NERC-LV-539-2

# OFF-SITE RADIOLOGICAL SAFETY for the CANNIKIN EVENT November 6, 1971

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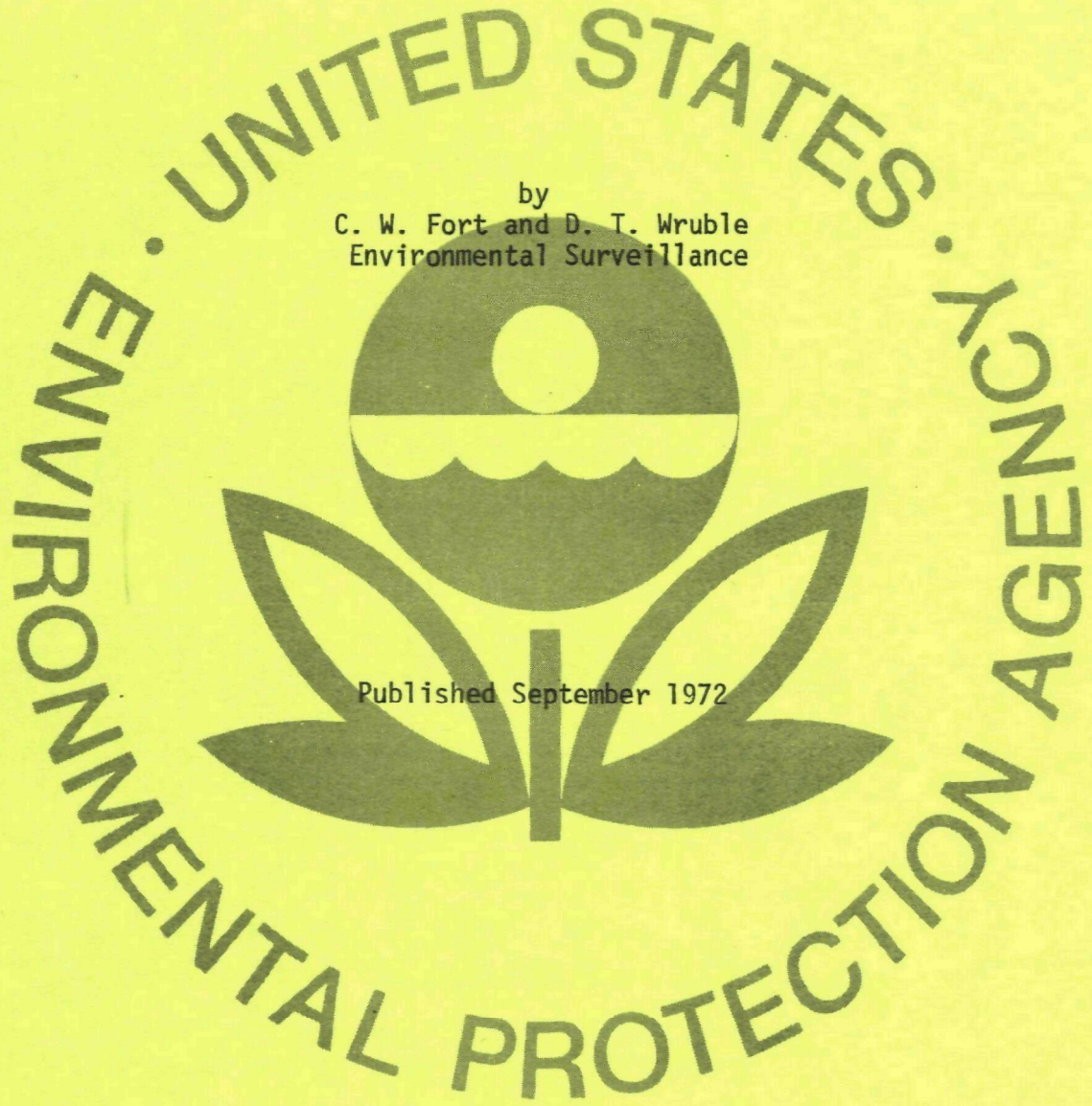
Environmental Surveillance




Published September 1972

National Environmental Research Center
U. S. ENVIRONMENTAL PROTECTION AGENCY
Las Vegas, Nevada

This surveillance performed under a Memorandum of Understanding No. AT(26-1)-539
for the
U. S. ATOMIC ENERGY COMMISSION

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ABSTRACT

The U. S. Environmental Protection Agency conducted an off-site radiological surveillance and public safety program in Alaska for the Cannikin Event, a high yield underground nuclear weapon test conducted on Amchitka Island on November 6, 1971. In addition to aerial and shipboard monitoring teams in the Amchitka area, personnel were stationed at twenty-five communities on Kodiak Island, the Alaska Peninsula, the Aleutian Island Chain, the Pribilof Islands, and Anchorage to monitor environmental radioactivity levels if a radioactive release occurred, and coordinate other public safety measures that might be required. Air, water, milk, precipitation, vegetation, soil, sediment, and marine foodstuff samples were also collected during the test period. No radioactivity above usual background levels was observed, and no public safety problems were encountered.

TABLE OF CONTENTS

LIST OF TABLES

## I. INTRODUCTION

The Cannikin Event was a high yield underground nuclear weapon test conducted by the U. S. Atomic Energy Commission on Amchitka Island, a member of the Rat Island group in the Aleutian Islands, at 1200 hours Bering Standard Time(BST) on November 6, 1971. In accordance with a Memorandum of Understanding between the Atomic Energy Commission (AEC) and Environmental Protection Agency (EPA), the EPA National Environmental Research Center-Las Vegas (NERC-LV)*conducted an off-site radiological surveillance and public safety program in Alaska for the test. This report summarizes the activities of NERC-LV monitoring personnel, describes the environmental monitoring program and presents the environmental monitoring results.

## II. OPERATIONAL GUIDE

In accordance with the AEC-EPA Memorandum of Understanding, the NERC-LV was responsible to the AEC Test Manager for providing an off-site safety program for the Cannikin Event as outlined in Chapter 0524, "AEC Standard Operating Procedure, Nevada Test Site Organization." NERC-LV responsibilities included:

1. Documenting the radiological situation in off-site areas through comprehensive environmental sampling and radiation monitoring.
2. Assuring continuous protection of public health and safety by determining potential and past radiation exposures, and implementing protective measures as directed by the Test Manager.
3. Conducting a public contact and information program in the off-site area to assure local residents that all reasonable safeguards were being employed to protect public health and property from test effects.
4. Collecting information regarding incidents which may be attributed to the test.

*At the time this work was performed, the NERC-LV was named Western Environmental Research Laboratory.

For planning the Cannikin Event, the radiological safety criteria were as described in the August 1, 1962 AEC Headquarters memorandum to the Manager, AEC Nevada Operations Office:

> "...the criterion shall be 3.9 Roentgens per year whole body exposure including any exposure from non-weapons test activities (but excluding background and medical x-rays). The criterion of 3.9 Roentgens is in the definite context used in the past, i.e., every reasonable effort should be made to keep the radiation exposures as low as possible, but for planning purposes, if unanticipated yet credible circumstances could result in estimated doses in excess of 3.9 Roentgens per year, then the detonation should be postponed until more favorable conditions prevail. Also, to avoid any given community receiving unusually high exposures over a period of years, the guide shall be not more than 10 Roentgens in any consecutive 10-year period."

## III. OPERATIONAL PROCEDURES

The NERC-LV surveillance program consisted of collecting a variety of environmental samples and radioactivity measurements at various locations in Alaska before and after the Cannikin test. Air, water, milk, snow, vegetation, soil, sediment and marine samples were collected. Radioactivity measurements were made with survey instruments, recorders and dosimeters. At the time of the test, monitoring personnel were stationed at twenty-two Alaskan communities and three military bases. Seven persons served on aircraft and sea vessels as monitors in the immediate Amchitka Island area. Monitoring activities were coordinated by the Project Officer in Anchorage and the Director of the NERC-LV served on the Test Manager's Advisory Panel on Amchitka.

### A. Official Briefings

In May 1971, the NERC-LV Director served on a briefing panel at open meetings in Anchorage and Juneau to describe the surveillance program of the NERC-LV to the Governor of Alaska, other State officials

and Alaska residents. Additionally, a short movie film describing the surveillance program was produced and made available to all interested groups in Alaska. This film was requested and seen by civic groups, schools, and service clubs in the state. In August 1971, the NERC-LV Project Officer presented a special briefing on the surveillance plan to the Commissioners of the Alaska State Departments of Environmental Conservation, Fish and Game, and Health and Social Services. Just prior to event day, the Project Officer and a NERC-LV staff member were members of a panel to brief the Governor of Alaska. At the time of the test, a NERC-LV staff member represented the EPA at the state capitol building in Juneau to brief State officials on monitoring activities, and another NERC-LV staff member was assigned to the AEC Anchorage Information Center.

B. Community Information and Stand-by

Five weeks before the event, the NERC-LV Project Officer and an AEC staff member began visiting inhabited locations on the Alaska Peninsula and Aleutian Island Chain to establish support for NERC-LV monitors who would stand by at each location for the event. This advance team also made arrangements for one of two separate AEC/NERC-LV briefing teams to visit each community and provide the residents with information regarding the Cannikin test. The briefing teams presented movies about the test and conducted question and answer periods. Generally, the briefing teams remained overnight at each location.

About two weeks before the event, NERC-LV monitoring personnel were on station at twenty-two communities representing all inhabited locations from Chignik on the Alaska Peninsula to Attu at the tip of the Aleutian Chain, as well as St. Paul and St. George in the Pribilof Islands. Two monitors were also stationed at Old Harbor and Akhiok on Kodiak Island several days prior to the event.

An additional two monitors were stationed in Anchorage at event time. The figure on page 13 shows these locations.

The monitors were responsible for radiological monitoring and coordinating public safety and information activities at each location. They were prepared to assist local residents in moving to high ground should a tsunami occur, and each individual was part of a two-way communications network (consisting of both telephone and radio-telephone systems) that was tied in to the Control Point on Amchitka Island. Information from the Control Point was relayed to all locations simultaneously, with the exception of Old Harbor and Akhiok. The monitors at these two locations were on a separate link and were kept advised by an AEC representative in Kodiak. Each monitor was equipped with portable radiation detection instruments, dosimeters, air sampling equipment and supplies for collection of other environmental samples.

C. Community Monitoring

Upon arrival at their standby locations, the monitors made radiation surveys in their communities and collected environmental samples including potable water, vegetation, soil, and stream or lake sediment samples. For radiation detection, each monitor was equipped with two Geiger-Mueller survey instruments for measurements in the background (0.01-0.02 mR/h) to 2 R/h range. All monitors had three thermoluminescent dosimeters (TLD's) to establish a fixed dosimetry station, and film badges that would have been issued to residents had venting of radioactivity occurred. All monitors were also equipped with air samplers.

D. Aerial Monitoring

Aerial monitoring was performed by four monitors, two each aboard Air Force C-130 aircraft. At event time, the two NERC-LV monitoring

teams were airborne near surface ground zero and were prepared to sample and track any airborne release of radioactivity. They were equipped with survey instruments to measure radioactivity levels and with air sampling equipment to collect particulate and compressed air samples from aircraft air intakes. They also carried counting equipment to perform on-board gross beta analysis of the particulate filters, if required.

Following the detonation, sampling aircraft made low altitude passes over surface ground zero to check for any airborne release of radioactivity. No such release was detected and the aircraft were released from their monitoring mission within two hours after the detonation.

E. Shipboard Monitoring

Three NERC-LV monitors were on board two naval vessels and a Coast Guard vessel near Amchitka on event day. These monitors collected air samples and marine water samples before and after the event, and each monitor was equipped with radiation detection instruments and dosimeters.

F. Human Surveillance

In cooperation with the Alaska Native Health Service, blood and urine samples were collected by that group from about 50 Atka residents several days prior to the event. The samples were analyzed at the NERC-LV for $^{55}Fe$ and tritium, respectively. No post-event blood or urine samples were collected. Prior to event day the NERC-LV monitor at Atka also obtained a whole-body count of 53 residents with a portable counting system to establish background gamma radionuclide body burden levels.

## IV. ENVIRONMENTAL SURVEILLANCE

For the Cannikin Event, various environmental samples were collected at forty-four locations within Alaska. Depending upon the location such samples included various combinations of air (particulate, gaseous and

moisture), water, snow, vegetation, soil and sediment samples. All samples were returned to NERC-LV for analysis. Dosimetry stations were established at sixteen locations about three months before the event to document background environmental radiation levels. Dosimeters were exchanged monthly and read at the NERC-LV Field Office in Anchorage.

A. Air Sampling

During August 1971, the Project Officer visited fifteen locations in Alaska to install air sampling equipment and to brief local operators on its use(see map p. 13). Air samplers consisted of an electrically-driven positive displacement vacuum pump which pulled air through a 4-inch diameter Gelman Type E glass fiber particulate filter followed by an activated charcoal cartridge for collection of reactive gases. Sampling rates were 8 to 10 cfm. Continuous 24-hour samples were collected by the station operators and mailed to the NERC-LV for analysis. All stations operated for about four weeks prior to the event. In addition to the fifteen regular air sampling stations, air samples were collected at seven monitor stand-by locations. Monitors at the remaining locations had air samplers and would have begun sampling had venting occurred.

Filters received an immediate gross beta count upon receipt at the Center. Any sample indicating a count rate over 500 cpm (approximately 1.5 $pCi/m^3$ for a 24-hour sample) would have been gamma scanned. Repeat beta counts were conducted on the fifth and twelfth day after collection, and the results extrapolated to estimate the activity at the mid-point of the collection period. All charcoal cartridges received a 10-minute gamma scan upon receipt at the NERC-LV. Had any scan indicated a net integrated gamma count rate greater than 300 cpm, isotopic identification would have been made.

Atmospheric moisture samples for tritium analysis were collected at eight locations in Alaska before and after the test. These samples were collected using molecular sieve samplers operated over a two-hour period.

B. Gamma Rate Recorders

Gamma rate recorders were operated at Cold Bay, Atka, Adak, Shemya and St. Paul by NERC-LV monitors beginning on the morning of D-day and continuing through H + 6 hours. The gamma rate recorder was a portable, battery operated unit consisting of a Geiger-Mueller survey instrument driving a Rustrak recorder. The instrument range was 0.01 mR/h to 2 R/h. The unit was capable of operating continuously for ten days.

C. Dosimetry

Three thermoluminescent dosimeters (TLD's) in sealed plastic bags were mailed from the NERC-LV Field Office in Anchorage to each of the regular air sampling stations at D-15 weeks. Upon arrival, the TLD's were placed in the vicinity of the air samplers. These TLD's were then exchanged on a monthly schedule. The last exchange was made a few days before the event.

Each packet of TLD's sent to the station operators included a control group of three TLD's that was returned immediately to the Field Office for read-out. This procedure provided in-transit background information for use in calculating the on-station TLD exposure. Station dosimeters were also returned to the Field Office for read-out. Extra TLD's were also issued to NERC-LV monitors before they left Anchorage for their stand-by stations.

The TLD's used were EG&G TL-12 thermoluminescent $CaF_2$:Mn dosimeters, with a sensitivity range of approximately 5 mR to 5000 R for external gamma measurements. The dosimeter response is energy independent within $\pm$ 14% for 70 keV to 1.25 MeV photons.

D. Water and Snow Sampling

One-gallon water samples were collected from potable water supplies before and after the test at the regular air sampling

stations and the stand-by locations. One-gallon samples of sea water were collected by the NERC-LV monitors on board ships. Snow samples were also collected at several locations before and after the test. Each sample was analyzed for tritium, gross alpha and beta activity, and each sample received a gamma scan.

E. Milk Sampling

Pre-event and post-event milk samples were collected from three Grade-A dairies in the Palmer area near Anchorage. These samples represented the only commercial milk producing area in Alaska. Water and milk-cow feed samples were also collected at these dairies. Each milk sample was analyzed for strontium and tritium, and each received a gamma scan. Water samples were analyzed as above, and the feed samples received a gamma scan and tritium analysis.

F. Vegetation and Soil Sampling

Natural vegetation and soil samples were collected several days prior to the test at twenty-two of the communities at which NERC-LV monitors were stationed. Vegetation was collected from a one-square-foot area. Two soil samples within this same area were also collected. The first sample consisted of the first one inch from the surface, and the second sample included the next two inches. Sediment samples were also collected at the standby locations from streams or lakes. Each soil, sediment and vegetation sample received a gamma scan and tritium analysis.

G. Marine Foodstuff Sampling

Pre-event marine foodstuff samples, including salmon, crab, scallop, cod, halibut and shrimp, were collected from commercial fishing areas off the Alaska and Washington coasts. These samples were provided from stored inventories by the National Canners Association office in Seattle, Washington. Additionally, marine samples collected near

Amchitka by the University of Washington during the immediate pre-event and post-event periods were sent to the NERC-LV for analysis. All samples were analyzed for tritium. Samples that weighed more than 50 gm were gamma scanned, and $^{90}Sr$ analysis was performed on at least one sample from selected locations.

Samples consisting of fresh whole fish, eviscerated with heads and tails removed, including salmon, halibut and cod, were ground in preparation for analysis. Samples consisting of canned products, including shrimp, salmon and crab, were analyzed without separate preparation. Only the edible portions of fresh crab and scallop were analyzed.

Post-event marine foodstuff representing the commercial fishing areas in Alaska will be sent to the NERC-LV once these samples are available. The analytical results of these samples will not appear in this report since the samples will not be collected prior to the summer or fall of 1972. A supplementary report of these analytical results will be issued.

## V. RESULTS

The NERC-LV aerial tracking team did not detect an airborne release of radioactivity from surface ground zero. A comparison of the analytical data of pre-event and post-event environmental samples shows no change in environmental radioactivity levels. A summary of all environmental sampling and dosimetry data is given in Tables 1 through 9. A detailed listing of all sample analyses can be obtained in a separate appendix to this report, NERC-LV-539-3, by writing to the Director, National Environmental Research Center, P. O. Box 15027, Las Vegas, Nevada, 89114.

Initial gross beta counts of particulate air filters showed no filters to have gross beta activities in excess of 500 cpm, the level which would indicate the possible presence of fresh fission products. For this reason, the filters were not gamma scanned. A charcoal cartridge was run with each particulate filter, and these received a gamma scan. No cartridge showed detectable amounts of fission products. A summary of particulate gross beta concentrations is given in Table 1.

The tritium levels in atmospheric moisture at all sampling locations are considered normal. Results are summarized in Table 2. The pre-event and

post-event samples from Adak had slightly higher tritium levels than both the pre-event and post-event samples observed at other locations, but no explanation for this difference is available at this time. Further sampling at Adak is planned in an attempt to verify these data.

The dosimetry data show a consistent exposure rate during the approximately 17-week exposure period. Average daily exposure rates for the entire period are given in Table 3.

Analytical results of milk samples collected in the Palmer area before and after the event are comparable. The data are summarized in Table 4. Data from milk cow feed and water samples collected with each milk sample are presented in Table 5. Continuing milk data are available through the EPA Pasteurized Milk Network sampling and analysis program. Results are regularly reported in *Radiation Data and Reports* (formerly *Radiological Health Data and Reports*).

The gamma scans of all water samples collected at the stand-by locations and the regular air sampling locations were negative for fresh fission products. The maximum tritium concentration in water was 1000 pCi/l in a sample collected near Palmer. No snow samples produced positive gamma scans, and the maximum tritium concentration was 500 pCi/l in a sample collected at Soldotna prior to the event. Analytical results are summarized in Table 6.

At this time, post-event results are available only for marine foodstuff samples collected near Amchitka. Post-event samples from the pre-event sampling locations will be analyzed as they become available from normal commercial fishing activities during 1972. A supplementary report will be issued with these post-event data. The post-event Amchitka samples analyzed by NERC-LV do not show increased levels of tritium or the presence of any fresh fission products. Data are summarized in Table 7.

Each vegetation sample collected at the monitor stand-by locations was analyzed for tritium and given a gamma scan. Tritium levels for all samples are at background concentrations, as shown in Table 8. Cesium-137

was detected in samples from all locations with the exception of St. Paul. A type of vegetation collected at several locations appeared to contain $^{137}Cs$ levels generally higher than other types sampled. This type of vegetation was not identified by name although it was described as a lush, matted, moss-like vegetation. The maximum $^{137}Cs$ level observed (3400 pCi/kg) came from this type vegetation in a sample collected at Attu. Results for stream- or lake-bottom sediments and for soil samples collected at each vegetation sampling site are given in Table 9.

A discussion of the results of urine and blood analysis and whole-body counting of Atka residents is to be presented in a separate report being prepared at the NERC-LV. Generally, the Atka urine tritium levels are comparable to those found in families living in rural areas of Nevada. The maximum level observed was 9400 pCi/l. The lowest concentration was <310 pCi/l.

Cesium-137 levels in Atka residents, as measured by whole-body counting, were found to be higher than in the Nevada Test Site area, but lower than levels observed in villages in the Arctic regions of Alaska. The highest $^{137}Cs$ body burden observed was 0.5 nCi/kg body weight which is estimated to give not more than about 4 mrad per year. The lowest body burden observed was 0.1 nCi/kg body weight.

Iron-55 levels in the blood of Atka residents appeared comparable(mean of 9 pCi/ml) to levels reported by Langford and Jenkins for Kotzebue residents in 1969.* It is estimated that the maximum dose to the Atka resident having the highest $^{55}Fe$ concentration is less than 1 mrad per year.

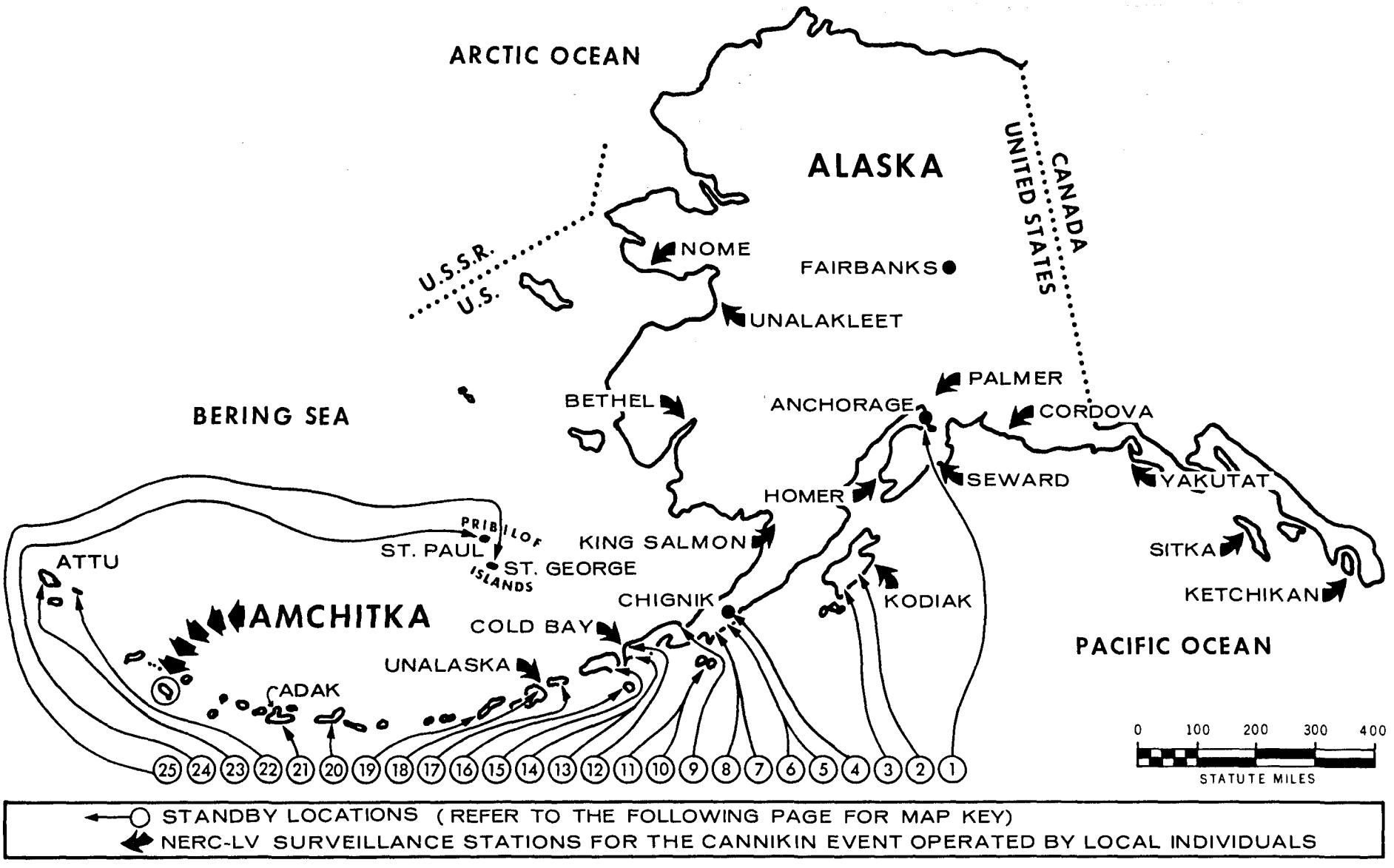
## VI. SUMMARY

The environmental sampling and analysis performed by NERC-LV for the Cannikin Event indicated no release of radioactivity to the environment. The surveillance program consisted of radiation monitoring on the ground and in the air using portable survey instruments, and the collection and analysis

*Langford, J. C. and C. E. Jenkins, "The Latitudinal Variations of $^{55}Fe$ in Man and Cattle," *Health Physics*, 21:71-77 (1971).

of air, water, precipitation, milk, vegetation, soil, sediment and marine foodstuff samples. Additionally, dosimetry stations provided integrated gamma radiation exposure levels at sixteen locations in Alaska. Pre-event blood and urine samples were collected from Atka residents, and whole-body counts of these residents were obtained prior to the event.

NERC-LV monitors were on standby at various locations on the Alaska Peninsula, the Aleutian Chain, the Pribilof Islands and Kodiak Island beginning about two weeks prior to the event. Each monitor had dosimeters, portable survey instruments, air samplers and supplies for the collection of other environmental samples.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BETHEL
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ANCHORAGE
CORDOVA
SEWARD
YAKUTAT
HOMER
PRIBILOF
ST. PAUL
ST. GEORGE
ISLANDS
KING SALMON
SITKA
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ATTU
CHIGNIK
KODIAK
AMCHITKA
COLD BAY
PACIFIC OCEAN
UNALASKA
ADAK
0 100 200 300 400
STATUTE MILES
25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
STANDBY LOCATIONS (REFER TO THE FOLLOWING PAGE FOR MAP KEY)
NERC-LV SURVEILLANCE STATIONS FOR THE CANNIKIN EVENT OPERATED BY LOCAL INDIVIDUALS

## MAP KEY

Standby Locations of NERC-LV Personnel on Event Day.

| Location | Map Key No. | Location | Map Key No. |
|---|---|---|---|
| Anchorage | 1 | Belkofski | 14 |
| Old Harbor | 2 | False Pass | 15 |
| Akhiok | 3 | Pauloff Harbor | 16 |
| Chignik | 4 | Akutan | 17 |
| Chignik Lagoon | 5 | Unalaska | 18 |
| Chignik Lake | 6 | Nikolski | 19 |
| Perryville | 7 | Atka | 20 |
| Ivanof Bay | 8 | Adak | 21 |
| Nelson Lagoon | 9 | Shemya | 22 |
| Sand Point | 10 | Attu | 23 |
| Squaw Harbor | 11 | St. Paul | 24 |
| Cold Bay | 12 | St. George | 25 |
| King Cove | 13 | | |

Table 1. Summary of Air Particulate Sampling Results.

| Sampling Location | Sampling Period 1971 | Number of Samples Collected | Range of Gross Beta Concentrations($pCi/m^3$) |
|---|---|---|---|
| Adak | 10/18-11/06 | 14 | <0.1-0.1 |
| Anchorage | 9/14-11/24 | 23 | <0.1-0.1 |
| Bethel | 9/14-11/19 | 31 | <0.1-0.1 |
| Cordova | 9/14-11/20 | 35 | <0.1-0.2 |
| Homer | 9/16-11/17 | 49 | <0.1-0.2 |
| Annette | 9/14-11/20 | 37 | <0.1-0.2 |
| King Salmon | 9/16-11/20 | 35 | <0.1-0.1 |
| Kodiak | 9/14-11/20 | 34 | <0.1-0.2 |
| Nome | 9/15-11/19 | 33 | <0.1-0.2 |
| Palmer | 9/14-11/20 | 37 | <0.1-0.3 |
| Atka | 10/26-11/07 | 12 | <0.1-0.1 |
| Seward | 9/14-11/16 | 32 | <0.1-0.2 |
| Shemya | 10/27-11/07 | 11 | <0.1-0.1 |
| Sitka | 9/14-11/14 | 31 | <0.1-0.2 |
| St. Paul | 10/26-11/08 | 13 | <0.1[a] |
| Unalakleet | 11/17-11/20 | 31 | <0.1-0.2 |
| Dutch Harbor | 10/12-11/16 | 23 | <0.1-0.3 |
| Cold Bay | 9/14-11/20 | 49 | <0.1-0.2 |
| Yakutat | 9/14-11/20 | 36 | <0.1-0.2 |
| Attu | 10/23-11/09 | 9 | <0.1[a] |
| Sand Point | 10/28-11/08 | 5 | <0.1[a] |
| Nikolski | 10/23-10/29 | 6 | <0.1[a] |

[a]All results <0.1 $pCi/m^3$

Table 2. Summary of Atmospheric Moisture Sampling Results.

| Sampling Location | $^3H$ Range (pCi/ml water) | $^3H$ Range (pCi/$m^3$ air) |
|---|---|---|
| Adak | 2.1 -3.5 | 2.0 -4.9 |
| Amchitka | | |
| USCG Confidence[a] | 0.58-1.1 | c |
| USS Thomas[a] | <0.4 -0.41 | <0.5 -0.49 |
| Anchorage | 0.47[b] | 0.40[b] |
| Atka | 0.83-0.85 | 1.2[d] |
| Homer | <0.4 -0.49 | 0.44[d] |
| Palmer | 1.0 -1.1 | 0.49[d] |
| Seward | 1.1 -1.2 | 0.89-0.94 |
| Shemya | 0.78-0.92 | 0.93-1.0 |
| St. Paul | 0.84-1.4 | c |

[a]Samples collected on sea vessels in Amchitka area.

[b]One sample only.

[c]Concentration per $m^3$ air could not be calculated from either one or both values in adjacent column because psychrometric information was not available.

[d]Two samples collected from each location; however, psychrometric information was available for only one sample at each location, allowing only a single calculation.

Table 3. Summary of Thermoluminescent Dosimetry Results.

| Station Location | Number of Exchanges | Exposure Period | Average Exposure(mR/day) | Exposure Range(mR/day) |
|---|---|---|---|---|
| Adak | 4 | 7/29-11/30 | 0.25 | 0.17-0.35 |
| Anchorage | 4 | 7/27-11/29 | 0.31 | 0.28-0.33 |
| Bethel | 4 | 7/24-11/19 | 0.28 | 0.22-0.31 |
| Cordova | 4 | 7/26-11/22 | 0.33 | 0.23-0.38 |
| Homer | 4 | 7/26-11/24 | 0.28 | 0.21-0.37 |
| Annette | 4 | 7/24-11/22 | 0.30 | 0.20-0.38 |
| King Salmon | 4 | 7/25-11/26 | 0.31 | 0.29-0.34 |
| Kodiak | 4 | 7/26-11/22 | 0.30 | 0.21-0.42 |
| Nome | 3 | 7/26-10/5, 10/28-11/26 | 0.27 | 0.23-0.31 |
| Palmer | 4 | 7/27-11/23 | 0.30 | 0.20-0.37 |
| Seward | 4 | 7/26-11/22 | 0.31 | 0.21-0.38 |
| Sitka | 4 | 7/26-11/20 | 0.28 | 0.22-0.33 |
| Unalakleet | 3 | 7/28-10/29 | 0.31 | 0.24-0.36 |
| Dutch Harbor | 2 | 7/28-8/30, 10/28-11/27 | 0.32 | 0.31-0.33 |
| Cold Bay | 3 | 7/26-10/28 | 0.28 | 0.20-0.35 |
| Yakutat | 4 | 7/26-11/20 | 0.36 | 0.33-0.40 |

Table 4. Summary of Milk Sampling Results.

| Sampling Location | Radioactivity Range in Milk (pCi/l) $^{3}H$ | $^{137}Cs$ | $^{89}Sr$ | $^{90}Sr$ |
|---|---|---|---|---|
| Muth Farm, Palmer | <370-710 | <10[a] | <3-3 | 4-7 |
| Weiland Farm, Palmer | 770-950 | 10-10 | <2-5 | 2-3 |
| Wright Farm, Palmer | <330-530 | 10-10 | 3-4 | 6-7 |

[a]All samples less than the minimum detectable activity.

Table 5. Summary of Milk Cow Feed and Water Sampling Results.

| Sampling Location | Radioactivity Range in Feed(pCi/kg) $^{3}H$ | $^{137}Cs$ | Water(pCi/l) $^{3}H$ | Gross β |
|---|---|---|---|---|
| Muth Farm, Palmer | < 50-100 | ND-110 | <320[b] | <3.2[b] |
| Weiland Farm, Palmer | 310-590 | ND-40 [a] | 600-1000 | <3.3[b] |
| Wright Farm, Palmer | <200-420 | 100-100[a] | <320[b] | <3.2[b] |

ND - Not detected

[a]Background levels of $^{95}Zr$ and $^{106}Ru$ also detected in some (or all) samples.

[b]All samples less than the minimum detectable activity.

Table 6. Summary of Water and Snow Sampling Results.

| Sampling Location | Type Sample[a] | $^3H$ Range (pCi/l) | Gross Beta Range (pCi/l) |
|---|---|---|---|
| Adak | D | <330-330 | 4-6 |
| Akhiok | D | <340-460 | < 3.2[b] |
| Akutan | D | <330-440 | < 3.2[b] |
| Amchitka | | | |
| USS Cochrane[c] | M | <320[d] | 310[b] |
| USCG Confidence[c] | M | <340[b] | 280-320 |
| USS Thomas[c] | M | <340[b] | 180-230 |
| Anchorage | D | <310-790 | < 3.2[b] |
| Anchor Point | S | <320[d] | 8[d] |
| Annette | D | <340[b] | 4-8 |
| Atka | D | <340[b] | < 3.2-4 |
| Attu | D | <320-340 | < 3.2[b] |
| Attu | S | <330[d] | 6[d] |
| Belkofski | D | <330-410 | < 3.1-6 |
| Bethel | D | <340-370 | < 3.2[b] |
| Chignik | D | <350-550 | < 3.1[b] |
| Chignik Lagoon | D | <350[b] | < 3.2[b] |
| Chignik Lake | D | <350-420 | < 3.2[b] |
| Cold Bay | D | <330-520 | < 3.2-6 |
| Cordova | D | <340[b] | < 3.1-3 |
| Dutch Harbor | D | <330[b] | < 3.3[b] |
| False Pass | D | <330-390 | < 3.2[b] |
| Homer | D | <330[b] | < 3.2[b] |
| Homer | S | <310[d] | < 3.1[d] |
| Ivanoff Bay | D | <310-380 | < 3.2[b] |
| Ivanoff Bay | S | <330-370 | 19-31 |
| King Cove | D | <330[b] | < 3.1[b] |
| King Salmon | D | <340[b] | < 3.2[b] |
| Kodiak(Woody Island) | D | <330-410 | < 3.2-5 |
| Kodiak | D | <310[d] | 6[d] |
| Moose Pass | S | <300[d] | 6[d] |

Table 6. Summary of Water and Snow Sampling Results(continued)

| Sampling Location | Type Sample[a] | $^{3}H$ Range (pCi/l) | Gross Beta Range (pCi/l) |
|---|---|---|---|
| Nikolski | D | <330-410 | < 3.2-4 |
| Nome | D | 510-660 | < 3.2-4 |
| Old Harbor | D | <340[b] | < 3.2[b] |
| Palmer | D | <330[b] | < 3.2 |
| Palmer | S | <320[b] | 22[e] |
| Pauloff Harbor | D | <330[b] | < 3.2[b] |
| Perryville | D | 330-350 | < 3.2[b] |
| Sand Point | D | <330-350 | < 3.2[b] |
| Sand Point | S | <310[d] | 14[d] |
| Seward | D | <330[b] | < 3.2[b] |
| Seward | S | <310[d] | 6[d] |
| Shemya | D | <370[b] | < 3.3[b] |
| Sitka | D | <330[b] | < 3.1[b] |
| Soldotna | S | <310-500 | 3-5 |
| Squaw Harbor | D | <340-450 | 5-6 |
| St. George | D | <330[b] | 7[e] |
| St. Paul | D | 420-510 | < 3.3[b] |
| Unalakleet | D | 610-640 | < 3.2[b] |
| Unalaska | D | <340[b] | < 3.2[b] |
| Yakutat | D | <340[b] | < 3.2[b] |

[a] D=Domestic water supply; S=Snow; M=Sea water.

[b] All samples less than minimum detectable activity.

[c] Samples collected by sea vessels in Amchitka area.

[d] One sample only.

[e] Two samples with identical results.

Table 7. Summary of Marine Foodstuff Sampling Results.

| Sampling Location | Type | $^{3}H$ Range (pCi/kg wet weight) | $^{90}Sr$ Range (pCi/kg wet weight) |
|---|---|---|---|
| Anacortes, Washington | King Salmon<br>Red Salmon<br>Silver Salmon | <200[a] | NA |
| Bellingham, Washington | Red Salmon<br>Silver Salmon<br>Pink Salmon | <200-220 | NA |
| La Conner, Washington | King Salmon<br>Red Salmon<br>Silver Salmon<br>Pink Salmon | <200-280 | <13[b] |
| Akutan, Alaska | King Crab | <300[b] | < 9[b] |
| Amchitka, Alaska | King Salmon<br>Chum Salmon<br>Pink Salmon<br>Red Salmon<br>King Crab<br>Cod<br>Halibut | <200-440 | NA |
| Annette, Alaska | Pink Salmon<br>Chum Salmon | <200-480 | <17[b] |
| Egegik (Bristol Bay) | Red Salmon | <200[a] | NA |
| False Pass | Red Salmon<br>Pink Salmon | <300[a] | <17[b] |
| King Cove | Red Salmon<br>Pink Salmon<br>King Crab<br>Shrimp | <200[a] | NA |
| Kodiak | King Crab<br>Red Salmon<br>Pink Salmon<br>Chum Salmon<br>Shrimp<br>Snow Crab | <300[a] | <11[a] |
| Mountain Village (Yukon River) | King Salmon<br>Chum Salmon | 400-540 | <10[b] |
| Naknek(Bristol Bay) | Red Salmon<br>Chum Salmon | <200-300 | NA |
| Nushagak (Bristol Bay) | King Salmon<br>Red Salmon<br>Chum Salmon | <100-330 | NA |

Table 7. Summary of Marine Foodstuff Sampling Results (continued).

| Sampling Location | Type | $^{3}H$ Range (pCi/kg wet weight) | $^{90}Sr$ Range (pCi/kg wet weight) |
|---|---|---|---|
| Seward | Scallop | <300[b] | < 8[b] |
| Sitka | King Salmon<br>Silver Salmon | <300[a] | <11[a] |
| Togiak (Bristol Bay) | King Salmon<br>Red Salmon<br>Chum Salmon | <200-440 | NA |
| Ugashik (Bristol Bay) | Red Salmon | <200[a] | <13[b] |
| Unalaska | Snow Crab | <300[b] | < 8[b] |

[a] All samples less than minimum detectable activity.

[b] One sample only.

NA - no analysis

Table 8. Summary of Vegetation Sampling Results.

| Sampling Location | $^{3}H$ Concentration (pCi/kg wet weight) | $^{137}Cs$ Concentration (pCi/kg wet weight) |
|---|---|---|
| Akhiok | <200 | 2600 |
| Akutan | <300 | 860 |
| Attu | <200 | 3400 |
| Belkofski | <200 | 330 |
| Chignik Lagoon | <200 | 1900 |
| Chignik Lake | <200 | 2200 |
| Cold Bay | <200 | 1200 |
| False Pass | <200 | 390 |
| Ivanoff Bay | <200 | 2200 |
| King Cove | <200 | 1000 |
| Nikolski | <200 | 360 |
| Old Harbor | <100, <200 | 440, 370 |
| Pauloff Harbor | 420 | 90 |
| Perryville | <100, <300 | 440, 550 |
| Sand Point | <200 | 2500 |
| Shemya | 230 | 320 |
| Squaw Harbor | <200 | 500 |
| St. George | <200 | 480 |
| St. Paul | <200 | ND |
| Unalaska | <300 | 450 |

ND - Not detected.

Table 9. Summary of Soil and Sediment Sampling Results.

| Sampling Location | Type Sample | $^{3}H$(pCi/kg wet weight) Top one inch | $^{3}H$(pCi/kg wet weight) Next two inches | $^{137}Cs$(pCi/kg wet weight) Top one inch | $^{137}Cs$(pCi/kg wet weight) Next 2 inches |
|---|---|---|---|---|---|
| Akhiok | Soil | <300 | <200 | 2.8 | 0.40 |
| Akutan | Soil | <300 | <200 | 2.0 | 1.5 |
| Akutan | Sediment | <100 | - | 0.39 | - |
| Atka | Soil | <200 | <200 | 1.0 | 0.54 |
| Atka | Sediment | 320 | - | 0.27 | - |
| Attu | Soil | 410 | <300 | 4.3 | 0.21 |
| Attu | Sediment | 52 | - | 0.78 | - |
| Belkofski | Soil | <100 | <100 | 0.50 | 0.12 |
| Belkofski | Sediment | <200 | - | 0.16 | - |
| Chignik | Soil | 300 | <100 | 9.6 | 2.4 |
| Chignik | Sediment | <100 | - | 0.14 | - |
| Chignik Lagoon | Soil | < 90 | < 60 | 2.0 | 1.2 |
| Chignik Lagoon | Sediment | < 60 | - | 0.14 | - |
| Chignik Lake | Soil | <200 | <100 | 2.0 | 0.16 |
| Chignik Lake | Sediment | <100 | - | 0.55 | - |
| Cold Bay | Soil | <100 | <100 | 1.5 | 2.0 |
| False Pass | Soil | <200 | <200 | 2.4 | 0.29 |
| Ivanoff Bay | Soil | <200 | < 40 | 1.5 | 0.63 |
| Ivanoff Bay | Sediment | <200 | - | 0.23 | - |
| King Cove | Soil | <100 | <100 | 0.22 | 0.02 |
| Nikolski | Soil | <200 | <200 | 1.4 | 0.73 |
| Nikolski | Sediment | <200 | - | 1.0 | - |
| Old Harbor | Soil | <200[a] | <200[a] | 2.2, 2.5 | 1.1, 1.5 |
| Pauloff Harbor | Soil | <200 | <200 | 1.4 | 1.6 |
| Pauloff Harbor | Sediment | <200 | - | 0.35 | - |
| Perryville | Soil | < 60[a] | 62, <20 | 1.4, 0.82 | 0.62, 0.3 |
| Perryville | Sediment | < 70 | - | 0.15 | - |
| Sand Point | Soil | <200 | <300 | 2.3 | 0.2 |
| Sand Point | Sediment | 260 | - | 0.72 | - |
| Shemya | Soil | <200 | 38 | 0.26 | 0.05 |

Table 9. Summary of Soil and Sediment Sampling Results(continued).

| Sampling Location | Type Sample | $^{3}H$(pCi/kg wet weight) Top one inch | $^{3}H$(pCi/kg wet weight) Next two inches | $^{137}Cs$(pCi/kg wet weight) Top one inch | $^{137}Cs$(pCi/kg wet weight) Next 2 inches |
|---|---|---|---|---|---|
| Squaw Harbor | Soil | <100 | 160 | 0.35 | 0.28 |
| Squaw Harbor | Sediment | 220 | - | 0.10 | - |
| St. George | Soil | <200 | <200 | 0.60 | 0.15 |
| St. George | Sediment | < 70 | - | 0.37 | - |
| St. Paul | Soil | 89 | <200 | 1.3 | 0.63 |
| St. Paul | Sediment | < 40 | - | 0.23 | - |
| Unalaska | Soil | <200 | <200 | 1.5 | 1.5 |
| Unalaska | Sediment | <100 | - | 0.66 | - |

[a]Sampling performed on two separate occasions.

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