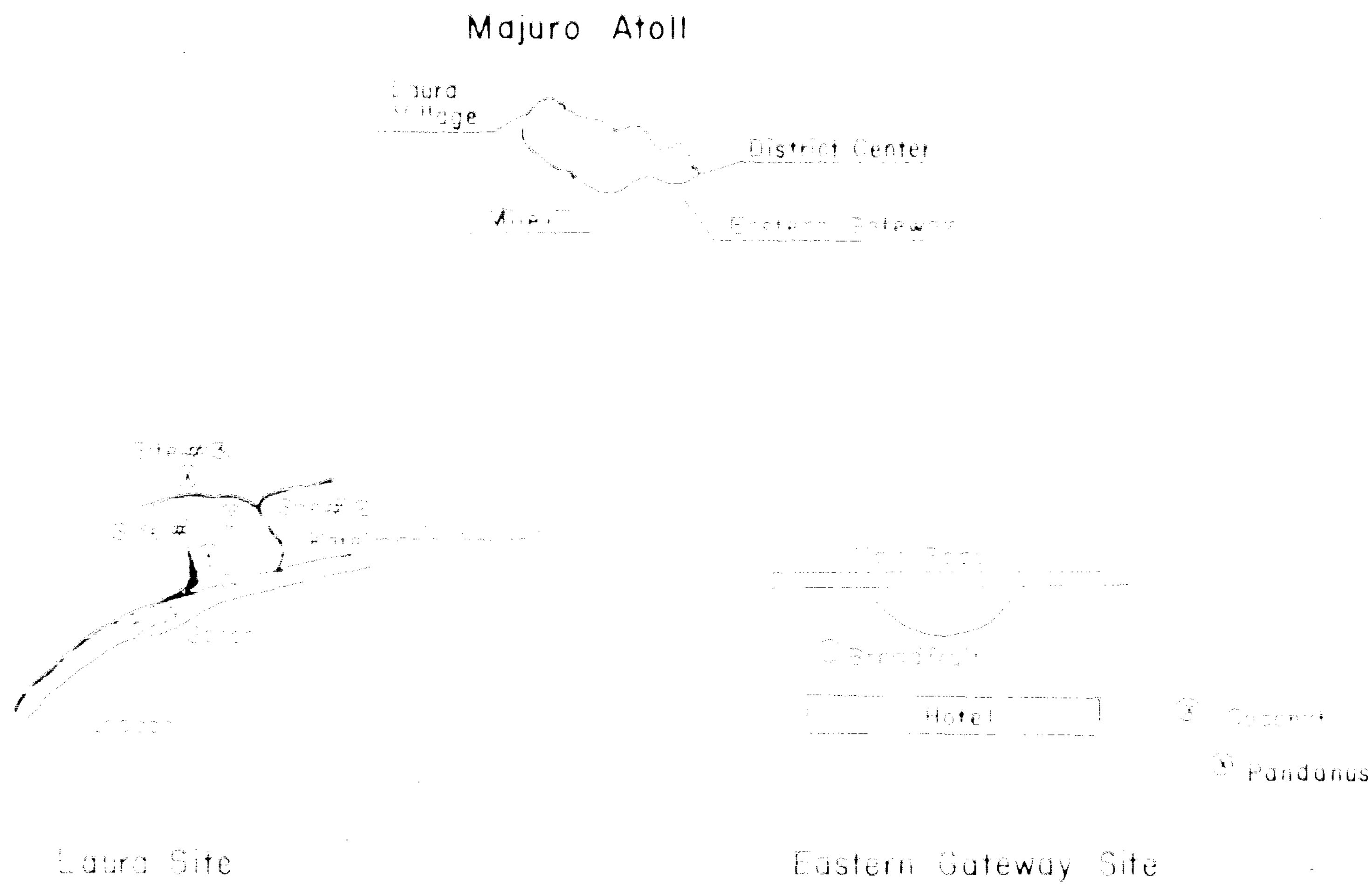

Figure 3. Locations sampled at Majuro Atoll in November 197[illegible].

Laboratory collected representative biological and soil samples with emphasis on food items common to the diet of the Marshallese people (i.e., fish, chicken, pandanus, breadfruit, coconut crabs, etc.) although nonstaple food items of these items were also collected and analyzed. Soils were collected to provide data for estimation of future distribution and quantities of radionuclides in the environment and biota.

The number of samples, after division into tissues or soil fractions, is shown in Table [illegible]. Seventy percent of the samples were biological - plants, fish, and coconut crabs - and thirty percent were soils - surface (0-2.5cm) and profile (0-50cm). Approximately equal numbers of samples came from each of five major collection areas.

ANALYTICAL METHODS

Gamma-Ray Spectrometry

All of the samples were analyzed by gamma-ray spectrometry either with a [illegible] X [illegible] sodium iodide (thallium-drifted) crystal and 200-channel pulse-height analyzer or with a germanium (lithium-drifted) diode detector and [illegible]-channel, pulse-height analyzer. Soil samples were analyzed on the Ge(Li) system, and the biological samples were analyzed on both systems.

All samples were oven dried, ground and a portion compressed into sample holders of polyvinyl chloride (PVC) pipe 2 inches in diameter and either 1.2 or [illegible] cm for radionuclide measurement. Fifty grams of tissue or [illegible] grams of soil could be compressed into the 2" X 1" holder. The densities of the biological and soil samples were 1.0 and [illegible], respectively. These samples were then analyzed for gamma-emitting radionuclides.

The gamma-emitting radionuclides in the samples counted on the NaI crystal were determined by a method of least squares. The radionuclide values for samples counted on the Ge(Li) detector were calculated either manually or with

Table 1. Disposition of Samples Collected on the November 1978 Trip to Micronesia.

Sampling Location	Samples Processed[a]			Samples Analyzed		
	Plants	Soil	Fish	γ	^{90}Sr	$^{239,240}Pu$
Majuro	29	12	8	47	26	18
Ponape	23	13	14	56	30	17
Truk	31	14	1	46	14	12
Guam	11	13	5	29	16	7
Palau[b]	25	15	3	43	23	13
Total	119	67	31	[illegible]	109	67

a. The number given is the total after the samples have been divided into tissues or increments of soil depth.

b. Three coconut crabs were also collected on an island south of Koror. The muscle, hepatopancreas, and exoskeletons from these crabs were ashed and analyzed for gamma-emitting radionuclides plus ^{90}Sr and $^{239,240}Pu$.

calculated by adding the counts in an energy range of five channels in a peak in the spectrum, subtracting the appropriate background counts, and applying correction factors to convert counts to picocuries (pCi). A set of previously counted reference spectra for the type of sample holder and radionuclide was used. All values were corrected for decay to the date of collection.

Strontium-90 and Plutonium Analyses

To measure ^{90}Sr content, ^{90}Y was chemically separated from ^{90}Sr, [illegible] on a filter paper and counted with a low-level beta counting system. Plutonium was extracted by ion exchange, electroplated on platinum discs, and [illegible] by alpha spectrometry with systems using surface barrier alpha detectors and pulse-height analyzers. Chemical yield was determined by use of [illegible] Pu tracer.

Error Limits

For a single sample, the errors given for all radionuclides listed are two-sigma, propagated, counting errors. The error term for the mean of more than one sample is one standard deviation and disregards counting errors.

Limits of Detection

Many factors influence the limit of detection, including the type of detector and analyzer, the presence of other radionuclides, the duration of the counting period, the size and density of the sample, and the geometric relationship of the sample and detector. Hence, the limits of detection varied considerably for various radionuclides and types of samples, but can be summarized by stating that detection limits were approximately as follows:

By gamma detection

^{40}K	2.1 pCi/g or less
[illegible]	0.41 [illegible]
^{60}Co, ^{125}Sb, ^{137}Cs, ^{210}Pb, ^{226}Ra, ^{232}Th, ^{238}U	0.12 pCi/g or less

By beta detection

^{90}Sr	0.2 pCi/g or less

By alpha detection

$^{239,240}Pu$	0.02 pCi/g or less

RESULTS AND DISCUSSION

Data are presented in Appendix Tables 1 through 11 for the results of the analyses of the samples collected by RMP in Micronesia in 1975. All data are given as picocuries per gram of dry weight (pCi/g, dry), except where specifically noted. Table 2 gives the mean wet weight to dry weight ratios for the biological samples. Thus the pCi/g, dry values may be converted to pCi/g, wet for purposes of computing dietary intake of the measured radionuclides. Since there are greater differences in the radioactivity values between sample types than areas of collection, other than soil, the results will be discussed by sample type.

Fish

Seven species of fish were collected from one or more of the five atolls. Goatfish, mullet and surgeonfish were the most common fish available and were collected at three sites each. As shown in Appendix Table 1, naturally occurring ^{40}K was the only radionuclide measured in fish tissues at a concentration greater than 0.6 pCi/g, dry and the average value was 4.6 pCi/g dry tissue. Cesium-137 was detected in only 6 of 31 samples. The maximum concentration of ^{137}Cs measured was 1.9 pCi/g, dry in the viscera of [illegible] from Ponape. Strontium-90 was detected in 1 of 35 tissue samples analyzed

Table 2. [illegible] Values and Wet Weight to Dry Weight Ratios of Some Micronesian Organisms.

Species	Number of Samples	Item	Mean Wet/Dry Ratio	Deviation
		FISH		
Mullet	(4)	Eviscerated Whole	3.[illegible]	± .[illegible]
"	(4)	Viscera	4.66	± .[illegible]
"	(1)	Entire	[illegible].56	
Parrotfish	(2)	Muscle	4.30	± .1[illegible]
"	(2)	Viscera	4.96	± .07
"	(2)	[illegible]	3.65	± .1[illegible]
Goatfish	(6)	Eviscerated Whole	3.[illegible]7	± .1[illegible]
"	(6)	Viscera	4.31	± .2[illegible]
Snapper	( )	Viscera	4.25	
"	(1)	Eviscerated Whole	3.76	
Flagtail	(1)	Viscera	3.72	
"	(1)	Eviscerated Whole	3.69	
Convict Surgeon	(1)	Viscera	[illegible].96	
" "	(1)	Eviscerated Whole	3.50	
Jack	(1)	Entire	3.02	
		PLANTS		
Breadfruit	(12)	Edible	6.17	± 1.1[illegible]
"	(12)	Inedible	6.24	± 1.1[illegible]
	(13)	Leaves	4.28	± .6[illegible]
Pandanus	(12)	Edible	7.21	± 1.1[illegible]
	(13)	Inedible	4.22	± .[illegible]
	(10)	Leaves	3.56	± .37
Coconut	(11)	Meat	2.60	± .37
	(3)	Leaves	2.27	± .2[illegible]
"	(7)	Copra	1.12	± .[illegible]
Taro	(5)	Edible	2.71	± .5[illegible]
"	(2)	Leaves	7.00	± .2[illegible]
"	(2)	[illegible]	14.20	± 1.5[illegible]
Papaya	(7)	Edible	12.19	± 3.[illegible]
"	(7)	Inedible	10.49	± 2.14
"	(7)	Seeds	4.32	± 1.3[illegible]
Cassava	(1)	Root	2.38	
Banana	(1)	Edible	4.07	

Table 7 (continued)

Species	Number of Samples	Tissue	Mean Wet/Dry Ratio	Deviation
		INVERTEBRATES		
Coconut crab	(1)	[illegible]	1.5[illegible]	
" "	(1)	Hepatopancreas	2.86	
" "	(1)	Muscle	4.[illegible]	

while ^{239,240}Pu was not above the limits of detection in any of the other samples analyzed.

The amount of ^{137}Cs in these fish was less than the amount reported (Robison, 1977) in fish from Utirik, Rongelap, and Ailinginae Atolls in the northern Marshall Islands which have low radiation levels, but which did receive some local fallout during the testing at Bikini and Enewetak atolls. The amount of ^{137}Cs in the few (6 of 20) fish samples which contained ^{137}Cs in quantities greater than our limits of detection was similar to ^{137}Cs concentrations in fish from Amchitka Island in the Aleutians (Nelson and Seymour, 1977), and in fish collected from Japanese coastal waters in 1973 and 1974 ([illegible], 1976).

The concentrations of ^{90}Sr and ^{239,240}Pu are also below the limits of detection in fish samples from the other atolls noted above and in the fish samples analyzed for this report.

Coconut Crabs

Three coconut crabs from Palau were dissected and the tissues pooled for analysis. Results of these analyses are shown below in pCi/g, dry.

Tissue	^{40}K	^{60}Co	^{137}Cs	^{90}Sr	[illegible]
Exoskeleton	17.0 ± [illegible]	2.2 ± 0.85	1.5 ± 0.09	[illegible]1.7 ± [illegible]	[illegible]
Hepatopancreas	ns[a]	ns	0.17 ± 0.09	<0.25	[illegible]
Muscle	[illegible]	ns	0.20 ± 0.09	<0.23	[illegible]

a. not significant

The values for ^{90}Sr and ^{137}Cs in these crabs are less by a factor of [illegible] than amounts in coconut crabs from Rongelap and Ailinginae atolls and are similar to amounts found in crabs from Kwajalein Atoll, which did not receive any appreciable local fallout from the testing at the Pacific Test Sites.

Plants

Four species of plants, pandanus, coconut, breadfruit and papaya, were collected from one to three sites within each of the five major collection locations. In addition bananas, taro and cassava were collected at some sites. Results of the analysis of these samples are given in Appendix Tables 2 through 6.

Naturally occurring ^{40}K was the most abundant radionuclide measured in the plant samples. Of the fallout radionuclides only ^{137}Cs was detected in more than 50 percent of the samples. Most values of ^{137}Cs were less than 1 pCi/g, but a value of 48 pCi/g was measured in the edible portion of a pandanus fruit from Guam. The inedible portion of this fruit also had a high ^{137}Cs value, 36 pCi/g. If these high unexplained values of ^{137}Cs are excluded, the ^{137}Cs values in plants from Guam are similar to values in plants from Palau and Truk where the lowest values were measured. Ponape had slightly higher amounts of ^{137}Cs in the plants, while plants from Majuro had the highest average amount of ^{137}Cs. About 50 percent of the ^{137}Cs values in the plants from Majuro were above 1 pCi/g. Strontium-90 values in plants followed a similar pattern, while $^{239+240}Pu$ values were above the limits of detection in one sample of copra from Majuro and in two samples of breadfruit from Ponape.

The values for ^{137}Cs and ^{90}Sr in plants from Guam, Palau, Ponape, and Truk were less than values for the same plants from the Marshall Islands (Nelson, 1977) but were similar to values found in food plants from Japan (NIRS, 1976) and Washington State (Nelson and Seymour, 1975).

Soil

Surface (0-5 cm) soil samples and shallow soil profiles were collected from several sites in each district. Results of the analysis of these samples are presented in Appendix Tables 7 through [illegible]. Soil from the atolls [illegible], Majuro, generally contained small (< 1 pCi/g) amounts of ^{90}Sr, ^{137}Cs, [illegible] and $^{239,240}Pu$, as did soils from the volcanic islands of Ponape, Truk, [illegible], and Palau. In addition to these radionuclides, these contained naturally occurring isotopes of radium and thorium. The soil from Guam also contained ^{226}Ra and ^{232}Th in addition to ^{137}Cs, ^{90}Sr, ^{232}Th, and $^{239,240}Pu$ (no analyses for ^{90}Sr were made on the soils from Guam). No major differences in the amount of ^{137}Cs, ^{90}Sr or $^{239,240}Pu$ found in the soil samples were noted [illegible] the five districts.

Soil from six northern stations on Guam had much higher values of [illegible], ^{226}Ra, ^{232}Th and ^{238}U than did the soil samples from the other stations [illegible] or from the other districts. For instance, the ^{226}Ra values from the [illegible] sites were two orders of magnitude higher than ^{226}Ra from other districts, and the ^{232}Th values were one order of magnitude higher. Also ^{238}U and [illegible] not detected in soils from any district other than Guam. The range of [illegible] for the radionuclides in the soils from Guam were as follows: ^{137}Cs [illegible], ^{232}Th ([illegible] to 22), ^{226}Ra ([illegible] to 28), ^{238}U ([illegible]) and ^{235}U ([illegible]).

Results of the analyses of the soil profiles indicated that the concentration of the fallout radionuclides ^{137}Cs and ^{90}Sr decreased with depth, while the concentration of the naturally occurring radionuclides remained relatively constant to the depth of our deepest samples. Most of the ^{137}Cs and ^{90}Sr was present in the top 5 cm of the soil profiles.

Considering only the fallout radionuclides, the values for ^{90}Sr, ^{137}Cs and $^{239,240}Pu$ in soils from Palau, Guam, Truk, Ponape and Majuro are less than values for these radionuclides in soils from atolls in the northern Marshalls such as Utirik, Rongerik, and Ailinginae, and are much less than the soils from Bikini and Rongelap atolls (Nelson, 1977).

SUMMARY AND CONCLUSIONS

This study of radionuclides in plants, fish, and soil from five [illegible] in Micronesia was one part of ERL's Pacific Radioecology Program. The [illegible] purpose of this part of the program is to determine the kinds and amounts of radionuclides in biological and environmental samples from the Central Pacific. The specific purpose of this study was to measure the radionuclides [illegible] found in common foods and soil from areas of Micronesia which did not [illegible] appreciable local fallout from the tests at Bikini and Enewetak atolls. Approximately 270 samples for this study were collected during [illegible], and 270 γ-spectrum, 169 strontium-90, and 67 plutonium 239,240 analyses [illegible] performed.

Results of the analyses indicate that naturally occurring ^{40}K is the [illegible] predominant radionuclide in the biological samples. Cesium-137 was the [illegible] fallout radionuclide detected in most of the biological samples. Amounts of ^{137}Cs present in the biota were usually less than 1 pCi/g of dry tissue, although plants from Majuro had slightly greater amounts of ^{137}Cs than plants from the other districts.

Soil samples from all districts usually contained less than 1 pCi/g of [illegible], ^{137}Cs, [illegible], and $^{239,240}Pu$, while soil from Truk, Palau, and [illegible] also contained less than 2 pCi/g naturally occurring isotopes of radium [illegible] thorium. Soil from Guam contained the same fallout and naturally occurring radionuclides and in addition contained [illegible] and [illegible]. Amounts of the naturally occurring radionuclides in the Guam soils were much higher than amounts of fallout or naturally occurring radionuclides from the other [illegible]

Considering only the fallout radionuclides, the values for ^{90}Sr, [illegible] and $^{239,240}Pu$ in fish, plants and soils from Palau, Guam, Truk, Ponape [illegible] Majuro are less than values for these radionuclides in similar samples from atolls such as Utirik, Rongerik and Ailinginae in the northern Marshall Islands.

and are much less than values of these radionuclides in samples from Florida and Georgia states.

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Appendix Table 1. Predominant Radionuclides in Fish Collected in Micronesia in November, 1975.

Collection Site	Species	Tissue	^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
			Radionuclide concentration in pCi/g, dry[a]			
Majuro Atoll Majuro I.	Mullet	Viscera	[illegible] ± 1.6	ns[c]	ns[c]	na
"	"	Evisc. whole[b]	[illegible]	ns	< 0.07	na
	Goatfish	Viscera	[illegible]	ns	< [illegible]	na
		Evisc. whole	[illegible] ± 1.3	ns	< 0.13	< [illegible]
"	[illegible]	Viscera	ns	ns	ns	ns
"	"	Evisc. whole	[illegible]	ns	ns	ns
	Tilapia	Viscera	5.5 ± [illegible]	ns	ns	[illegible]
	"	Evisc. whole	[illegible]	ns	ns	ns
[illegible]	[illegible]	Evisc. whole	5.8 ± [illegible]	ns	ns	ns
[illegible]	Goatfish	Viscera	[illegible]	ns	< [illegible]	ns
"	"	Evisc. whole	[illegible]	ns	< [illegible]	ns
"	"	[illegible]	[illegible]	[illegible]	ns	ns
	"	Evisc. whole	[illegible]	[illegible]	< [illegible]	[illegible]
	"	Viscera	ns	ns	ns	ns
	"	Evisc. whole	2.3 ± 1.1	ns	< 0.02	< [illegible]
"	Mullet	Entire	[illegible] ± 1.3	[illegible]	< 0.05	< [illegible]
"		Viscera	[illegible]	ns	< 0.45	na
"		Evisc. whole	2.8 ± 3.2	ns	< 0.08	< 0.002
"	Convict Surgeon	Viscera	9.5 ± [illegible]	ns	< [illegible]	na
"	"	Evisc. whole	ns	ns	0.35 ± .09	< .04
"	Parrotfish	Muscle	4.0 ± 1.2	0.07 ± 0.06	na	< 0.03
"	"	Viscera	3.4 ± 2.3	ns	[illegible]	na
"		Remainder	3.2 ± 1.7	ns	na	na

Table 1. (Continued)

Collection Site	Species	Tissue	Radionuclide concentration in pCi/g, dry[a] ^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
Palau/Malakal I.	Jack	Entire	8.3 ± 1.1	[illegible] ± 0.9	< 0.3	< 0.004
	Goatfish	Evisc. whole	5.5 ± 0.1	0.06 ± 0.04	< 0.23	< 0.003
	"	Evisc. whole	3.3 ± [illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. [illegible]

b. [illegible]

c. [illegible]

Appendix Table 2 Some Radionuclides in Plants Collected on Majuro Atoll in November 1975.

Collection Site	Sample Type	Radionuclide concentration in pCi/g, dry[a]			
		^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
Eastern Gateway	Pandanus, edible fruit	4.0 ± 1.6	1.9 ± 0.1	<0.02	na[b]
"	" inedible fruit	[illegible] ± 1.6	2.0 ± 0.[illegible]	na	na
"	" [illegible]	[illegible]	0.51 ± 0.15	na	na
[illegible] Village	" edible fruit	[illegible]	1.6 ± [illegible]	na	<.001
"	" inedible fruit	[illegible]	[illegible]	<.[illegible]	<.002
"	" [illegible]	[illegible]	[illegible]	<.[illegible]	[illegible]
[illegible]	" edible fruit	[illegible]	[illegible]	[illegible]	<.[illegible]
"	" inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	" leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Coconut, [illegible]	[illegible]	[illegible]	<.[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	<.[illegible]	[illegible]
"	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Village	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	leaves	[illegible]	[illegible]	<.[illegible]	<.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	<.[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	<.[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	<.[illegible]	[illegible]
[illegible]	[illegible], edible portion	[illegible]	[illegible]	[illegible]	[illegible]
"	" inedible portion	[illegible]	[illegible]	[illegible]	[illegible]
"	" [illegible]	[illegible]	[illegible] ± 0.2	na	na
[illegible] Village	" edible portion	[illegible]	[illegible]	<.[illegible]	<.[illegible]
"	" inedible portion	[illegible]	[illegible]	[illegible]	[illegible]
"	" leaves	[illegible]	[illegible] ± 0.13	0.15 ± [illegible]	<.001
"	Papaya, edible fruit	19.[illegible] ± 1.9	[illegible] ± 0.1[illegible]	[illegible]	<.001
"	" inedible fruit	[illegible] ± 2.6	2.3 ± 0.17	na	na
"	" seeds	22.[illegible]	1.0 ± 0.10	na	na
"	Banana, edible fruit	[illegible]	[illegible]	<.[illegible]	<.001

a. The error values are two-sigma, propagated, counting errors for a single sample.

b. [illegible] not significant; the net sample count is less than the two-sigma counting error. na- not analyzed.

Appendix Table 3. Some Radionuclides in Plants Collected in Ponape District in November 1975.

Collection site	Sample type	Radionuclide concentration in pCi/g, dry[a] ^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
Kolonia	Pandanus, edible fruit	9.6 ± 1.6	[illegible] ± 0.13	[illegible]	na[b]
	inedible fruit	[illegible] ± 0.6	1.2 ± 0.6	[illegible]	na
	leaves	[illegible]	[illegible]	[illegible]	na
[illegible]	edible fruit	[illegible]	[illegible]	[illegible]	na
	inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. The error values are two-sigma, propagated, counting errors for a single sample.

b. ns = not significant; the net sample count is less than the two-sigma counting error. na = not analyzed.

Appendix Table 4. Some Radionuclides in Plants Collected in Truk District in November 1975.

Collection site	Sample Type	^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
		Radionuclide concentration in pCi/g, dry[a]			
Fefan I.	Pandanus, edible fruit	16.0 ± 1.0	0.15 ± 0.05	0.06 ± 0.03	na[b]
"	inedible fruit	[illegible]	[illegible]	na	na
"	leaves	[illegible]	0.06 ± 0.03	na	na
Moen I.	" edible fruit	[illegible]	0.28 ± 0.03	<.11	na
"	" inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	na	[illegible]	na
[illegible]	" edible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	" inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	" leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Breadfruit, edible fruit	[illegible]	na	[illegible]	[illegible]
"	" inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	" leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	" edible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	" inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	" leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	" edible fruit	[illegible]	na	[illegible]	[illegible]
"	" inedible fruit	[illegible]	na	[illegible]	[illegible]
"	" leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible] ± 0.2	na	[illegible]	[illegible]
Fefan I.	Papaya, edible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	inedible fruit	13.0 ± 1.0	0.61 ± 0.07	na	na
"	" seeds	19.0 ± 1.0	0.72 ± 0.07	na	na
Dublon	" edible fruit	11.0 ± 0.4	1.9 ± 0.03	[illegible]	<.001
"	" inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	" seeds	15.0 ± 0.6	3.0 ± 0.1	na	na
"	Coconut copra	[illegible] ± 0.7	na	[illegible]	na

a. The error values are two-sigma, propagated, counting errors for a single sample.

b. [illegible] significant, the sample count is less than the two sigma counting error. na = not analyzed.

Appendix Table 5. Some Radionuclides in Plants Collected in the Palau Islands in November 1975.

Collection Site	Sample Type		Radionuclide concentration in pCi/g, dry[a]			
			[illegible]	^{137}Cs	^{90}Sr	$^{239,240}Pu$
[illegible]	Pandanus,	edible fruit	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	seeds	[illegible]	[illegible]	[illegible]	[illegible]
"	Taro,	root	[illegible]	ns	[illegible]	[illegible]
"	"	stem	23.0 ± 0.9	0.24 ± 0.05	[illegible]	na
"	"	leaves	[illegible] ± 3.3	0.76 ± 0.23	<0.26	na
"	Cassava,	root	[illegible]	ns	[illegible]	na

a. The error values are two-sigma, propagated, counting errors for a single sample.

b. ns = not significant; the sample count is less than the two sigma counting error. na = not analyzed.

Appendix Table 6. Some Radionuclides in Plants Collected on Guam in November 1975.

Collection Site		Sample Type	Radionuclide concentration in pCi/g, dry[a] ^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
Agat	Pandanus,	edible fruit	[illegible]	1.1 ± 0.04	<0.23	<0.001
"	"	inedible fruit	[illegible]	[illegible].64 ± 0.10	na	na
"	"	leaves	[illegible]	1.3 ± 0.10	na	na
[illegible]	"	edible fruit	22.[illegible]	nd[b]	[illegible]	<0.001
[illegible]	"	inedible fruit	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	"	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	leaves	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	edible fruit	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	inedible fruit	[illegible]	[illegible]	na	na
Inarajan	"	edible fruit	10.0 ± 1.3	na	[illegible]	[illegible]
"	"	inedible fruit	32.0 ± 1.6	0.12 ± 0.10	na	na
"	"	seeds	36.0 ± 0.7	na	na	na
Dededo	Taro,	root	5.8 ± 0.3	0.06 ± 0.02	<0.18	<0.001
"	"	stem	33.0 ± 1.1	nd	na	na
"	"	leaves	[illegible] ± 1.1	0.31 ± 0.08	na	na

a. The error values are two sigma, propagated, counting errors for a single [illegible].

b. nd = not detectable; the sample count is less than the two sigma counting error. na = not analyzed.

Appendix Table 7. Some Radionuclides in Soil Collected on Majuro Atoll in November 1975.

Collection Site	Sample Depth in cm	Radionuclide concentration in pCi/g, dry[a]			
		^{90}Sr	^{137}Cs	^{238}U	$^{239,240}Pu$
Eastern Gateway	Surface composite	[illegible] ± 0.33	0.11 ± 0.03	ns[b]	[illegible] ± 0.020
"	0 - 2.5	[illegible] ± 0.10	0.07 ± 0.04	ns	[illegible] ± 0.09
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ns[b]
[illegible]	5 - 10	[illegible]	ns	[illegible]	[illegible]
[illegible]	[illegible]	ns	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	ns	ns	ns	ns
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] - 2.5	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	ns	ns	[illegible]	ns
[illegible]	5 - [illegible]	ns	ns	ns	ns
[illegible]	Surface composite	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]

a. [illegible]

b. [illegible]

Appendix Table 8. Some Radionuclides in Soil Collected in the Ponape District in November 1975.

Collection site	Sample Depth in cm	Radionuclide concentration in pCi/g, dry[a] ^{90}Sr	^{137}Cs	^{226}Ra	^{228}Th	^{232}Th	^{238}U	$^{239,240}Pu$
[illegible]	Surface composite	<0.19	0.49 ± 0.05	0.56 ± 0.06	1.4 ± 0.12	0.31 ± 0.26	0.54 ± 0.37	na[b]
[illegible]	[illegible] – 2.5	[illegible]	0.00 ± 0.03	ns[b]	ns	ns	ns	0.03 ± 0.02
[illegible]	2.5 – 5	<0.19	[illegible] ± 0.11	[illegible] ± 0.06	ns	ns	1.2 ± 0.6	0.008 ± 0.014
[illegible]	[illegible]	ns	[illegible] ± [illegible]	[illegible] ± 0.06	ns	[illegible] ± 0.19	[illegible] ± [illegible]	na
[illegible]	[illegible] – 2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<[illegible]
[illegible]	2.5 – 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] – 2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2.5 – 5	<[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. [illegible] sample.

b. ns = not significant; the net sample count is less than the two-sigma counting error. na = not analyzed.

Appendix Table 9. Some Radionuclides in Soil Collected at Truk in November 1975.

Collection Site	Sample Depth in cm	Radionuclide concentration in pCi/g, dry[a]						
		^{90}Sr	^{137}Cs	[illegible] Ra	^{228}Th	[illegible] Th	[illegible] U	$^{239,240}Pu$
Fefan 1	0 - 2.5	0.16 ± 0.16	0.41 ± 0.06	0.41 ± 0.06	0.49 ± 0.11	[illegible]	ns[b]	0.092 ± 0.009
"	2.5 - 5	[illegible]	[illegible]	[illegible] ± 0.06	0.62 ± [illegible]	[illegible]	[illegible]	[illegible]
"	5 - [illegible]	na	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	na
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. [illegible]

b. ns= not significant; the net sample count is less than the two-sigma counting error. na= not analyzed.

Appendix Table 10. Some Radionuclides in Soil Collected in the Palau Islands in November 1975.

Collection Site	Sample Depth in cm	Radionuclide concentration in pCi/g, dry[a]				
		^{90}Sr	^{137}Cs	^{226}Ra	^{232}Th	$^{239,240}Pu$
[illegible]	Surface composite	[illegible]	[illegible] ± 0.01	0.24 ± 0.05	0.60 ± [illegible]	na[b]
	[illegible] - 2.5	ns	[illegible]	ns	ns	na
	2.5 - 5	ns	[illegible] ± 0.02	ns	ns	na
	[illegible]	[illegible]	[illegible]	[illegible]	ns	ns
[illegible]	Surface composite	[illegible]	[illegible]	[illegible]	ns	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2.5 - 5	[illegible]	[illegible]	[illegible]	ns	[illegible]
	[illegible]	ns	[illegible]	[illegible]	[illegible]	ns
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ns	[illegible][c]
	[illegible] - 5	ns	[illegible]	[illegible]	ns	ns
	[illegible]	ns	[illegible]	[illegible]	[illegible]	ns
	[illegible]	ns	[illegible]	[illegible]	ns	ns
	[illegible]	ns	[illegible]	[illegible]	[illegible]	ns
	[illegible]	ns	ns	[illegible]	ns	ns
	[illegible]	ns	ns	ns	ns	ns

a. The error values are [illegible] counting error [illegible] single sample.

b. ns = not significant: the net sample count is less than the two-sigma counting error. na = not analyzed.

c. These two samples were pooled for the $^{239,240}Pu$ analysis.

Appendix Table 11. Some Radionuclides in Soil Collected on Guam in November 1975.

Collection Site	Sample Depth in cm	Radionuclide concentration in pCi/g, dry[a]					
		^{137}Cs	^{210}Pb	^{210}Ra	^{232}Th	^{235}U	$^{239,240}Pu$
Agana	0 - 2.5	0.24 ± 0.06	20.0 ± 7.2	79.0 ± 0.4	4.1 ± 0.8	5.6 ± 0.1	0.010 ± .004
"	2.5 - 5	1.0 ± 0.2	22.0 ± 5.7	ns	ns	ns	0.003 ± .002
"	[illegible]	ns[b]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dededo	0 - 2.5	ns	[illegible]	[illegible]	[illegible]	[illegible]	na
"	[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]	na
"	[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]	na
"	[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]	na
"	[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]	na
"	[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]	na
"	[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]	na
Talofofo	[illegible]	[illegible]	ns	[illegible]	[illegible]	[illegible]	na
"	[illegible]	[illegible]	ns	[illegible]	[illegible]	[illegible]	na
"	[illegible]	[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]

a. [illegible]

b. [illegible]

APPENDIX 4

RADIOLOGICAL SURVEY OF PLANTS, ANIMALS AND SOIL AT FIVE ATOLLS IN THE MARSHALL ISLANDS

SEPTEMBER - OCTOBER 1974

by

Victor A. Nelson

APPENDIX 4

NVO-269-36

RADIOLOGICAL SURVEY OF PLANTS, ANIMALS AND SOIL AT FIVE ATOLLS IN THE MARSHALL ISLANDS SEPTEMBER–NOVEMBER 1976

By

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2 May 1978

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Prepared for the U. S. Department of Energy
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INTRODUCTION

As stated in a previous progress report (Nelson 1977),

"The Division of Operational Safety of DOE (now Safety Standards and Compliance) portion of the Laboratory of Radiation Ecology (LRE) Pacific Radioecology Program (formerly Enewetak Atoll Program) began in July 1974 and is continuing. The purpose of this program is to determine the kinds and amounts of radionuclides distributed in the fishes, plants, animals, and soils of the Central Pacific, especially the Marshall Islands, and to furnish these data to SSC/DOE and other appropriate agencies (Lawrence Livermore Laboratory, Nevada Operations Office DOE) so that they may make an estimation of the dose of ionizing radiation received by the people living throughout the Central Pacific."

Here we report the results of the analyses of samples collected on a field trip conducted in September-October 1976.

SAMPLING PROGRAM

Atolls visited in the Marshall Islands are shown in Figure 1. This trip was a joint survey with personnel from Brookhaven National Laboratory. Representative biological and soil samples were collected with emphasis on food items common to the diet of the Marshallese people (i.e., fish, coconut, pandanus, breadfruit, coconut crabs, etc.) although nonedible portions of these items were also collected and analyzed. Soils were collected to provide data for estimating future distribution and quantities of radionuclides in the environment and biota. Sampling sites are shown in Figures 2 through [illegible]

The number of samples after division into tissues or soil fractions, is shown in Table 1. Slightly less than half the samples were [illegible] plants, [illegible], clams, and coconut crabs — and the rest were soils — surface (0-2.5cm) and profile (0-100 cm).

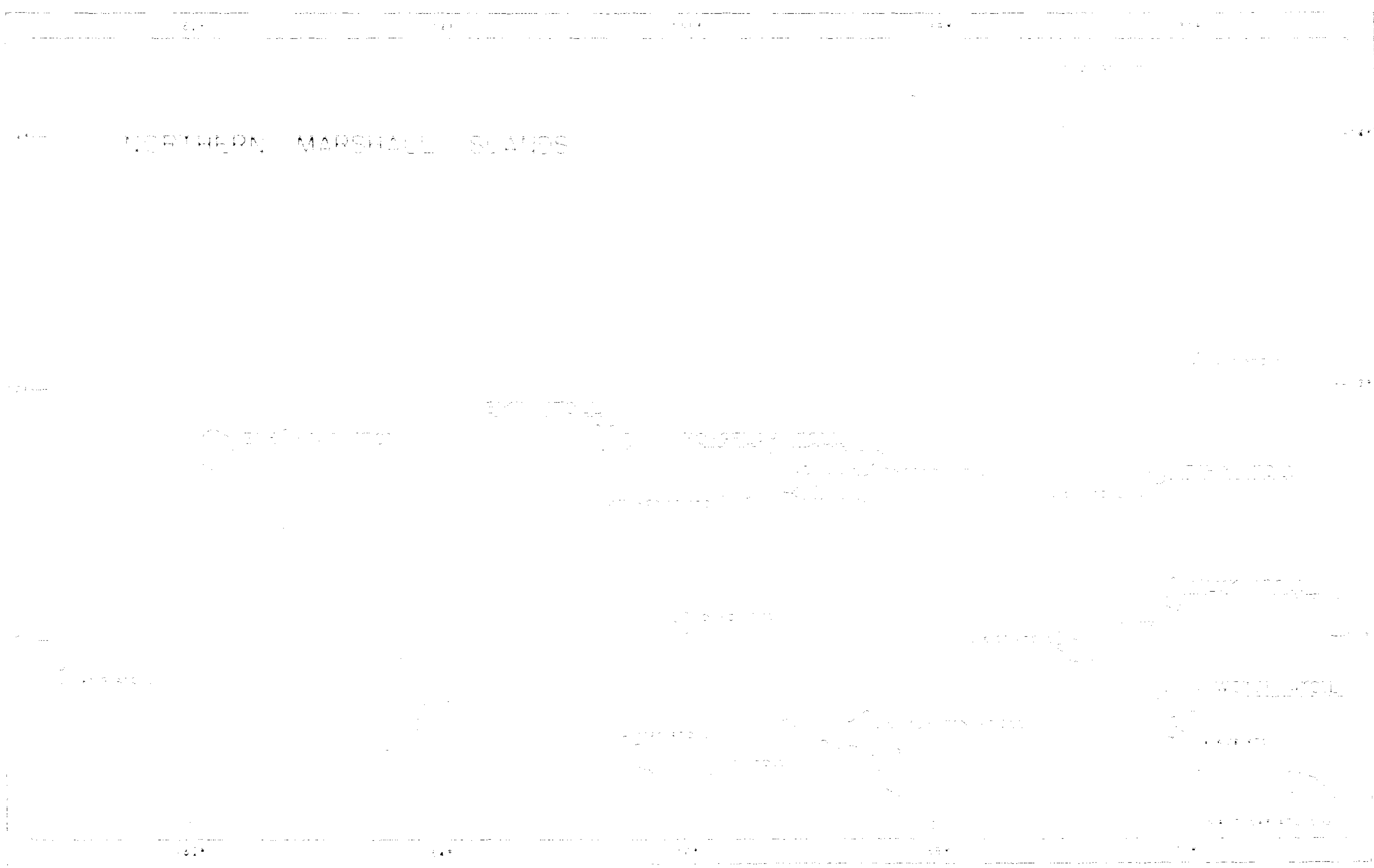


Figure 1. Five atolls (underlined) in the northern Marshall Islands where samples were collected September-October 1976.

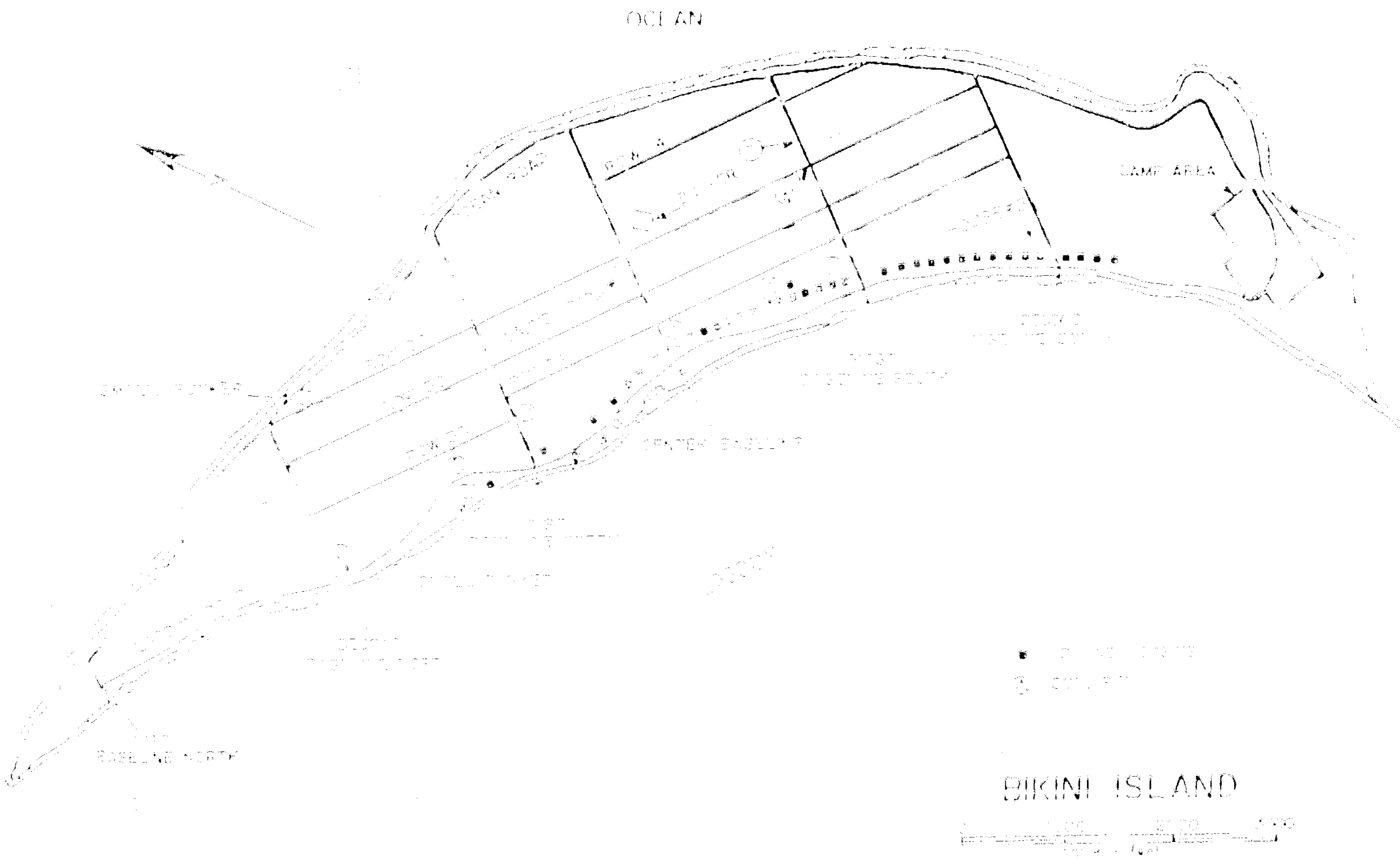


Figure 9. Sampling sites on Bikini Island, Bikini Atoll, October 1976.

Figure 3. Sampling Sites on Wormej and Wotje Islands, Wotje Atoll and on Ailuk and Elgen Islands, Ailuk Atoll, September 1976.

Figure 4. Sampling Sites on Utirik and Aon Islands, Utirik Atoll and on Naen Island, Rongelap Atoll, September 1976.

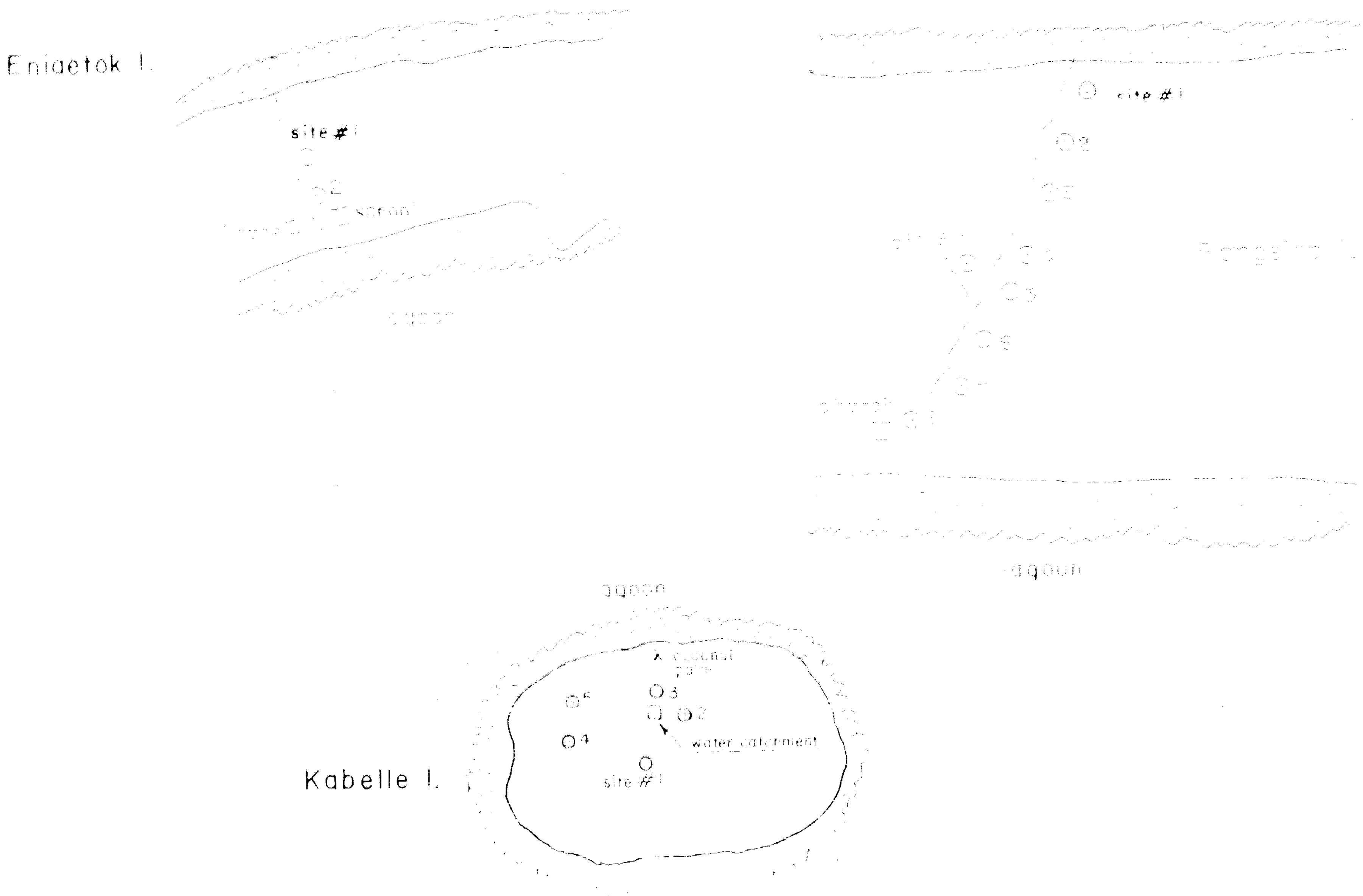


Figure 5. Sampling Sites on Eniaetok, Rongelap, and Kabelle Islands, Rongelap Atoll, September 1976.

TABLE 1. Number of samples processed and analyzed that were collected during the September-October 1976 field trip to the Marshall Islands

Atoll	SAMPLES PROCESSED					SAMPLES ANALYZED		
	[illegible]	Soil	Marine	Coconut Crab	Total	γ	^{90}Sr	$^{239,240}Pu$
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

In addition to the samples the laboratory collected, personnel from Brookhaven National Laboratory collected samples, made in situ measurements, and took radiation survey readings with sodium iodide (NaI) scintillation detectors and a pressurized ion chamber. The results of the Brookhaven analyses and measurements may be combined with the EML results in a series of joint reports to the open literature.

ANALYTICAL METHODS

Gamma-Ray Spectrometry

All of the samples were analyzed by gamma-ray spectrometry, either with a 4 x 4 inch sodium iodide (thallium activated) crystal and 200-channel pulse-height analyzers or with a germanium (lithium-drifted) diode detector and 4096-channel pulse height analyzer. Soil samples were analyzed on the Ge(Li) system and the biological samples were analyzed on both systems.

All samples were oven dried, ground and uniformly compressed in polyvinyl chloride (PVC) pipe 2 inches in diameter and either ½ or 1 inch deep. This was used as a sample holder for radionuclide measurement. Fifty grams of [illegible] or 100 grams of soil could be compressed into the 2 x 1 inch container. The densities of the biological and soil samples were 1.0 and 1.35, respectively. These samples were then analyzed for gamma-emitting radionuclides.

The gamma-emitting radionuclides in samples counted on the NaI counter were determined by a matrix method of [illegible]. The radionuclide values in samples counted on the Ge(Li) detector were calculated manually or with a computer by adding the counts in an energy range of five channels under a peak in the spectrum, subtracting the appropriate background counts, and applying correction factors to convert counts to picocuries (pCi). A set of previously recorded reference spectra for the different geometries and radionuclides was used. All values were corrected for decay to the date of collection.

Strontium-90 and Plutonium Analyses

To measure ^{90}Sr content, ^{90}Y was chemically separated from ^{90}Sr, collected on a filter paper and counted with a low level beta counting system. Plutonium was extracted by ion exchange, electroplated on platinum discs, and analyzed by alpha spectrometry with systems using surface barrier alpha detectors and multichannel analyzers. Chemical yield was determined by use of ^{236}Pu as a tracer.

Error Limits

For a single sample, the errors given for all radionuclides listed are two-sigma, propagated, counting errors. The error term for more than one sample is one standard deviation and disregards counting error.

Limits of Detection

Many factors influence the limits of detection, including the type of detector and analyzer, the presence of other radionuclides, the duration of the counting period, the size and density of the sample, and the geometric relationship of the sample and detector. Hence, the limits of detection vary considerably for various radionuclides and types of samples, but can be generalized by stating that the detection limits were approximately as follows:

By gamma detection	
^{40}K	2.1 pCi/g or less
[illegible]	0.41 " "
^{60}Co, ^{106}Ru, ^{137}Cs, ^{155}Eu, ^{241}Am	0.07 pCi/g or less
By beta detection	
^{90}Sr	0.2 pCi/g or less
By alpha detection	
$^{239,240}Pu$	0.02 pCi/g or less

RESULTS

Data are presented for the results of the analyses of the samples collected by LLL in the Marshall Islands in 1978. Appendix Tables 1 through 33 give the data for single samples. The data are first presented atoll by atoll and then summarized by comparisons between atolls for selected sample types. All data are given as picocuries per gram of dry weight except where expressly noted.

Ailuk and Wotje Atolls

Samples from Bigen and Ailuk Islands at Ailuk Atoll and from Wotje and Wormej Islands at Wotje Atoll were collected during the September-October 1978 field trip. Results of the analyses on these samples of fish, plants and soil for gamma emitting radionuclides, ^{90}Sr and $^{239,240}Pu$ are given in Appendix Tables 1 (fish), 2 and 3 (plants) and 4 through 7 (soil).

In the fish, naturally occurring ^{40}K was the most abundant radionuclide. Except for a small amount of ^{137}Cs in one fish sample, no fallout radionuclides were detected in any of the other fish samples. In plants ^{40}K was also the predominant radionuclide, however ^{137}Cs was above the limits of detection in all plant samples and ^{90}Sr was measurable in about one third of the samples analyzed. Of the plants sampled, pandanus fruit had the most ^{137}Cs and unprocessed arrowroot tubers had the most ^{90}Sr. Processing the arrowroot tubers for food removes most of the ^{90}Sr.

Cesium-137 was the predominant radionuclide in the soil samples from Wotje and Ailuk atolls, but the amount measured was less than 1 pCi/g in all samples except four from Bigen Island, the northernmost sampling location on these two studies. Concentrations of ^{137}Cs in these four samples ranged from 1.3 to 1.6 pCi/g. Strontium-90 and $^{239,240}Pu$ were measurable in the samples analyzed. Concentrations were less than a picocurie in all samples but one, the [illegible] soil from a 0- to 5-cm [illegible] Island. Soil at this site contained 3.6 pCi of $^{239,240}Pu$ per gram. Americium-241 was detected in only a few of the soil samples.

Utirik Atoll

The two predominant radionuclides in plant samples from Utirik Atoll were ^{90}Sr and ^{137}Cs (Appendix Table 8). Of all [illegible] samples analyzed, the edible portion of the three pandanus fruit samples contained the greatest amount of ^{137}Cs (average 14 pCi/g). Values of ^{90}Sr in the plants ranged up to 2. [illegible]. Plutonium-239, 240 values were below the limits of detection in the five [illegible] samples analyzed.

Soil samples from Utirik Atoll contained ^{137}Cs, ^{90}Sr and $^{239,240}Pu$ in most of the samples analyzed for these radionuclides (Appendix Tables 9 [illegible]). Americium-241 and ^{60}Co were also detected in many of the surface soil [illegible]. Cesium-137 values ranged up to 5.3 pCi/g and averaged about 3 pCi/g in the [illegible] surface soil samples. Soil samples from 5-10 cm below the surface contained [illegible] from 0.5 pCi of ^{137}Cs per gram. In the surface samples analyzed, ^{90}Sr values ranged from 0.6 to 3.2 pCi/g while $^{239,240}Pu$ values ranged from 0.08 to [illegible]. Americium-241 and ^{60}Co values were less than a pCi/g.

Rongelap Atoll

Most samples of marine organisms from Rongelap contained ^{60}Co and [illegible] as the predominant radionuclide (Appendix Tables [illegible] and 11). Cobalt-60 was present in less than pCi/g amounts, except in the [illegible] of one clam kidney which contained [illegible] 7.8 to 16 pCi/g. Samples of terrestrial organisms also contained ^{137}Cs and [illegible] with [illegible] as the predominant radionuclide in the plants (Appendix Table [illegible]) and ^{90}Sr in the coconut crabs (Appendix Table [illegible]). Most plant samples contained [illegible] to 100 pCi of ^{137}Cs per gram of dry tissue; however, coconut milk sample contained up to 360 pCi/g. The exoskeleton of the coconut crabs contained 10 to 560 pCi of ^{90}Sr per gram. The other tissues contained 1 to 20 pCi/g.

The results of the analyses of the soil samples are given in Appendix Tables 14 through 17. Cesium-137 and ^{90}Sr are the predominant radionuclides and ^{60}Co, ^{155}Eu, ^{241}Am, and $^{239,240}Pu$ were also detected in most of the samples analyzed for these specific radionuclides. Antimony-125 was also detected in the soils from Naen Island. Radionuclide values were lowest on Rongelap and Eniaetok Islands and highest on Naen. Cesium-137 and ^{90}Sr values in surface soils from Naen averaged several hundred pCi/g and ranged up to 970 and 623 pCi/g for ^{137}Cs and ^{90}Sr, respectively. Cesium-137 values in soil from Rongelap Island were less than a hundred pCi/g. Plutonium-239 and 240 values in Rongelap and Eniaetok Island soils were commonly 1 to 2 pCi/g, while in Naen soils values for these radionuclides ranged to 65 pCi/g.

Bikini Atoll

Plants were the only sample type collected at Bikini Atoll. Results of the analyses of these samples are in Appendix Table 18. Cesium-137 and ^{90}Sr are the predominant radionuclides. The greatest ^{137}Cs and ^{90}Sr values were in the leaves of the pandanus. Leaves from a pandanus plant near [illegible] (see Figure 2) contained 2380 pCi of ^{137}Cs per gram while leaves from a plant near House 25 contained 685 pCi of ^{90}Sr per gram. Plutonium-239,240 values were mostly less than the limits of detection.

DISCUSSION AND CONCLUSIONS

Comparison between Atolls

Moving in a northerly direction, radioactivity values were least in the samples from Majuro Atoll, increased slightly at Ailuk Atoll and increased significantly at Utirik. From Utirik, radioactivity values increased to the west.

Thus, Rongelap Atoll had higher values than Utirik and Bikini had the highest values of any atoll sampled during this survey. This pattern has been noted previously (Nelson, 1977) and is a result of the fallout distribution from the 1 March 1954 Bravo test on Bikini Atoll. The south to north increase in radioactivity is also apparent at Rongelap Atoll where the southern islands have radioactivity levels about a factor of ten lower than the northern islands.

<u>Differences Due to Sample Type</u>

As noted previously (Nelson, 1977) ^{90}Sr and ^{137}Cs are the predominant radionuclides in biological and soil samples from the terrestrial environment. In addition, ^{241}Am and ^{239,240}Pu are important in soils from Rongelap Atoll and Bikini Atoll (Nelson, 1977) because of the quantity of these radionuclides and because they are alpha-emitters, which have a higher potential health hazard than most of the gamma-emitters. Pandanus leaves continue to be the best indicator species for ^{137}Cs because they concentrate ^{137}Cs and are abundant and available throughout the year. These leaves may also be used as indicator for ^{90}Sr [illegible] coconut crabs are not available. The exoskeletons of these crustaceans contain more ^{90}Sr than any other biological sample analyzed. However these crabs are often scarce or absent on the more populated islands.

In the marine environment ^{40}K is the predominant radionuclide. Cobalt-60 was the only fallout radionuclide present in a significant number of the marine samples and the values for this radionuclide were usually less than 1 pCi/g. The kidney of the Tridacna had the greatest amounts of ^{60}Co of the marine samples analyzed.

SUMMARY

The current portion of the [illegible] Radioecology Program began on 1 Jul. 1974. The purpose of this program is to determine the types and amounts of radionuclides in biological and environmental samples from the Central Pa[illegible] mately the Marshall Islands. A field trip was conducted for this purpose in September-October 1976. About 300 samples were collected and about 217 analyses, 130 strontium-90 and 75 plutonium-239, 240 analyses were performed.

Results of the analyses indicate that ^{90}Sr and ^{137}Cs are predominant in the terrestrial environment and, in addition, ^{241}Am and $^{239,240}Pu$ are also important in the soil from Rongelap Atoll. Cobalt-60 is the predominant radionuclide in the marine organisms, while ^{65}Zn is important in the kidney of the Tridacna clam.

Amounts of radioactivity between atolls and between islands within Rongelap Atoll vary with distance from the test site at Bikini Atoll and in relation to the fallout pattern from the March 1954 Bravo test. Plants from Bikini Island had the highest amounts of radioactivity, primarily ^{137}Cs, while plants from Naen Island at Rongelap Atoll had slightly lower amounts. The southern islands of Rongelap Atoll and Utirik Atoll had intermediate amounts of radioactivity, while Ailuk and Mejit Atolls had the lowest amounts of radioactivity of the atolls visited during this 1976 trip.

REFERENCE CITED

Nelson, V. A. 1977. Radiological survey of plants, animals, and soil at Christmas Island and Seven Atolls in the Marshall Islands: U. S. ERDA Report NVO-269-32. College of Fisheries, University of Washington, Seattle.

APPENDIX TABLE 1

Some Radionuclides in Fish Collected at Rongelap, Ailuk, and Wotje Atolls in September 1976

Atoll/Island	Species	Tissue	Radionuclide Concentration in pCi/g, dry[a] ^{40}K	^{60}Co	^{137}Cs	^{90}Sr
Rongelap/Rongelap	Yellowfin Tuna	Liver	na[b]	0.18±0.03	0.01±0.03	na[b]
Rongelap/[illegible]	Goatfish	Evisc. whole[c]	[illegible]	[illegible]	ns	na
		Viscera	[illegible]±7.3	[illegible]	ns	na
Rongelap/Eniaetok	Goatfish	Evisc. whole	[illegible]	[illegible]	ns	<0.13
"	"	Viscera	ns	ns	ns	na
"	Mullet	Evisc. whole	[illegible]	[illegible]	[illegible]	<0.10
"	"	Viscera	[illegible]	ns	ns	na
[illegible]	[illegible]	Evisc. whole	[illegible]	ns	[illegible]	[illegible]
	"	Viscera	[illegible]	ns	[illegible]	ns
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ns	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	ns	ns	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	ns	ns	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	ns	ns	[illegible]
[illegible]	[illegible]	Evisc. whole	[illegible]	ns	[illegible]	ns
		Viscera	[illegible]	ns	ns	ns

a. [illegible]

b. [illegible]

c. [illegible]

APPE[illegible]IX TABLE 2

Predominant Radionuclides in Plants Collected
at Wotje Atoll in September 1976

Island	Site	Sample Type		Radionuclide Concentration in pCi/gm dry[a]			
				^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
[illegible]	[illegible]	Coconut,	[illegible]	[illegible]	[illegible]	[illegible]	<0.001
			[illegible]	na[b]	na	[illegible]	na
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				[illegible]	[illegible]	na	na
	[illegible]			[illegible]	[illegible]	[illegible]	na
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Pandanus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	na	na
			[illegible]	[illegible]	[illegible]	[illegible]	na
	[illegible]			[illegible]	[illegible]	[illegible]	na
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	na
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	na
			[illegible]	[illegible]	[illegible]	[illegible]	na
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	na	na
			[illegible]	[illegible]	[illegible]	[illegible]	na
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	na	na
			[illegible]	[illegible]	[illegible]	[illegible]	na
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	na	na
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	na	na
			seeds	[illegible]	[illegible]	na	na
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			skin	[illegible]	[illegible]	na	na
			seeds	[illegible]	[illegible]	na	na
Wotje	Village	Taro,	root	[illegible]	[illegible]	[illegible]	<0.001
		Yam,	whole	[illegible]	[illegible]	[illegible]	<0.001
		Squash,	whole	[illegible]	[illegible]	[illegible]	[illegible]

a. The error values for all radionuclides are two-sigma, propagated, counting errors for a single sample.

b. na = not analyzed

APPENDIX TABLE 3

Predominant Radionuclides in Plants Collected on Ailuk Atoll in September 1976

Island	Site	Sample Type		Radionuclide Concentration in pCi/g, dry[a] ^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Leaves	[illegible]	[illegible]	[illegible]	na
[illegible]	[illegible]		Leaves	[illegible]	[illegible]	[illegible]	na
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	na
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	na
			[illegible]	[illegible]	[illegible]	[illegible]	na
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. The error values for all radionuclides are one sigma, propagated, counting errors for a single sample.

b. na = not analyzed

c. [illegible]

APPENDIX TABLE 4

Predominant Radionuclides in Soil Collected on
Wormei Island, Wotje Atoll, September 1976

Collection Location	Soil Depth (cm)	^{137}Cs	^{60}Co	^{241}Am	$^{239,240}Pu$	^{90}Sr
		Radionuclide Concentration in pCi/g, dry[1]				
Site #1	0-2.5	0.59±1.00	0.63±0.07	0.07±0.02	0.07±0.04	0.37±0.13
"	2.5-5	0.48±1.00	0.23±0.09	ns[2]	0.08±0.03	0.27±0.22
"	5-10	0.36±0.11	ns	ns	ns[4]	ns
Site #2	0-2.5	[illegible]	[illegible]	ns	ns	[illegible]
"	2.5-5	0.19±0.05	ns	ns	ns	ns
"	5-10	[illegible]	ns	0.20±0.12	ns	ns
"	10-15	[illegible]	[illegible]	ns	ns	ns
"	15-20	ns	ns	ns	ns	ns
"	20-25	ns	[illegible]	ns	ns	ns
"	25-30	ns	[illegible]	ns	ns	ns
"	30-35	ns	[illegible]	ns	ns	ns
"	35-40	ns	[illegible]	ns	ns	[illegible]
Site #3	0-2.5	[illegible]	[illegible]	ns	[illegible]	[illegible]
"	2.5-5	[illegible]	ns	ns	ns	ns
"	5-10	[illegible]	[illegible]	ns	ns	ns
Site #6	0-2.5	[illegible]	ns	ns	ns	0.47±0.22
"	2.5-5	0.13±0.05	ns	ns	ns	ns
Site #7	0-2.5	0.68±0.12	ns	ns	ns	ns
"	2.5-5	0.25±0.12	ns	0.20±0.14	0.12±0.02	ns

1. The errors given for all radionuclides are two sigma, propagated, counting errors for a single sample.

[illegible] counting error [illegible] not

APPENDIX TABLE 5

Some Radionuclides in Soil Collected on
[illegible] Island, Wotje Atoll, September 1976

Collection Location	Soil Depth (cm)	Radionuclide Concentration in pCi/g, dry[a]				
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Site #1	0-2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	2.5-5	[illegible]	ns[b]	ns	ns	ns
"	5-10	[illegible]	[illegible]	ns	ns	ns
Site #2	0-2.5	[illegible]	ns	ns	ns	[illegible]
	2.5-5	[illegible]	ns	ns	ns	ns
	5-10	[illegible]	ns	[illegible]	ns	ns
Site #3	0-2.5	[illegible]	ns	ns	ns	ns
"	[illegible]	[illegible]	[illegible]	ns	ns	ns
"	5-10	ns	ns	ns	ns	ns
	[illegible]	[illegible]	ns	ns	ns	ns
"	[illegible]	ns	ns	ns	ns	ns
	[illegible]	ns	ns	ns	ns	ns
"	[illegible]	ns	[illegible]	ns	ns	ns

a. The error [illegible] for all radionuclides [illegible]

b. ns - not significant, the net sample count is less than the two-sigma, propagated counting error.
na - not analyzed.

A P P E N D I X   T A B L E   6

Some Radionuclides in Soil Collected on Alice Island, [illegible] Atoll, September 1975

Collection Location	Soil Depth (cm)	Radionuclide Concentration in pCi/g, dry[a]		
		^{137}Cs	[illegible]	Other
Site #1	0-2.5	0.48±0.06	1.1±0.34	^{90}Sr 0.77±0.27
	2.5-5	0.28±0.08	0.62±0.24	
	5-10	0.23±0.08	1.4±0.36	
	10-15	0.15±0.07	ns[b]	
	15-25	0.07±0.03	ns	
	25-35	0.05±0.03	ns	
	35-50	ns	ns	
	50-75	ns	ns	
	75-100	ns	0.46±0.24	
Site #2	0-2.5	0.73±0.12	0.56±0.30	
	2.5-5	0.32±0.05	ns	
	5-10	0.15±0.05	0.52±0.32	
Site #3	0-2.5	ns	ns	
	2.5-5	0.37±0.09	0.95±0.28	
	5-10	0.18±0.07	ns	
Site #4	0-2.5	0.38±0.12	0.65±0.29	
	2.5-5	0.12±0.05	0.72±0.31	
	5-10	ns	ns	
Site #5	0-2.5	0.61±0.11	0.68±0.33	
	2.5-5	0.22±0.06	ns	
	5-10	0.10±0.04	0.62±0.27	
Site #6	0-2.5	0.27±0.07	0.58±0.30	^{90}Sr 0.37±0.13
	2.5-5	0.15±0.07	0.57±0.32	
	5-10	ns	ns	

a. The error values for all radionuclides are two-sigma propagated counting errors for a single sample.

b. ns = not significant; the net sample count is less than the two-sigma propagated counting error.

APPENDIX TABLE [illegible]

Some Radionuclides in Soil Collected on [illegible] Island
[illegible] Atoll, September 1978

Collection Location	Soil Depth (cm)	Radionuclide Concentration in pCi/g, dry[a]			
		^{137}Cs	^{90}Sr	Other	
Site #1	0-2.5	1.2 ± 0.15	nd[b]	$^{239+240}Pu$	0.068 ± [illegible]
				^{90}Sr	0.56 ± [illegible]
	2.5-5	0.70 ± 0.1[illegible]	nd		
	5-10	0.53 ± 0.11	0.92 ± 0.53		
	10-15	0.25 ± 0.08	nd		
	15-25	0.[illegible] ± 0.06	nd		
	25-[illegible]	[illegible]	nd		
Site #2	0-2.5	0.9[illegible] ± 0.13	0.54 ± 0.36		
	2.5-5	0.41 ± 0.09	nd		
	5-10	0.21 ± 0.07	nd		
Site #3	0-2.5	1.1 ± 0.13	nd	[illegible]	3.8 ± 1.5
				[illegible]	0.27 ± 0.12
	2.5-5	0.27 ± 0.11	nd		
	5-10	0.38 ± 0.08	nd	$^{239+240}Pu$	0.056 ± [illegible]
Site #4	0-2.5	0.84 ± 0.12	nd	^{90}Sr	0.41 ± 0.1[illegible]
	2.5-5	1.0 ± 0.12	nd		
	5-10	1.2 ± 0.13	0.58 ± 0.74		

a. The error values for all radionuclides are two sigma, propagated, counting errors for a single sample.

b. nd = not significant; the net sample count is less than the two-sigma, propagated counting error.

APPENDIX TABLE 8

Predominant Radionuclides in Plants Collected on Utirik Atoll in September 1976

Island	Sample Type		^{3}H	^{137}Cs	^{90}Sr	$^{239,240}Pu$
			Radionuclide Concentration in pCi/g, dry[a]			
[illegible]	Coconut	[illegible]	[illegible]	[illegible]	[illegible]	ns[b]
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	ns
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	nd
	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"	[illegible]	nd	nd	[illegible]	[illegible]
[illegible]	Pandanus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Breadfruit	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. The error values for all radionuclides are the 2-sigma propagated counting errors for a single sample.

b. ns = not significant; the net sample count is less than the 2-sigma propagated counting error. nd = not analyzed.

APPENDIX TABLE [illegible]C

Some Radionuclides in Soil Collected on [illegible] Island, [illegible] Atoll, September 1976

Collection Location	Soil Depth (cm)	Radionuclide Concentration in pCi/g, dry[a] ^{90}Sr	^{137}Cs	^{241}Am	Other
Site #1	0-2.5	0.16±0.08	3.5±0.[illegible]	0.26±0.12	
"	2.5-5	ns[b]	0.86±0.10	0.21±0.15	
"	5-10	0.09±0.06	0.52±0.[illegible]	ns	
Site #2	0-2.5	0.12±0.06	[illegible]±0.20	0.64±0.14	$^{239,240}Pu$ [illegible] ^{90}Sr [illegible]
"	2.5-5	ns	0.25±0.0[illegible]	ns	
"	5-10	ns	0.16±0.03	ns	
Site #3	0-2.5	0.09±0.05	5.0±0.[illegible]	0.[illegible]±0.34	
"	2.5-5	ns	0.83±0.10	ns	
"	5-10	ns	0.[illegible]±0.03	ns	
Site #4	0-2.5	0.10±0.05	[illegible]±0.30	0.[illegible]±0.13	^{60}Co [illegible]
"	2.5-5	0.17±0.10	1.9±0.17	0.26±0.13	
"	5-10	ns	0.47±0.10	ns	
Village	0-2.5	ns	[illegible]	ns	^{60}Co [illegible] $^{239,240}Pu$ [illegible]

a. The error values for all radionuclides are two sigma, propagated, counting error of a single result.

b. ns = not significant; the net sample count is less than the two sigma, propagated counting error.

APPENDIX TABLE 10

Some Radionuclides in Soil Collected at Utirik Atoll

September 1976

Island	Collection Location	Soil Depth (cm)	Radionuclide Concentration in pCi/g, dry[a]			
			^{137}Cs	[illegible]	^{241}Am	[illegible]
Bikrak	Center of Isle	[illegible]	0.97±0.18	1.5±0.4	ns[b]	
"	"	0-2.5	2.3±0.23	ns	0.7±0.11	[illegible] 0-0.16
"	"	2.5-5	3.0±0.29	ns	0.43±0.19	[illegible] 9-0.16
"	"	5-10	1.9±0.17	0.67±0.24	0.17±0.07	
"	"	10-15	0.82±0.07	ns	ns	
"	"	15-25	ns	ns	ns	
"	"	25-35	ns	ns	ns	
"	"	35-50	ns	ns	ns	
Aon	Site #1	0-2.5	3.2±0.2[illegible]	ns	ns	[illegible]
"	"	2.5-5	1.6±0.16	ns	0.15±0.09	[illegible]
"	"	5-10	0.19±0.07	0.29±0.27	ns	
"	"	10-15	0.38±0.06	ns	ns	
"	Site #2	0-2.5	1.4±0.[illegible]	ns	0.28±0.20	[illegible]
"	"	2.5-5	0.36±0.09	ns	0.21±0.19	
"	"	5-10	0.[illegible]±0.08	0.92±0.3[illegible]	ns	
"	"	10-15	0.18±0.07	ns	ns	
"	"	15-25	0.07±0.06	0.7[illegible]±0.30	ns	
"	Site #3	0-2.5	1.6±0.17	ns	0.27±0.[illegible]	
"	"	2.5-5	0.52±0.15	1.3±0.28	ns	
"	"	5-10	ns	ns	ns	

a. The [illegible] values for all radionuclides are two-sigma, propagated, counting error [illegible] sample.

b. [illegible] significant; the net sample count [illegible] less than the two-sigma, propagated [illegible].

APPENDIX TABLE 11

Predominant Radionuclides in Tridacna Clams from [illegible] Island, Rongelap Atoll, September 1976

Island	Number of Clams	Tissue	Radionuclide Concentration in pCi/g, dry[a]		
			[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Muscle	[illegible]	[illegible]	
		Mantle	[illegible]	[illegible]	
[illegible]	[illegible]	Kidney	[illegible]	[illegible]	
		Remainder	[illegible]	[illegible]	
[illegible]	[illegible]	Muscle	[illegible]	[illegible]	
		Mantle	[illegible]	[illegible]	
		Kidney	[illegible]	[illegible]	
		Remainder	[illegible]	[illegible]	
[illegible]	[illegible]	Muscle	[illegible]	[illegible]	
		Mantle	[illegible]	[illegible]	
		Kidney	[illegible]	[illegible]	
		Remainder	[illegible]	[illegible]	

a. [illegible]

[illegible]

APPENDIX TABLE 12

Predominant Radionuclides in Plants Collected
at Rongelap Atoll in September 1976

Island	Site	Sample Type		Radionuclide Concentration in pCi/g, dry[a] ^{60}Co	^{137}Cs	^{90}Sr	$^{239,240}Pu$
Rongelap	[illegible]	Coconut	Meat	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	nd[b]	[illegible]	[illegible]	nd[b]
			[illegible]	[illegible]	[illegible]	nd	nd
				[illegible]	[illegible]	[illegible]	nd
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	nd	nd
			[illegible]	[illegible]	[illegible]	[illegible]	nd
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]		[illegible]	[illegible]	nd
			[illegible]	[illegible]	[illegible]	[illegible]	nd
					[illegible]	[illegible]	nd
Rongelap	[illegible]	Pandanus	[illegible]	[illegible]	[illegible]	[illegible]	nd
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	nd
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	nd
	[illegible]	[illegible]		[illegible]	[illegible]	nd	nd

a. [illegible]

b. nd = not significant; [illegible]

APPENDIX TABLE 13

Predominant Radionuclides in Coconut Crabs Collected at Rongelap Atoll in September 1976

Island	Tissue	Radionuclide Concentration in (pCi/g, [illegible])[a] — ^{3}H	^{60}Co	^{137}Cs	^{90}Sr	$^{239,240}Pu$
[illegible]	Muscle	[illegible]	[illegible]	130±0.?	[illegible]	0.012±0.002
"	Hepatopancreas	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Exoskeleton	[illegible]	ns[b]	[illegible]	[illegible]	[illegible]
Naen	Muscle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Hepatopancreas	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Exoskeleton	ns	[illegible]	[illegible]	[illegible]	ns[b]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	ns	ns	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	ns	ns	[illegible]	[illegible]	[illegible]

a. [illegible]

b. ns = [illegible]

APPENDIX TABLE 14

Some Radionuclides in Soil Collected on Rongelap Island, Rongelap Atoll, in September 1976

Collection Location	Soil Depth (cm)	Radionuclide Concentration in pCi/g, dry[a] [illegible]	[illegible]	[illegible]	[illegible]
1. Sample sites along road from church to ocean					
Site #1 "Ocean side ridge"	0-2.5	0.30±0.07	37 ±0.8	0.36±0.07	1.4 ±0.13
Site #2	0-2.5	0.55±0.07	13 ±0.4	[illegible]	[illegible]
Site #3	0-2.5	[illegible]	15 ±0.3	[illegible]	[illegible]
Site #4 "Center of island"	0-2.5	[illegible]	12 ±0.4	[illegible]	[illegible]
Site #5	0-2.5	[illegible]	50 ±0.7	[illegible]	[illegible]
Site #6	0-2.5	ns[b]	18 ±0.4	[illegible]	[illegible]
"	2.5-5	[illegible]	[illegible]	[illegible]	[illegible]
"	5-10	ns	[illegible]	[illegible]	[illegible]
Site #7 "Edge of village"	0-2.5	[illegible]	[illegible]	[illegible]	[illegible]
Site #8 [illegible]	0-2.5	ns	[illegible]	ns	ns
[illegible]	[illegible]	ns	[illegible]	ns	ns
"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2.5-5	[illegible]	[illegible]	[illegible]	[illegible]
	5-10	ns	[illegible]	ns	ns
	10-15	[illegible]	[illegible]	ns	ns
"	15-20	ns	[illegible]	ns	ns
"	20-25	ns	[illegible]	ns	ns
"	25-30	ns	[illegible]	ns	ns

a. The error values are the [illegible] counting errors for a single sample.

b. [illegible] the net [illegible] equal to [illegible] than the two sigma counting error.

APPENDIX TABLE 15

Predominant Radionuclides in Soil Collected on Eniaetok Island, Rongelap Atoll, September 1976

Collection Location	Soil Depth (cm)	[illegible]	[illegible]	[illegible]Eu	[illegible]	[illegible]Pu	[illegible]
		Radionuclide Concentration in pCi/g, dry[a]					
[illegible]	0-2.5	1.69±0.12	23±[illegible]	2.[illegible]±0.33	3.5±[illegible]	nd[b]	[illegible]
[illegible]	2.5-5	[illegible]	[illegible]	[illegible]	[illegible]	nd	nd
[illegible]	[illegible]	nd[b]	[illegible]	nd	[illegible]	nd	nd
[illegible]	0-2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	nd
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	5-[illegible]	nd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. The error given for all radionuclides is the [illegible] counting error for a single sample.

b. nd = not significantly different [illegible]

APPENDIX TABLE 16

Predominant Radionuclides in Soil Collected on
Kabelle Island, Rongelap Atoll, in September 1976

Collection Location	Soil Depth (cm)	Radionuclide Concentration in pCi/g, dry[a]					
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]Sr
Site #1 [illegible]	0-2.5	[illegible]	34 ±0.6	[illegible]	[illegible]	[illegible]	[illegible]
"	2.5-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	5-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	ns[b]	[illegible]	ns	[illegible]	ns[b]	ns
"	15-20	[illegible]	[illegible]	[illegible]	[illegible]	ns	ns
"	20-25	ns	[illegible]	ns	ns	ns	ns
Site #2 [illegible]	0-2.5	[illegible]	[illegible]	[illegible]	[illegible]	ns	[illegible]
"	2.5-5	[illegible]	[illegible]	ns	[illegible]	ns	ns
"	5-10	[illegible]	[illegible]	ns	ns	ns	ns
Site #3 [illegible]	0-2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	2.5-5	[illegible]	[illegible]	[illegible]	[illegible]	ns	ns
"	5-10	[illegible]	[illegible]	[illegible]	[illegible]	ns	ns
Site #4							
"	0-2.5	1.8 ±0.[illegible]	22 ±0.[illegible]	6.[illegible] ±0.36	[illegible]	[illegible]	[illegible]
"	2.5-5	[illegible] ±0.14	2 ±0.9	3.5 ±0.37	6.3 ±0.4	ns	ns
"	5-10	[illegible]	32 ±1.[illegible]	0.75±0.20	[illegible].6 ±0.23	ns	ns
Site #5	0-2.5	0.47±0.09	52 ±0.7	1.6 ±0.26	3.3 ±0.37	4.[illegible]	23 ±3.5
"	[illegible]	[illegible]±0.07	6.2±0.3	ns	0.15±0.11	na	na
"	5-10	ns	3.7±0.2	ns	ns	na	na

a. The error values for all radionuclides are two-sigma, propagated, counting errors for a single sample.

b. ns = not significant; the net sample count is less than the two-sigma, propagated counting error. na = not analyzed.

A P P E N D I X   T A B L E   17

Predominant Radionuclides in Soil Collected on Naen Island, Rongelap Atoll, in September 1976

Collection Location	Soil Depth (cm)	^{60}Co	^{125}Sb	^{137}Cs	^{155}Eu	^{241}Am	$^{239+240}Pu$	^{90}Sr
		Radionuclide Concentration in pCi/g, dry						
Site #1	0-2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	2.5-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	5-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	10-15	[illegible]	[illegible]	[illegible]	ns	ns	[illegible]	[illegible]
"	15-20	ns	ns	[illegible]	ns	ns	na	na
"	20-25	ns	ns	[illegible]	ns	[illegible]	na	na
"	25-30	ns	ns	[illegible]	ns	ns	na	[illegible]
Site #2	0-2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	na	[illegible]
"	2.5-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	na	na
"	5-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	na	na
"	10-15	[illegible]	[illegible]	[illegible]	ns	[illegible]	na	na
"	15-20	[illegible]	ns	[illegible]	[illegible]	[illegible]	na	na
"	[illegible]	[illegible]	ns	[illegible]	ns	ns	na	na
"	[illegible]	ns	ns	[illegible]	ns	ns	na	na
"	50-75	ns	ns	[illegible]	ns	ns	na	na
Site #3	0-2.5	1.2 ±0.12	0.34±0.10	136 ±1	5.9 ±0.34	11 ±0.14	[illegible] 12.5	82 ± [illegible]
"	2.5-5	3.1 ±0.21	1.9 ±0.67	[illegible]	6.9 ±0.50	14 ±0.39	na	na
"	5-10	2.1 ±0.16	1.2 ±0.49	155 ±1.1	5.2 ±0.45	3.4 ±0.62	na	na
"	10-15	0.77±0.11	0.91±0.20	44 ±0.7	0.78±0.24	2.0 ±0.31	na	na
"	15-25	0.27±0.08	0.56±0.11	[illegible]	0.22±0.11	0.31±0.13	na	na
"	[illegible]	[illegible]	0.27±0.15	[illegible]	ns	ns	na	na
"	[illegible]	0.06±0.04	ns	0.6 ±0.1	ns	ns	na	na
"	50-75	ns	ns	ns	ns	ns	na	na

Table 17 (Cont.)

Collection Location	Soil Depth (cm)	Radionuclide Concentration in pCi/g, dry[a] ^{60}Co	^{125}Sb	^{137}Cs	^{155}Eu	^{241}Am	$^{239,240}Pu$	^{90}Sr
[illegible]	0-2.5	5.5 ±0.10	[illegible]	[illegible]	[illegible]	22 ±[illegible]	57 ±3.[illegible]	236 ±36
[illegible]	2.5-5	1.1 ±0.[illegible]	ns	56 ±[illegible]	[illegible] ±0.10	[illegible]	na	54 ±4.[illegible]
[illegible]	5-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ns	[illegible]
[illegible]	[illegible]	ns	ns	[illegible]	ns	ns	ns	na
[illegible]	[illegible]	ns	ns	[illegible]	ns	[illegible]	ns	ns
[illegible]	[illegible]	[illegible]	ns	[illegible]	ns	ns	ns	ns
[illegible]	[illegible]	ns	[illegible]	[illegible]	ns	[illegible]	ns	ns
[illegible]	0-2.5	8.4 ±0.[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2.5-5	[illegible]	[illegible]	22 ±[illegible]	[illegible]	[illegible]	ns	ns
[illegible]	5-10	[illegible]	ns	[illegible]	ns	[illegible]	ns	ns
[illegible]	[illegible]	ns	[illegible]	[illegible]	ns	ns	ns	ns
[illegible]	[illegible]	ns	ns	[illegible]	ns	ns	ns	ns
[illegible]	0-2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2.5-5	[illegible]	ns	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	5-10	[illegible]	[illegible]	[illegible]	ns	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	ns	[illegible]	[illegible]	[illegible]	ns	ns
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ns	[illegible]	ns	ns

a. The error values for all radionuclides are two-sigma, propagated, counting errors for a single sample.

b. ns = not significant; the net sample count is less than the two-sigma, propagated counting error. na = not analyzed.

APPENDIX TABLE 18

Predominant Radionuclides in Plants Collected on
Bikini Island in September and October 1976

Sample Type	Collection Site	Radionuclide Concentration in pCi/g, dry[d] ^{40}K	^{137}Cs	^{90}Sr	$^{239,240}Pu$
Coconut, [illegible]	1st BLS, row 35.5	ns[b]	3990.4	na[b]	na
[illegible]	[illegible]	ns	[illegible]	na	na
[illegible]	[illegible]	ns	[illegible]	na	na
[illegible]	[illegible]	[illegible]	[illegible]	na	na
[illegible]	[illegible]	ns	[illegible]	na	na
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a. [illegible]

b. ns = not significant, the net sample count is less than the two-sigma, propagated counting error. na = not analyzed

APPENDIX G

GAMMA EMITTING RADIONUCLIDES IN PLANTS AND SOIL SAMPLES COLLECTED AT BIKINI ISLAND IN OCTOBER 1977 AND APRIL 1976

APPENDIX G

Gamma Emitting Radionuclides in Plant and Soil Samples

Collected at Bikini Island in October 1977 and 1974-76

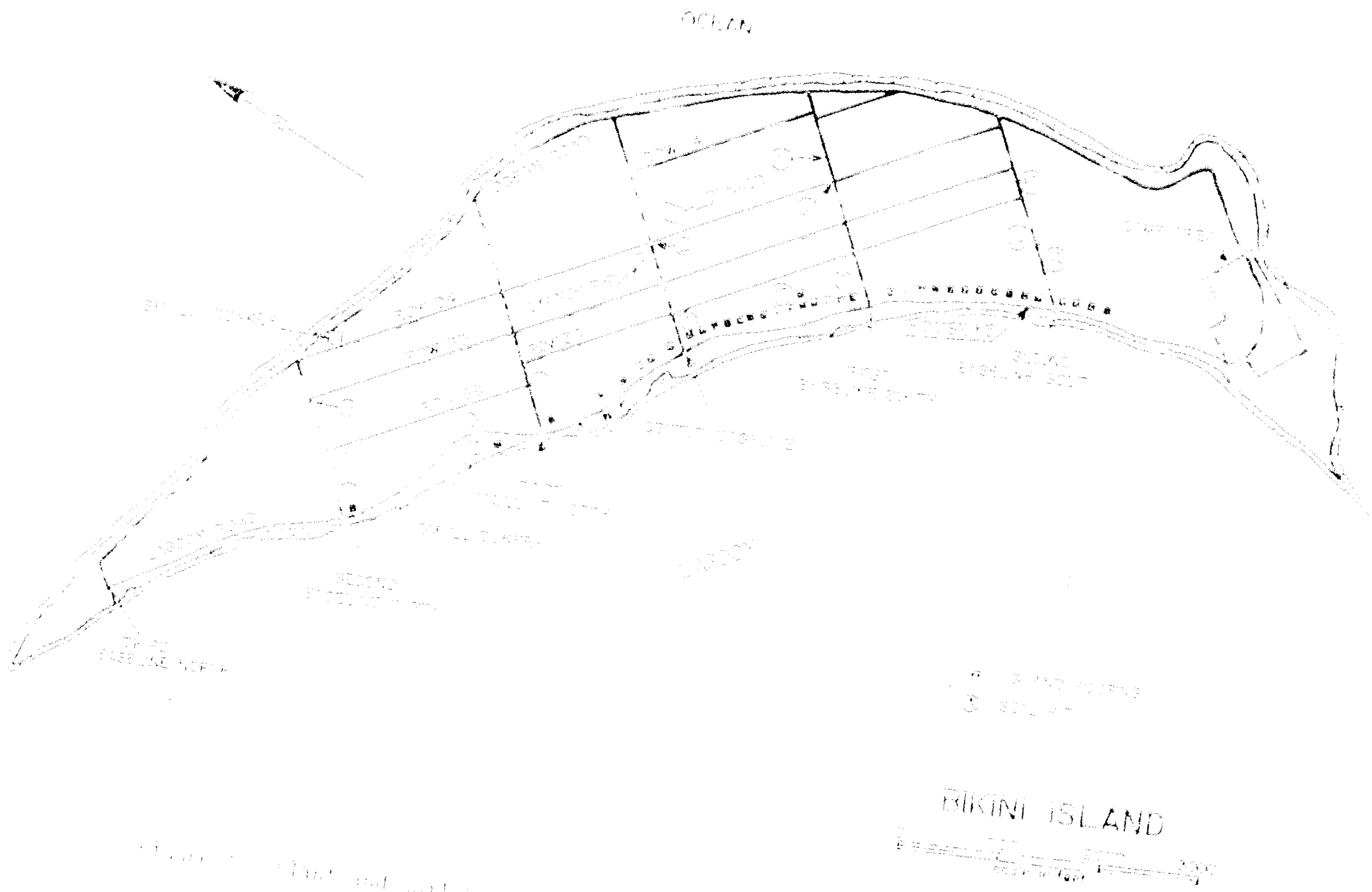
A field trip to Bikini Island in the spring of 1977 was cancelled because of the unavailability of the support ship, the [illegible]. However, a collection of samples was made in October 1977 as part of [illegible] program, the laboratory's "Biogeochemistry of Transuranic Elements" supported by the Division of Biomedical and Environmental Research. This collection was [illegible] on a space available basis and therefore was not as extensive as planned for the original field trip but some of the samples were collected at sites where samples had been collected in 1974, 1975 or 1976. Following is the final report of the gamma emitting radionuclides in the October 1977 Bikini Island samples and also, for the purpose of comparison, the results of analysis of similar samples collected in previous years.

The locations of the sites at Bikini Island where samples were collected in October 1977 are shown in Figure 1. The dominant gamma emitting radionuclide is ^{137}Cs and the results of analysis for this radionuclide in 33 samples from edible plants — coconut, pandanus, breadfruit [illegible] — are presented in Table 1 and in Figure 2. The values range from [illegible] × $10^{[illegible]}$ to 4.[illegible] × 10^{4} pCi per gram of dry sample. Also in this table and figure are the results of analysis for ^{137}Cs in samples collected from the same sites [illegible] in either 1974, 1975 or 1976. A perusal of the data in Table 1 and Figure 2 indicates no strong decreasing trend for ^{137}Cs in these samples for the 1974-1977 period. In fact, many of the 1977 values are greater than those for earlier years. However, the differences between years for the ^{137}Cs values probably are not statistically significant because the values in Table 1 are single sample counts and the sample may not have been collected in all cases from the same plant or tree as samples in other years.

Soil profile samples were collected at two sites, Pit 29 and Pit [illegible], in October 1977 and the results of analysis of these samples for ^{137}Cs, ^{241}Am, [illegible], and ^{60}Co are given in Table 2. The dominant radionuclide was ^{137}Cs and the radionuclide of second greatest abundance was ^{241}Am. Also presented in Table 2 are the results of analysis of soil profile samples collected at Pit 29 in 1974. The 1977 values appear to be greater than the 1974 values for [illegible] but the difference may not be statistically significant.

The data for ^{137}Cs in soil profile samples from Pit 29 for 1977 and 1974 are shown graphically in Figure 3. For samples above 30 cm, the 1977 values are slightly greater than the 1974 values which suggests little or no downward movement of ^{137}Cs during this period. The decrease of ^{137}Cs with soil depth [illegible] to be approximately exponential with the values of the surface and at 40 cm being $10^{[illegible]}$ and [illegible] × $10^{[illegible]}$ pCi per gram of dry sample, respectively. Also in Figure 3 are ^{137}Cs values for pandanus and breadfruit samples collected at the same site (Pit 29) as the soil profile samples. The maximum value was [illegible] × $10^{[illegible]}$ pCi of ^{137}Cs per gram of dry sample for the edible portion of [illegible] fruit collected in October 1977.

The 1977 radionuclide values appeared to be significantly greater at Pits 9, K and C and at house 37 and [illegible] than [illegible] in recent years. For this reason, the persons collecting the samples were asked about the opportunities to collect samples in 1977 that duplicated the samples collected in recent years. Pit 9 was positively identified but the face of the pit from which samples had been collected earlier could not be identified because of sloughing. Pit [illegible] was dug in a depression in the ground but there was no positive identification that this was the former site of Pit K. Pit C [illegible] trench that could not be located. As a result the [illegible] sampled in 1975 could not be positively identified as there were several [illegible] in the area. At house 21, the trench could not be found but the [illegible] behind the house that was sampled in 1977 was probably the [illegible] previously. At [illegible], row 35, the trench could not be found and the [illegible] sampled was one of three that was present. Therefore, because of the uncertainty in obtaining duplicate samples, some [illegible] in the estimate of the difference in radionuclide values between years [illegible].



... Plant and soil sampling sites of Bikini Island, October 1977

Table 1. Cesium 137 values for Plants collected on Bikini Island in Octob 1977 and for similar samples collected between 1974 and 1976.

Sample Type		Collection Site	¹³⁷Cs in pCi/g of dry sample* 1977	1976	1975	[illegible]
Coconut	Leaves	Soil Pit A	240		105	
"	"	" 2	92		181	
"	"	" 5	31	133	114	
"	"	" [illegible]	134		316	
"	"	" [illegible]	190		159	
"	"	" 16	58		69	
"	"	" 27	70			
"	"	" 23	110	40		
"	"	" 21	144	103	59	32
"	"	Tree 38, Row 3	[illegible]	39		
"	Meat	Soil Pit 2	687			
"	"	" 5	78			
"	Milk	" 2	2940			
"	"	" 5	672			
Pandanus	Edible Portion	House 25	3020			[illegible]
"	Inedible Portion	"	[illegible]			[illegible]
"	Leaves	"	[illegible]	1050		[illegible]
"	Edible Portion	Soil Pit 21	450	398		
"	Inedible Portion	"	234	164		
"	Leaves	"	[illegible]	104		
"	Edible Portion	Soil Pit 9	2070			
"	Inedible Portion	"	2550			
"	Leaves	"	477	2050		
"	"	Soil Pit C	3050	[illegible]	537	
Breadfruit	Leaves	Soil Pit C	52	42	63	
"	"	" D	282	329	37	
"	"	" 29	62	57	95	[illegible]
"	"	Soil Pit [illegible]	72	26	29	
"	Edible Portion	"	50	64		
"	Inedible Portion	"	87	55		
Papaya	Leaves	House 224	158			
"	Edible Portion	"	592	39		
"	Inedible Portion	"	626	74		

* Single sample values. Counting error (2SD), [illegible]% of the net count.

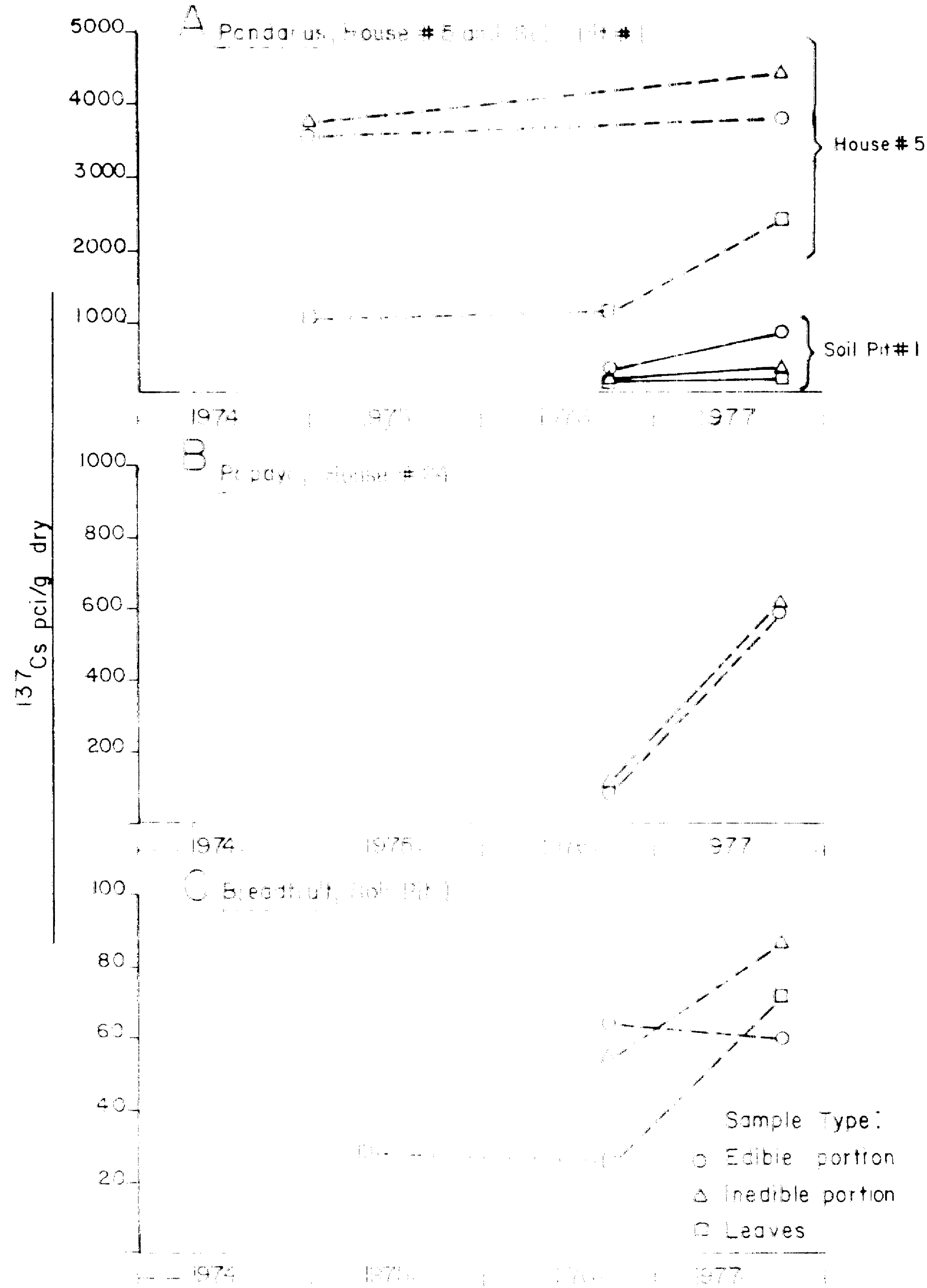


Figure 2. Cesium-137 values for food plant samples collected at various locations on [illegible] Island, 1974-1977.

Table 2. Predominant gamma-emitting radionuclides in soil profile samples collected at Bikini Island in [illegible] 1977 and [illegible] 1976

Collection Site	Soil Fraction	Collection Date	Radionuclide concentration in pCi/g, dry[a] Am	Cs	Co	Eu
Pit #9	0-2.5 cm	[illegible] Oct. 1977	[illegible] ± 0.[illegible]	[illegible] ± 1.1	1.8 ± 0.1	[illegible] ± 0.3
	2.5-5	"	6.6 ± 0.[illegible]	101 ± 0.9	[illegible].4 ± 0.1	[illegible].9 ± 0.3
	5-10	"	[illegible].7 ± 0.[illegible]	[illegible] ± 0.4	0.4 ± 0.1	0.4 ± 0.1
	10-15	"	2.[illegible] ± 0.[illegible]	13 ± 0.3	ns[b]	ns
	15-20	"	ns	3.7 ± 0.2	ns	ns
	20-25		ns	1.7 ± 0.[illegible]	ns	ns
	25-35	"	0.4 ± 0.[illegible]	0.4 ± 0.1	ns	ns
	35-47	"	0.7 ± 0.[illegible]	0.2 ± 0.1	0.2 ± 0.1	ns
	47-59	"	1.7 ± 0.2	0.2 ± 0.1	ns	ns
Pit K	0-2.5 cm	30 Oct. 1977	2.6 ± [illegible]	78 ± 0.5	0.6 ± 0.1	[illegible].7 ± 0.2
	2.5-5	"	2.4 ± 0.[illegible]	72 ± 0.9	0.[illegible] ± 0.1	[illegible].7 ± 0.2
	5-10	"	2.6 ± 0.[illegible]	52 ± 0.7	0.[illegible] ± 0.1	[illegible].7 ± 0.2
	10-15	"	[illegible] ± 0.[illegible]	36 ± 0.6	0.3 ± 0.1	[illegible] 4 ± 0.2
	15-25	"	1.5 ± 0.[illegible]	[illegible]6 ± 0.6	0.3 ± 0.1	[illegible] 3 ± 0.2
	25-35	"	[illegible] ± 0.2	15 ± 0.3	0.[illegible] ± 0.03	[illegible] ± 0.2
Pit #9	0-2.5 cm	8 Dec. 1976	3.8 ± 0.[illegible]	[illegible] ± 0.5	[illegible].2 ± 0.1	[illegible] ± 0.1
	2.5-5		[illegible] ± 0.2	72 ± 0.[illegible]	[illegible] ± 0.1	[illegible].7 ± 0.1
	5-10	"	[illegible] ± 0.[illegible]	28 ± 0.4	0.[illegible] ± 0.1	[illegible] ± 0.1
	10-15		ns	2.5 ± 0.[illegible]	ns	ns
	15-25	"	ns	1.2 ± 0.1	0.01 ± 0.02	ns
	25-50	"	ns	0.4 ± 0.06	ns	ns
	50-75	"	ns	0.1 ± 0.03	ns	ns
	75-100	"	ns	0.[illegible] ± 0.03	ns	ns

a. Values for single samples ± counting error ([illegible]).

b. ns = sample count not significant.

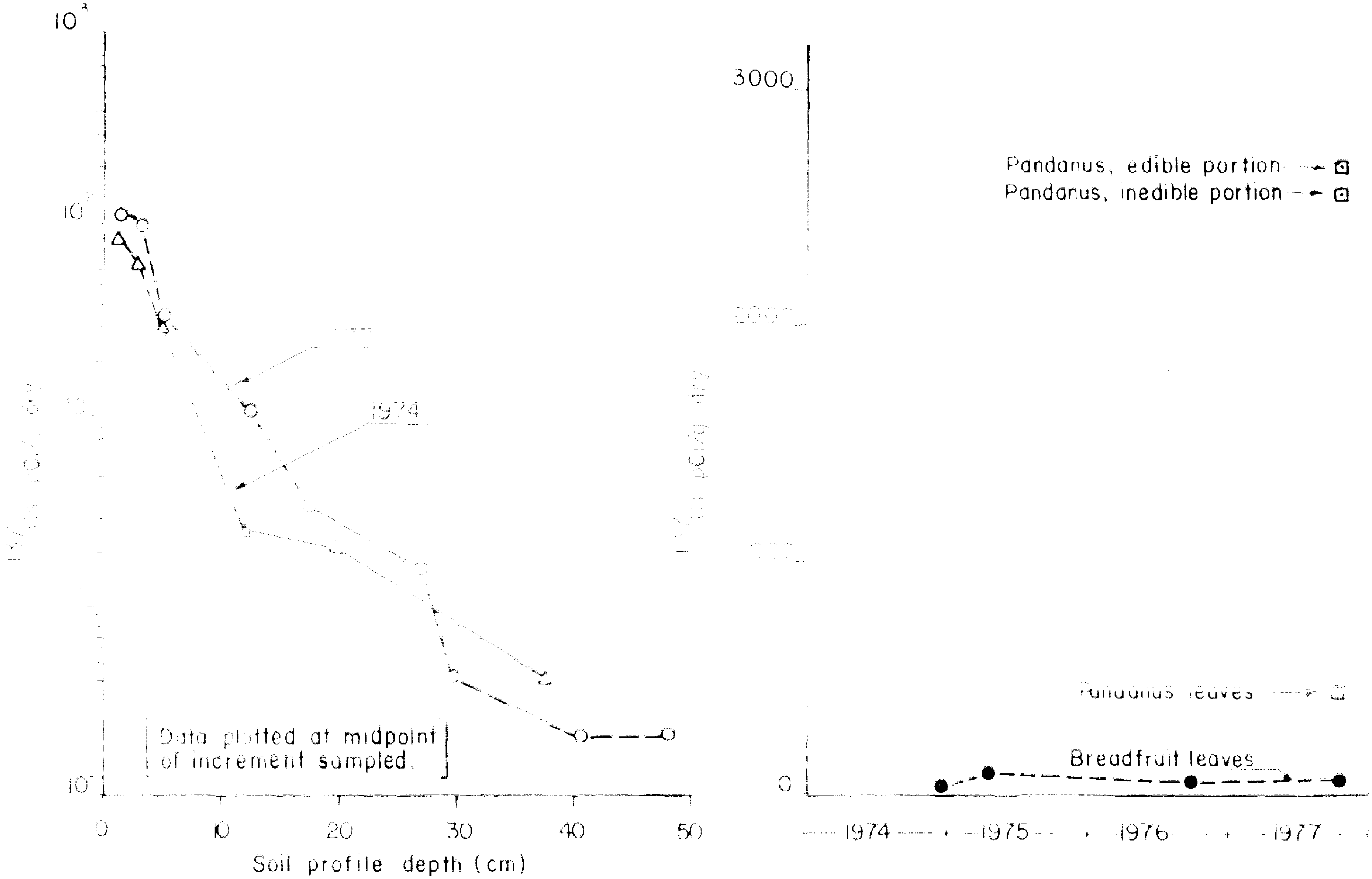


Figure 3. Cesium-137 values in soil and plant samples from Pit #9 on Bikini Island, 1974-1977.

APPENDIX 6

INTERLABORATORY COMPARISON PROGRAM

AND RADIONUCLIDE DETECTION LIMITS

APPENDIX 6

Interlaboratory [illegible] Program [illegible] Detection Limits

Since 197[illegible], the laboratory has [illegible] extensively in interlaboratory comparison programs [illegible] of "unknown" radionuclides in both standard and environmental samples. [illegible] these results and from the results of routine [illegible] of duplicate [illegible] samples, we have corrected and improved our methods [illegible] and [illegible] established and maintained the quality of our analytical [illegible].

For the interlaboratory program we [illegible] about 170 samples including about [illegible] The [illegible] programs are with the International Atomic Energy Agency (IAEA), the [illegible] Protection Agency (EPA) and the Environmental Measurements [illegible] (EML), (formerly the Health and Safety Laboratory (HASL)). For IAEA, [illegible] samples are analyzed yearly; for EPA [illegible] quarterly; and for EML, samples of fresh water, sea water, [illegible] marine sediments, fish meal, vegetation meal, [illegible]

The results of [illegible] laboratories participating in these programs have been tabulated [illegible] prepared of the tabulation, "Summary of Quarterly [illegible] Results [illegible] Analysis". The report was prepared by [illegible] available upon request. Generally, our results [illegible] compared [illegible] known values in the standards and with the mean [illegible] "unknown" radionuclides in the environmental samples.

The methods of analysis [illegible] for the interlaboratory program and commonly used in our laboratory for the analysis of [illegible] are as follows:

1. alpha emitting [illegible] methods for ^{210}Po, [illegible]Pu, [illegible]Pu and [illegible] zinc sulfide [illegible] tube counting for gross alpha measurements.

2. beta emitting [illegible] separation and counting for ^{90}Sr and [illegible]I; liquid scintillation method [illegible] low background, gas counting methods for [illegible]

3. gamma emitting radionuclides [illegible] NaI(Tl) detection systems for radionuclides such as [illegible] etc.; for x-ray emitters such as [illegible] chemical [illegible] proportional counting.

The limits of detection for [illegible] important since they govern the amount of a radionuclide that [illegible] present in a sample. Many factors influence the limit of detection [illegible] the type of detector and analyzer, the presence of other [illegible] of the counting period, the size and density [illegible] relationship of the sample and detector. Hence, [illegible] vary considerably for various radionuclides and types of samples, [illegible] summarized by stating that the detection limits [illegible] follows:

By gamma detection	
^{40}K	2.1 pCi/g or less
^{7}Be, ^{103}Ru, ^{106}Ru, ^{144}Ce, [illegible], [illegible]	0.21 (?) " "
^{95}Nb, ^{95}Zr, ^{125}Sb, ^{137}Cs, [illegible], ^{226}Ra	0.02 (?) " "
By beta detection	
^{3}H	4[illegible] pCi/liter or less
^{90}Sr	0.2 pCi/g or less
By X-ray detection	
^{55}Fe	0.04 " "
By alpha detection	
$^{239,240}Pu$	0.02 " "