health and safety laboratory

FALLOUT PROGRAM
QUARTERLY SUMMARY REPORT

October 1, 1964

UNITED STATES ATOMIC ENERGY COMMISSION
NEW YORK OPERATIONS OFFICE

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HEALTH AND SAFETY LABORATORY

FALLOUT PROGRAM
QUARTERLY SUMMARY REPORT

(June 1, 1964 through September 1, 1964)

Prepared by

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Environmental Studies Division

Preceding reports in this series:

HASL-42, -51, -65, -77, -84, -88,
-95, -105, -111, -113, -115,
-117, -122, -127, -131, -132,
-135, -138, -140, -142, -144,
and -146.

October 1, 1964

UNITED STATES ATOMIC ENERGY COMMISSION

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NYOO

Health and Safety

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ABSTRACT

This report presents current data from the HASL Fallout Program, the New Zealand Department of Scientific and Industrial Research, Argonne National Laboratory and the Argentine Comision Nacional de Energia Atomica. Radionuclide levels in fallout, world-wide soils collected in 1963-64, milk, tap water, and upper air samples are given in tabular form. Also included are interpretive reports and notes dealing with strontium-90 levels in the diets and bones of Argentine children and San Juan, Puerto Rico residents, cesium-137, stable strontium and radium-226 in two human skeletons, latitudinal deposition of strontium-90 in the United States, a statistical analyses of the 1963-64 soils analytical data, and expected and measured plutonium-238 concentrations in air from a satellite failure. A bibliography of recent literature pertinent to fallout studies is given at the end of the report.

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Introduction

Every three months, the Health and Safety Laboratory issues a report summarizing current information obtained at HASL pertaining to fallout. This report, the latest in the series, contains information that became available during the period from June 1, 1964 to September 1, 1964. The next report is scheduled for publication on January 1, 1965. Preceding reports in the series, starting with HASL-42, "Environmental Contamination from Weapon Tests", and continuing through HASL-51, -65, -69, -77, -84, -88, -95, -105, -111, -113, -115, -117, -122, -127, -131, -132, -135, -138, -140, -142, -144, -146, and 149 (this report); may be purchased from the Office of Technical Service, U.S. Department of Commerce, Washington 25, D.C.

To give a more complete picture of the current fallout situation and to provide a medium for rapid publication of fallout data, these quarterly reports often contain information from other laboratories and programs, some of which are not part of the general AEC program. To assist in developing, as rapidly as possible, provisional interpretations of the data, special interpretive reports and notes prepared by scientists working in the field of fallout are also included from time to time. Many of these scientists are associated in some way with the general AEC program. Information developed outside of HASL is identified as such and is gratefully acknowledge by the Laboratory. In this report, data from the New Zealand Department of Scientific and Industrial Research, The Comision Nacional de Energia Atomic in Argentina, The Division of Biological and Medical Research at Argonne National Laboratory, and the U.S. Department of Agriculture Plant Industry Station at Beltsville, Maryland, are included.

A portion of the radiochemical analyses are carried out by commercial laboratories under contract to the HASL Environmental Studies and Radiochemistry Divisions. The results of these analyses are reported as part of HASL's regular fallout program. The contractor analytical laboratories are Nuclear Science and Engineering Corporation, Pittsburgh, Pennsylvania; Isotopes, Incorporated, Westwood, New Jersey; Radiochemistry, Incorporated, Louisville, Kentucky; Tracerlab, Incorporated, Richmond, California; Controls for Radiation, Incorporated, Cambridge, Massachusetts; Hazleton-Nuclear Science Corporation, Palo Alto, California and Food, Chemical & Research Laboratories, Incorporated, Seattle, Washington.

This report is divided into four main parts:

1. HASL Fallout Program Data,
2. Data from Sources Other Than HASL,
3. Interpretive Reports and Notes, and
4. Recent Publications Related to Fallout.

FALLOUT PROGRAM

Quarterly Summary Report

October 1, 1964

Part I - HASL Fallout Program Data

1. Fallout Deposition Collections

1.1 Monthly Precipitation

1.11 1964 Sr-90 Data for 156 World-Wide Sites

At present, there are 49 monthly monitoring sites in the United States and 107 in foreign countries. A map showing the sites is presented as Figure 1, page 3. These collections are made using either stainless steel pots with exposed areas of 0.82 square feet, or plastic funnels with exposed areas of 0.77 square feet to which are attached ion-exchange columns.

The strontium-90 data presented in tables 1a and 1b, pages 4 through 24 cover only 1964. Results through 1963 were given in the last quarterly report (HASL-146). When all of the 1964 samples have been analyzed, these results will be included in a complete presentation of data for each site since sampling began.

Monthly strontium-90 levels for New York City since 1954 are shown in graph form in Figure 2, page 8.

HASL MONTHLY FALLOUT SAMPLING NETWORK

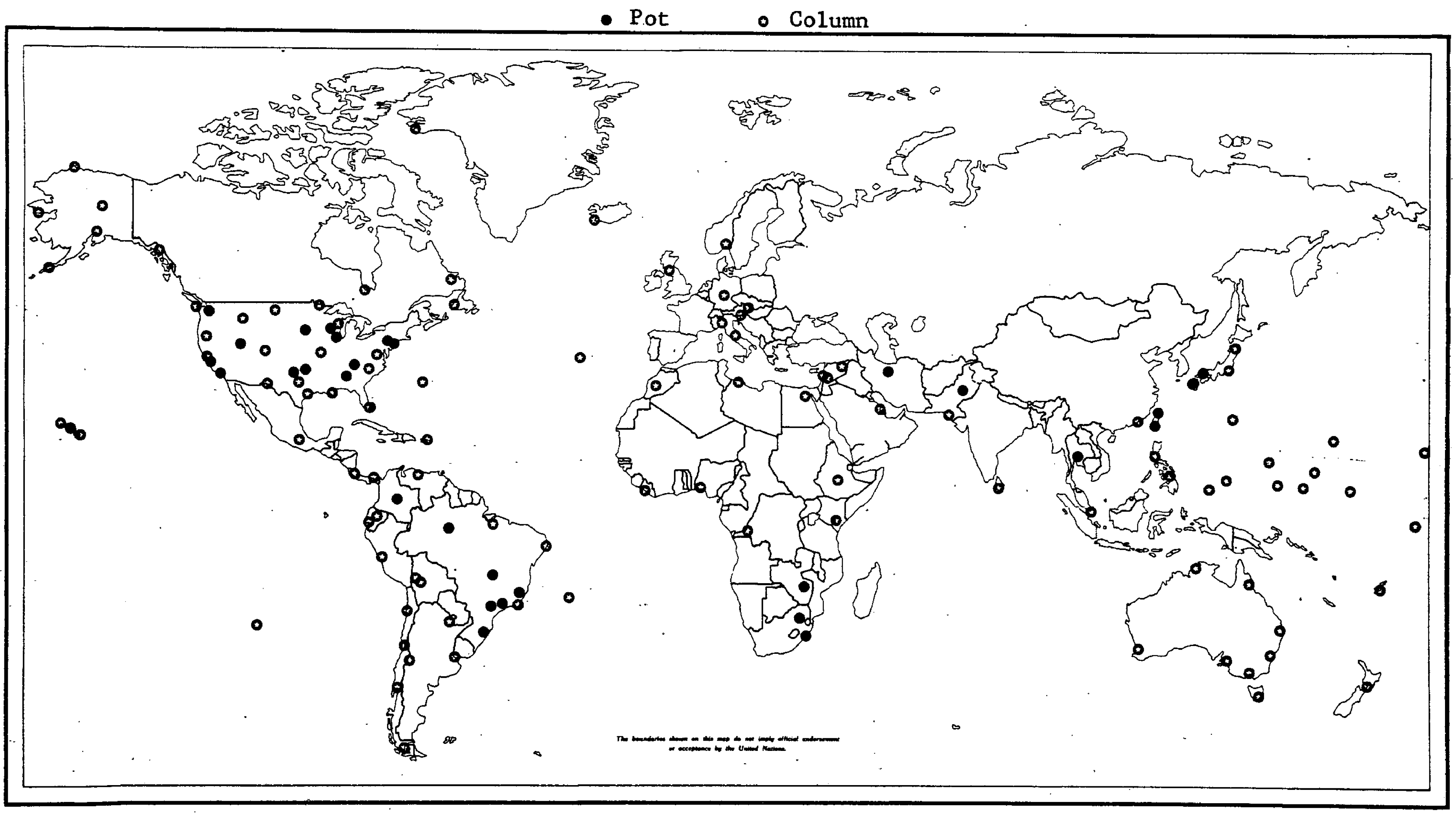


FIGURE I

Table 1a

MONTHLY Sr-90 DEPOSITION - 1964

UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
ALABAMA, BIRMINGHAM (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2	2.36	6.18	4.09									
ALASKA, ANCHORAGE (Column)												
Precip. (in.)	0.35	1.15	1.15									
Sr-90 (mc/mi^2)	0.42	0.56	1.02									
ALASKA, BARROW (Column)												
Precip. (in.)	not recd.	not recd.	not recd.									
Sr-90 (mc/mi^2)												
ALASKA, COLD BAY (Column)												
Precip. (in.)	1.33	1.73	1.32									
Sr-90 (mc/mi^2)	1.56	1.19	1.31									
ALASKA, FAIRBANKS (Column)												
Precip. (in.)	0.21(1)	0.46(2)	0.18(3)									
Sr-90 (mc/mi^2)	0.15	0.28	0.18									
ALASKA, JUNEAU (Column)												
Precip. (in.)	3.14	8.48	4.38									
Sr-90 (mc/mi^2)	2.20	4.06	3.21									
ALASKA, NOME (Column)												
Precip. (in.)	not recd.	not recd.	0.74									
Sr-90 (mc/mi^2)			0.18									

(1) 4.8" snow.
(2) 9.9" snow.
(3) 5.5" snow.

MONTHLY Sr-90 DEPOSITION - 1964

UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CALIFORNIA, W. LOS ANGELES (Pot)												
Precip. (in.)	1.58	0.01	1.92									
Sr-90 (mc/mi^2)	0.53	0.10	2.02									
CALIFORNIA, PALO ALTO (Pot)												
Precip. (in.)	monthly collections from July 1963 are reported on page 28 and include, in addition to Sr-90, other fission product and tracer radionuclides.											
Sr-90 (mc/mi^2)												
CALIFORNIA, PALO ALTO (Column)												
Precip. (in.)	3.41	0.04	1.41	0.035								
Sr-90 (mc/mi^2)	1.99	0.26	1.03	0.181								
CALIFORNIA, SAN FRANCISCO (Column)												
Precip. (in.)	4.35	0.27	1.95									
Sr-90 (mc/mi^2)	1.86	0.36	1.41									
COLORADO, DENVER (Column)												
Precip. (in.)	0.26	1.04	1.38									
Sr-90 (mc/mi^2)	0.23	0.48	0.58									
FLORIDA, CORAL GABLES (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)	1.94	1.01	0.32									
FLORIDA, MIAMI (Column)												
Precip. (in.)	0.55	2.21	0.50									
Sr-90 (mc/mi^2)	0.49	1.23	0.48									
HAWAII, HILO (Column)												
Precip. (in.)	14.65	18.22	19.58									
Sr-90 (mc/mi^2)	8.00	8.18	13.53									

MONTHLY Sr-90 DEPOSITION - 1964

UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
HAWAII, LIHUE (Column)												
Precip. (in.)	7.01	1.73	10.16									
Sr-90 (mc/mi^2)	4.19	0.40	3.44									
HAWAII, MAUNA LOA (Column)												
Precip. (in.)	0.32	0.28	2.50									
Sr-90 (mc/mi^2)	0.30	0.26	0.80									
HAWAII, OAHU (Pot)												
Precip. (in.)	4.41	1.49	5.69									
Sr-90 (mc/mi^2)	1.06	1.80	4.60									
ILLINOIS, ARGONNE (Pot)												
Precip. (in.)	0.36	0.60	3.01									
Sr-90 (mc/mi^2)	0.74	0.33	3.34									
LOUISIANA, NEW ORLEANS (Column)												
Precip. (in.)	9.60	5.35	5.45									
Sr-90 (mc/mi^2)	5.07	3.10	3.29									
MINNESOTA, INTERNATIONAL FALLS (Column)												
Precip. (in.)	0.74	0.63	0.65									
Sr-90 (mc/mi^2)	0.17	0.45	0.47									
MISSOURI, COLUMBIA (Column)												
Precip. (in.)	0.75	1.64	3.66									
Sr-90 (mc/mi^2)	1.23	1.06	3.36									
MONTANA, HELENA												
Precip. (in.)	0.31	0.26	0.52									
Sr-90 (mc/mi^2)	0.39	0.45	0.13									

MONTHLY Sr-90 DEPOSITION - 1964

UNITED STATES SITES

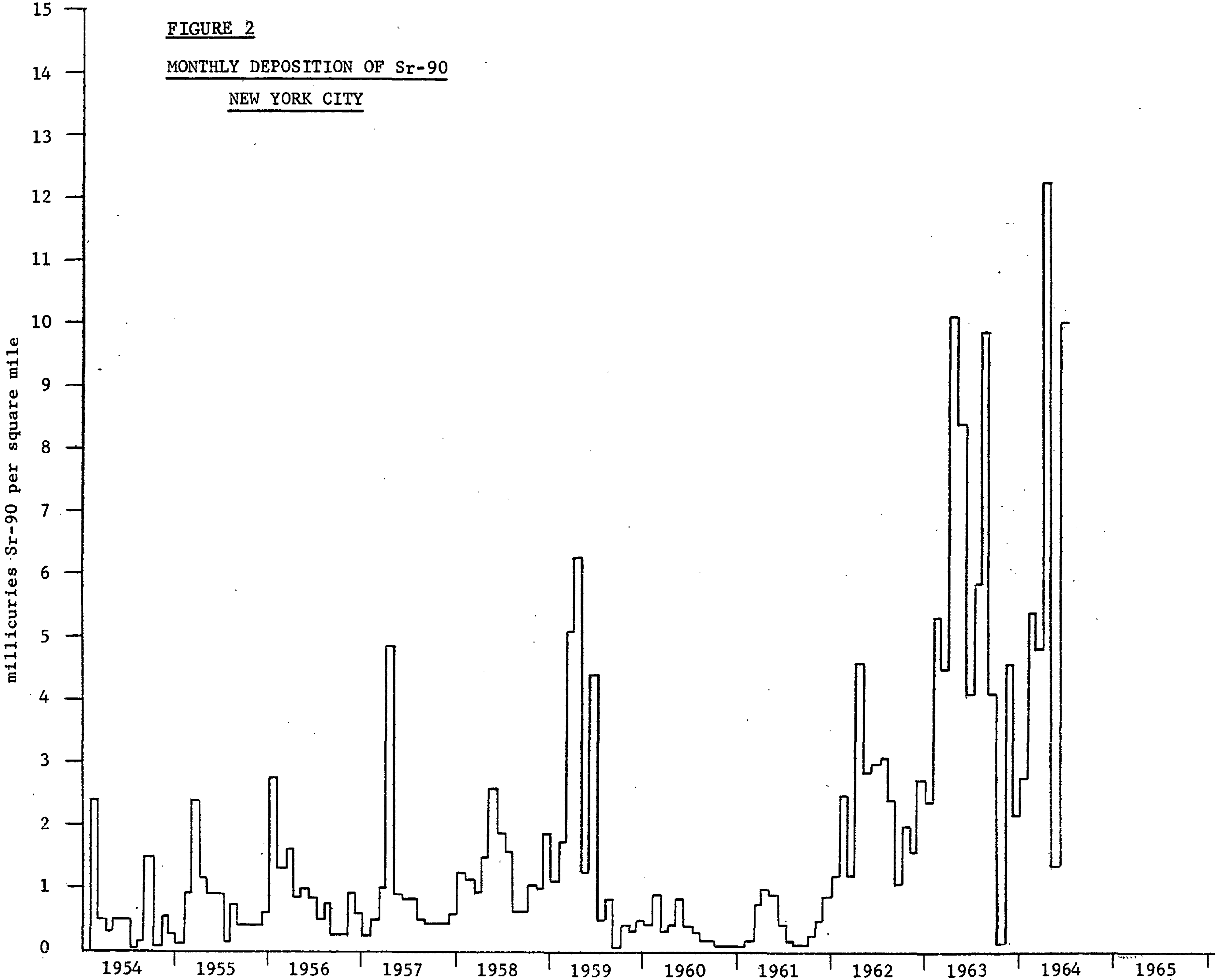
Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
NEW JERSEY, WESTWOOD (Pot)												
Precip. (in.) / Sr-90 (mc/mi^2)	monthly collections from July 1963 are reported on page 28 and include, in addition to Sr-90, other fission product tracer radionuclides.											
NEW JERSEY, WESTWOOD (Column) #												
Precip. (in.)	3.48	1.89	4.24	6.14	1.05							
Sr-90 (mc/mi^2)	1.37	1.38	3.49	lost	2.06							
Sr-89 (mc/mi^2)	0.34	<1.12	0.57	Lost	--							
Sr-89/Sr-90	0.2	*	0.2									
NEW YORK, NEW YORK (Pot)												
Precip. (in.)	4.62	2.93	2.57	5.09	0.57	2.67	4.17					
Sr-90 (mc/mi^2)	2.70	5.44	4.75	12.27	1.36	10.08						
Sr-89/Sr-90	0.3	--	--	--	--	--						
Cs-137/Sr-90	1.8	1.4	1.4	1.4								
NORTH DAKOTA, WILLISTON (Column)												
Precip. (in.)	0.45	0.12	0.94									
Sr-90 (mc/mi^2)	0.79	0.04	0.12									
OHIO, WOOSTER (Pot)												
Precip. (in.)	1.52	1.45	7.58									
Sr-90 (mc/mi^2)	2.88	1.41	4.00									
OKLAHOMA, TULSA (Pot)												
Precip. (in.)	0.63											
Sr-90 (mc/mi^2)	0.57											
OREGON, MEDFORD (Column)												
Precip. (in.)	5.60	0.82	2.15									
Sr-90 (mc/mi^2)	1.58	0.49	1.32									
SOUTH CAROLINA, COLUMBIA (Column)												
Precip. (in.)	6.27	5.33	6.16									
Sr-90 (mc/mi^2)	0.87	3.81	4.40									

See graph on following page (Figure 2).

FIGURE 2

MONTHLY DEPOSITION OF Sr-90

NEW YORK CITY



MONTHLY Sr-90 DEPOSITION - 1964

UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
SOUTH DAKOTA, VERMILLION (Pot)												
Precip. (in.)	0.16	0.11	1.82									
Sr-90 (mc/mi^2)	0.35	0.40	1.55									
TEXAS, DALLAS (Column)												
Precip. (in.)	3.27	1.25	4.53									
Sr-90 (mc/mi^2)	1.31	2.80	4.04									
TEXAS, EL PASO (Column)												
Precip. (in.)	trace	trace	0.99									
Sr-90 (mc/mi^2)	1.22	0.13	1.78									
TEXAS, HOUSTON (Column)												
Precip. (in.)	2.89	4.97	2.24									
Sr-90 (mc/mi^2)	0.94	3.63	1.41									
U.S. COAST GUARD "ECHO" STATION	(12/31-1/19)	(1/20-31)	(2/1-9)	(2/10-3/1)	(3/2-23)	(3/23-4/13)						
Precip. (in.)	0.97	0.79		2.32	2.07							
Sr-90 (mc/mi^2)	0.71	3.43	0.79	1.44	1.74	lost						
U.S. WEATHER BUREAU STATION (Column) (Sterling, Va.)												
Precip. (in.)	3.35	2.61	2.27									
Sr-90 (mc/mi^2) #1	1.79	2.54	2.59									
#2	2.15	2.74	2.64									
UTAH, SALT LAKE CITY (Pot)	(1/6-31/64)											
Precip. (in.)	1.01	0.35	2.27									
Sr-90 (mc/mi^2)	2.17	1.06	4.60									
WASHINGTON, SEATTLE (Pot)												
Precip. (in.)	8.16	1.55	3.20									
Sr-90 (mc/mi^2)	3.10	2.11	2.51									

MONTHLY Sr-90 DEPOSITION - 1964

NITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
WASHINGTON, TATOOSH ISLAND (Column)												
Precip. (in.)		6.80	8.62									
Sr-90 (mc/mi^2)	6.98	3.42	5.61									
WISCONSIN, GREEN BAY (Column)												
Precip. (in.)	1.14	0.26	1.76									
Sr-90 (mc/mi^2)	1.36	0.18	1.34									

Table 1b

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
ARGENTINA, BUENOS AIRES (Column)												
Precip. (in.)	1,52	7.24	9.05	3.39								
Sr-90 (mc/mi^2)	0.25	0.38										
ARGENTINA, FORMOSA (Column)												
Precip. (in.)	1.86	1.75	7.26	13.7								
Sr-90 (mc/mi^2)	0.08	0.09										
ARGENTINA, MALARQUÉ (Column)												
Precip. (in.)	0.13	0.06	1.76	0.18								
Sr-90 (mc/mi^2)	0.06	0.04										
AUSTRALIA, ADELAIDE (Pot)												
Precip. (in.)	0.41	0.36	0.09	2.34								
Sr-90 (mc/mi^2)	0.19	0.18	0.05	0.30								
AUSTRALIA, BRISBANE (Pot)												
Precip. (in.)	3.17	6.16	11.62	3.52								
Sr-90 (mc/mi^2)	0.40	0.47	0.42	0.28								
AUSTRALIA, DARWIN (Pot)												
Precip. (in.)	12.56	0.07	13.81	4.97								
Sr-90 (mc/mi^2)	0.65	0.35	0.52	0.23								
AUSTRALIA, HOBART (Pot)												
Precip. (in.)	1.61	6.72	2.18	1.12								
Sr-90 (mc/mi^2)	0.26	0.73	0.11	0.19								
AUSTRALIA, MELBOURNE (Pot)												
Precip. (in.)	0.09	4.70	1.10	3.94								
Sr-90 (mc/mi^2)	0.09	0.68	0.33	0.37								

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AUSTRALIA, PERTH (Pot)												
Precip. (in.)	0.00	0.14	1.49	2.82								
Sr-90 (mc/mi^2)	0.07	0.06	0.10	0.084								
AUSTRALIA, SYDNEY (Pot)												
Precip. (in.)	0.71	1.98	6.75	5.49								
Sr-90 (mc/mi^2)	0.20	0.35	0.66	0.40								
AUSTRALIA, TOWNSVILLE (Pot)												
Precip. (in.)	6.75	20.25	5.44	1.51								
Sr-90 (mc/mi^2)	0.24	0.30	0.05	0.017								
AUSTRIA, KLAGENFURT (Column)												
Precip. (in.)	0.01	0.39	1.83									
Sr-90 (mc/mi^2)	0.31	0.36	1.46									
AUSTRIA, VIENNA (Column)												
Precip. (in.)	0.29	1.15	2.84									
Sr-90 (mc/mi^2)	0.30	1.49	2.72									
AZORES, LAJES FIELD (Column)												
Precip. (in.)	11.25	14.23	7.82									
Sr-90 (mc/mi^2)	4.58	6.37	3.49									
BERMUDA, KINDLEY AFB (Column)												
Precip. (in.)	6.57	5.58	1.91									
Sr-90 (mc/mi^2)	2.93	3.72	1.72									
BOLIVIA, CHACALTAYA (Column)												
Precip. (in.)	3.77	2.62	5.33									
Sr-90 (mc/mi^2)	0.12	0.08	0.08									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
BOLIVIA, LA PAZ (Column)												
Precip. (in.)	11.58											
Sr-90 (mc/mi^2)	0.09	0.07	0.08									
BRAZIL, BELÉM (Column)												
Precip. (in.)	19.15	20.45	23.75									
Sr-90 (mc/mi^2)	0.47	2.43	0.17									
BRAZIL, BRASILIA (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
BRAZIL, ITAICI, SÃO PAULO (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
BRAZIL, MANAUS (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
BRAZIL, NOVA FRIBURGO (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
BRAZIL, RECIFE (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
BRAZIL, RIO DE JANEIRO (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)												

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
BRAZIL, SÃO JOSÉ DOS CAMPOS (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
BRAZIL, SÃO LEOPOLDO (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
BRAZIL, TRINDADE ISLAND (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.32	0.19										
CANADA, ONTARIO, MOOSONEE (Column)												
Precip. (in.)	2.5	1.44	1.30									
Sr-90 (mc/mi^2)	1.12	0.35	0.26									
CANADA, NEWFOUNDLAND, ERNEST HARMAN AB (Column)												
Precip. (in.)	3.83	3.98	2.92									
Sr-90 (mc/mi^2)	0.12	0.97	0.89									
CANADA, NEWFOUNDLAND, GOOSE AB (Column)												
Precip. (in.)	1.54	3.47										
Sr-90 (mc/mi^2)	0.13	0.36										
CANTON ISLAND (Column)												
Precip. (in.)	15.08	1.04	0.64									
Sr-90 (mc/mi^2)	0.54	0.13	0.02									
CEYLON, COLOMBO (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.27	0.36	0.06									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CHILE, ANTOFAGASTA (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.08	0.04	0.03									
CHILE, EASTER ISLAND (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
CHILE, PUERTO MONTT (Column)												
Precip. (in.)	3.22	4.38	7.50									
Sr-90 (mc/mi^2)	0.06	0.36	0.42									
CHILE, PUNTA ARENAS (Column)												
Precip. (in.)	1.65	0.78										
Sr-90 (mc/mi^2)	0.14	0.23										
CHILE, SANTIAGO (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.03	2.84 ?										
CHILE, SANTIAGO (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.12	0.09	0.10									
COLOMBIA, BOGOTA (Pot)												
Precip. (in.)	0.25											
Sr-90 (mc/mi^2)	0.08											
CONGO, LEOPOLDVILLE - SITE #1 (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	1.11	0.41	0.52									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CONGO, LEOPOLDVILLE - SITE #2 (Column)												
Precip. (in.)	6.11	3.85	5.71									
Sr-90 (mc/mi^2)	0.48	0.39	0.83									
COSTA RICA, TURRIALBA (Column)												
Precip. (in.)	2.81	0.12	0.87									
Sr-90 (mc/mi^2)	0.44	0.44	0.29									
ECUADOR, GUAYAQUIL (Column)												
Precip. (in.)	8.53	6.44	16.64									
Sr-90 (mc/mi^2)	0.21	0.21	2.04									
ECUADOR, QUITO (Column)												
Precip. (in.)	not											
Sr-90 (mc/mi^2)	recd.	0.12	0.03									
ENIWETOK ATOLL (Column)												
Precip. (in.)	2.02	1.09	0.13									
Sr-90 (mc/mi^2)	0.83	0.66	0.44									
ETHIOPIA, ADDIS ABABA (Column)												
Precip. (in.)	0.27		4.79									
Sr-90 (mc/mi^2)	0.10	0.25	0.18									
FIJI ISLANDS, SUVA (Column)												
Precip. (in.)		17.99	17.21									
Sr-90 (mc/mi^2)	0.54	0.28	0.24									
GERMANY, RHEIN MAIN AFB (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.06	0.78	0.66									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GREENLAND, THULE (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.26	0.14	0.06									
GUAM (Column)												
Precip. (in.)	2.47	3.89	3.37									
Sr-90 (mc/mi^2)	0.86	1.89	0.49									
HONG KONG (Column												
Precip. (in.)												
Sr-90 (mc/mi^2)	2.69	0.32										
ICELAND, KEFLAVIK (Column)	(1/11-31)											
Precip. (in.)	5.42	4.25	4.26									
Sr-90 (mc/mi^2)	0.98	2.69	1.94									
IRAN, TEHRAN (Pot)												
Precip. (in.)	0.13	1.31										
Sr-90 (mc/mi^2)	0.37	0.76										
ITALY, FLORENCE (Column)												
Precip. (in.)		3.28										
Sr-90 (mc/mi^2)	0.38	2.18	5.38									
ITALY, MILAN (Column)	(1/7-2/1/64)											
Precip. (in.)	0.55	3.35	7.24									
Sr-90 (mc/mi^2)	4.01	1.70	5.30									
IWO JIMA (Column)												
Precip. (in.)	1.24	0.72	0.53									
Sr-90 (mc/mi^2)	1.26	0.58	0.27									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
JAPAN, HIROSHIMA (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)	1.18	1.97	2.57									
JAPAN, MISAWA (Column)												
Precip. (in.)	3.60	5.55	1.72									
Sr-90 (mc/mi^2)	1.42	1.97	1.66									
JAPAN, NAGASAKI (Pot)												
Precip. (in.)			4.08									
Sr-90 (mc/mi^2)	1.98	1.84	2.31									
JAPAN, TACHIKAWA (Column)												
Precip. (in.)		2.53	3.25									
Sr-90 (mc/mi^2)	0.07	0.62	0.72									
JOHNSTON ISLAND (Column)												
Precip. (in.)	1.03	1.16	0.76									
Sr-90 (mc/mi^2)	0.19	0.49	0.20									
KENYA, KIKUYU (Pot)												
Precip. (in.)	1.44	3.42										
Sr-90 (mc/mi^2)	0.06	1.05										
KENYA, NAIROBI (Column)												
	(1/10-2/4)		(3/14-4/13)									
Precip. (in.)	1.86	3.36	4.08									
Sr-90 (mc/mi^2)	0.18	0.29	0.93									
KOROR ISLAND (Column)												
Precip. (in.)	7.07	16.45	6.98									
Sr-90 (mc/mi^2)	1.49	1.08	0.08									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
LEBANON, BEIRUT (Column)												
Precip. (in.)	19.16	12.18	3.59									
Sr-90 (mc/mi^2)	3.76	10.51	7.22									
LIBERIA, MONROVIA (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.06		0.08									
LIBYA, SHARAH SHAHAT (Column)												
Precip. (in.)	3.99	3.19										
Sr-90 (mc/mi^2)	1.36	1.12										
LIBYA, BEN GASHIR (Column)												
Precip. (in.)	0.23	1.10										
Sr-90 (mc/mi^2)	2.64	0.54	0.79									
LIBYA, CYRENE (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
LIBYA, WHEELUS AB (Column)												
Precip. (in.)	5.12	1.38	trace									
Sr-90 (mc/mi^2)	3.10	0.62	0.22									
MAJURO ISLAND (Column)												
Precip. (in.)	1.40	6.99	7.23									
Sr-90 (mc/mi^2)	0.63	1.02	0.61									
MALAYSIA, SINGAPORE (Column)												
Precip. (in.)	6.06	17.1	9.32									
Sr-90 (mc/mi^2)	0.26	0.05	0.49									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
MEXICO, MEXICO CITY (Column)												
Precip. (in.)	1.22											
Sr-90 (mc/mi^2)	0.17											
MOROCCO, RABAT (Column)												
Precip. (in.)	0.20	2.00	~4									
Sr-90 (mc/mi^2)	2.79	2.79	2.92									
NEW ZEALAND, WELLINGTON (Column)												
Precip. (in.)	2.96	0.98	3.61									
Sr-90 (mc/mi^2)	0.50	0.22	0.21									
NIGERIA, LAGOS (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.17	0.75										
NORWAY, OSLO (Column)												
Precip. (in.)	14.5	20.1										
Sr-90 (mc/mi^2)	1.66	0.56	0.30									
PAKISTAN, KARACHI (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
PAKISTAN, KARACHI (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
PANAMA CANAL ZONE (Column)												
Precip. (in.)	0.33	1.34	0.20									
Sr-90 (mc/mi^2)	0.21	0.43	0.08									

MONTHLY Sr-90 Deposition - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan. (1/12-2/12)	Feb. (2/12-3/11)	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
PERU, LIMA (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	0.11	0.06										
PERU, LIMA (Column) - 80th Meridian Station												
Precip. (in.)	0.01	0.01	trace									
Sr-90 (mc/mi^2)	0.48	0.03	0.06									
PHILIPPINE ISLANDS, CEBU CITY (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
PHILIPPINE ISLANDS, CLARK AB (Column)												
Precip. (in.)	0.04	0.08	0.20									
Sr-90 (mc/mi^2)	0.59	0.11	0.01									
PHILIPPINE ISLANDS, QUEZON CITY (Column)												
Precip. (in.)	1.24	0.08										
Sr-90 (mc/mi^2)	0.06	0.04	0.04									
PONAPÉ ISLAND (Column)												
Precip. (in.)	3.59	19.76	14.03									
Sr-90 (mc/mi^2)	0.71	1.05	1.41									
PUERTO RICO, SAN JUAN (Column)												
Precip. (in.)	2.02	1.75	1.27									
Sr-90 (mc/mi^2)	0.67	0.76	1.06									
SAUDI ARABIA, DHAHRAN (Column)												
Precip. (in.)		2.00										
Sr-90 (mc/mi^2)	1.68	3.50										

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
SCOTLAND, PRESTWICK (Column)												
Precip. (in.)	2.48	0.54	0.92									
Sr-90 (mc/mi^2)	3.94	1.49	1.99									
SOUTHERN RHODESIA, SALISBURY (Pot)												
Precip. (in.)	6.54	7.54	0.68									
Sr-90 (mc/mi^2)	0.18	0.21	0.07									
SYRIA, DAMASCUS (Column)												
Precip. (in.)	not	4.04	0.43									
Sr-90 (mc/mi^2)	recd.	3.11	1.40									
SYRIA, KAMISHLY (Column)												
Precip. (in.)	not	5.75	3.72									
Sr-90 (mc/mi^2)	recd.	3.18	7.45									
TAIWAN, TAINAN (Pot)												
Precip. (in.)	1.93	0.03	3.1									
Sr-90 (mc/mi^2)	0.61	0.05	0.21									
TAIWAN, TAIPEI (Pot)												
Precip. (in.)												
Sr-90 (mc/mi^2)	5.15	2.18	3.27									
TAIWAN, TAITUNG (Pot)												
Precip. (in.)	1.50	1.68	2.32									
Sr-90 (mc/mi^2)	0.53	0.61	1.58									
THAILAND, BANGKOK (Pot)												
Precip. (in.)	0.44		0.59	1.18	21.83	3.94	11.02					
Sr-90 (mc/mi^2)	0.18	0.08	0.11									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
THAILAND, BANGKOK (Column)												
Precip. (in.)			0.59	1.78	21.83	3.94	11.02					
Sr-90 (mc/mi^2)	0.06											
TRUK ISLAND (Column)												
Precip. (in.)	2.00	10.80	2.44									
Sr-90 (mc/mi^2)	0.68	0.99	0.53									
UAR, ALEXANDRIA (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
UAR, CAIRO (INSHAS) (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)												
UNION OF SOUTH AFRICA, DURBAN (Pot)												
Precip. (in.)	7.8	2.92	3.7									
Sr-90 (mc/mi^2)	0.80	1.05	0.16									
UNION OF SOUTH AFRICA, PRETORIA (Pot)												
Precip. (in.)	6.95	0.24	1.99									
Sr-90 (mc/mi^2)	0.68	0.18	0.09									
VENEZUELA, CARACAS - SITE #1 (Column)												
Precip. (in.)	0.47	0.06										
Sr-90 (mc/mi^2)	0.15	0.05	0.24									
VENEZUELA, CARACAS - SITE #2 (Column)												
Precip. (in.)												
Sr-90 (mc/mi^2)	1.20	0.05	0.04									

MONTHLY Sr-90 DEPOSITION - 1964

OUTSIDE UNITED STATES SITES

Site:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
WAKE ISLAND (Column)												
Precip. (in.)	0.92	0.61	1.08									
Sr-90 (mc/mi^2)	1.14	0.61	1.49									
YAP ISLAND (Column)												
Precip. (in.)	2.37	6.91	4.01									
Sr-90 (mc/mi^2)	0.76	1.35	1.57									

1.1 Monthly Precipitation - cont'd.

1.12 Fission Product and "Tracer" Radionuclides at 6 U.S. Sites from July 1963 Through June 1964

It was considered desireable to obtain data on short and long-lived fission products and unique tracers in precipitation at sites representing the major geographical regions of the United States. Beginning in July 1963, monthly precipitation collections at six sites have been analyzed for the fission product radionuclides: Sr-89, Sr-90, Zr-95, Cs-137, and Ce-144; and the "tracer" radionuclides: Mn-54, Fe-55, and Sb-124. The sites are at Westwood, New Jersey, Appleton, Wisconsin; Chattanooga, Tennessee; Midwest City, Oklahoma; Palo Alto, California; and Seattle, Washington. Available results are reported in the following table 1c, page 26. Beginning in July 1964, the same six sites remained in operation but Sr-89 and Sb-124 analyses have been discontinued since concentrationsof these radionuclides had reached undetectable levels.

FISSION PRODUCT AND "TRACER" RADIONUCLIDES IN MONTHLY COLLECTIONS AT 6 U. S. SITES FROM JULY 1963 THROUGH JUNE 1964 - **Table 1c**

Period	Westwood	Appleton	Chattanooga	Midwest City	Palo Alto	Seattle
mc Sr^{90}/mi^2						
July 1963	13.4			4.33	0.40	1.27(1)
August	5.72	3.88	1.50	1.44	0.85	1.79
September	5.34	3.98	0.96	0.97	0.29	2.41
October	1.56	1.73	0.12	0.38	0.37	2.70
November	2.55	2.44	2.02	3.14	0.87	3.85
December	1.43	0.53	1.59	0.22	0.08	2.77
January 1964	2.69	1.54	3.35	0.46	1.91	3.91
February	1.10	0.30	4.80	2.66	0.25	1.48
March	3.51	2.13	4.88			3.65
April	6.68	3.50	11.4			4.00
May	2.23	6.38	5.47			4.84
June	6.20	2.00	3.70			2.98
mc Cs^{137}/mi^2						
July 1963	17.3			7.37	0.12	1.35(1)
August	12.2	5.60	2.63	4.44	0.52	2.31
September	8.73	6.44	1.66	1.97	0.65	3.18
October	2.57	3.53	0.32	0.90	0.87	2.09
November	4.86	4.39	4.19	2.52	1.92	4.10
December	1.64	0.45	3.00	0.78	0.57	4.78
January 1964	5.19	2.72	5.23	0.67	2.32	5.48
February	2.47	0.66	10.4	4.45	0.86	2.43
March	6.48	3.88	12.4	4.87	1.80	4.85
April	11.6	6.13	25.0			4.91
May	3.53	10.8	8.45			6.21
June	10.7	3.40	6.53			
mc Fe^{55}/mi^2						
July 1963	72.0			17.6	0.60	7.72
August	28.8	37.6	14.3	4.14	2.14	14.7
September	21.3	15.9	3.20	2.89	0.76	9.27
October	10.8	6.74	≤0.39	1.50	1.50	20.5
November	5.30	3.90	4.09	13.0	4.86	10.6
December	8.48	1.87	9.58	2.26	1.58	lost
January 1964	15.2	2.97	8.93	2.58	8.64	20.6
February	2.99	0.70	15.8	17.5	2.61	5.98
March	1.93	1.19	2.70	1.64	3.78	22.9
April	33.8	18.1	78.4			15.4
May						10.7
June						

Period	Westwood	Appleton	Chattanooga	Midwest City	Palo Alto	Seattle
mc Sr^{89}/mi^2						
July 1963	32.2			19.9	1.80	3.55(1)
August	10.4	7.27	2.60	4.32	2.38	3.87
September	6.69	5.39	0.96	1.55	0.38	0.55
October	1.56	1.73	<0.14	0.46	0.37	2.57
November	1.52	1.39	1.17	3.14	0.78	0.55
December	0.48	0.25	0.99	0.18	0.06	1.06
January 1964	0.68	0.34	0.90	<0.09	<0.43	0.64
February	0.19	<0.11	0.85	<0.46	0.08	0.23
March	<0.22	0.34	<0.20			<0.11
April	-	-	-			<0.09
May	-	-	-			0.10
June	-	-	-			<0.10
mc Zr^{95}/mi^2						
July 1963	86.0			17.7	0.28	6.25(1)
August	lost	lost	11.8	8.58	1.30	12.4
September	20.9	19.4	7.01	5.11	1.76	9.32
October	5.29	5.71	<4.09	2.93	1.59	7.76
November	lost	5.58	3.44	2.75	2.67	5.75
December	4.51	1.31	4.32	0.10	0.70	4.23
January 1964	4.14	2.41	5.49	12.1	27.2	2.98
February	1.09	0.40	4.35	13.8	3.52	2.22
March	2.67	1.59	lost	0.33	0.47	1.71
April	4.85	2.55	8.65			2.00
May	0.89					1.33
June	1.34					
mc Sb^{124}/mi^2						
July 1963	0.83			*	*	≤2.55
August	≤1.26	≤0.28	0.21	*	*	≤0.84
September	≤0.27	≤1.71	≤0.14	*	*	0.59
October	≤0.26	≤0.67	≤0.83	*	*	0.60
November	≤1.48	≤1.53	≤3.49	*	*	0.97
December	lost	lost	≤0.46	*	*	<1.78
January 1964	≤0.45	lost	lost	*	*	
February	≤0.58	≤1.08	≤0.06	*	*	
March	≤0.40	≤0.75	≤1.18	*	*	
April	-	-	-			
May	-	-	-			
June	-	-	-			

Period	Westwood	Appleton	Chattanooga	Midwest City	Palo Alto	Seattle
mc Ce^{144}/mi^2						
July 1963	186			60.5	0.93	14.0(1)
August	124	74.5	29.5	41.1	4.26	30.5
September	94.3	70.4	18.3	23.2	7.03	32.5
October	29.2	33.2	4.93	6.80	5.93	36.3
November	53.9	44.6	38.8	13.0	12.2	42.3
December	30.0	12.9	39.5	6.74	5.26	44.4
January 1964	57.8	25.7	51.3	6.16	16.9	49.4
February	18.5	5.42	72.5	37.7	8.58	19.5
March	49.2	25.0	94.8	32.0	17.3	33.3
April	75.8	43.5	168			38.1
May	22.1	75.1	68.3			31.8
June	62.2	19.1	33.6			
mc Mn^{54}/mi^2						
July 1963	24.0			7.43	<0.06	3.62
August	16.3	5.04	1.64	4.50	0.86	7.19
September	11.7	7.45	2.01	2.48	0.93	3.52
October	2.98	3.80	< 0.72	1.00	1.52	5.86
November	lost	2.49	1.32	2.51	1.74	5.27
December	3.44	<1.25	1.76	0.63	0.72	3.02
January 1964	5.36	2.20	3.58	0.37	2.33	4.44
February	1.28	0.46	6.29	2.82	0.32	1.89
March	3.80	2.35	5.03	3.66	0.83	3.58
April	6.56	3.12	10.4			3.86
May	2.58	7.39	5.48			4.33
June	4.91	1.88	3.26			
Precipitation in Inches						
July 1963	4.76			5.94	dry	1.81(1)
August	1.80	1.98	0.83	2.45	trace	1.57
September	4.69	3.82	0.94	1.81	0.18	0.94
October	0.92	0.62	dry	0.20	0.99	4.19
November	4.48	1.69	6.82	1.99	2.74	7.92
December	1.51	0.57	4.70	0.67	trace	4.75
January 1964	3.48	1.04	5.63	0.67	3.41	7.39
February	1.89	0.16	5.50	1.98	0.25	1.25
March	2.24	1.66	11.4	1.34+	1.39	2.97
April	6.14	2.60	9.83			1.33
May	1.05	5.32	4.94			1.39
June	2.46	1.51	3.32			3.07

(1) Collections began on the 15th.
* Undetectable.
Note: Radionuclide data extrapolated to midpoint of collection month.

1.2 Weekly Precipitation

1.21 Sr-89 and Sr-90 at 6 U.S. Sites from July 1963 Through June 1964

In July 1963 weekly precipitation collections were initiated at six sites in the United States: Westwood, New Jersey; Appleton, Wisconsin; Chattanooga, Tennessee; Midwest City, Oklahoma; Palo Alto, California; and Seattle, Washington. These collections were analyzed for strontium-89 and strontium-90 only and the available results are reported in the following table 1d, page 28. These weekly collections and analyses were terminated in July 1964.

TABLE 1d

WEEKLY PRECIPITATION COLLECTIONS FOR Sr-90 AND Sr-89 AT 6 U. S. SITES FROM JULY 1963 THROUGH JUNE 1964

Period	Precipitation in Inches: Westwood	Appleton	Chattanooga	Midwest City	Palo Alto	Seattle	mc Sr^{90}/mi^2: Westwood	Appleton	Chattanooga	Midwest City	Palo Alto	Seattle
7/1-8/63	0.91			0.02	dry		2.77			0.27	0.03	
7/8-15/63	0.34			2.81	dry		2.98			1.64	0.01	
7/15-22/63	1.98			dry	dry	1.79	5.60			0.02	0.01	0.67
7/22-31/63	1.53	0.34	3.05(2)	3.11	dry	0.02	2.77	1.86	4.54	2.00	0.02	0.62
8/1-8/63	0.05	0.59	0.03	trace	dry	dry	0.54	0.86	0.10	0.09	0.05	0.08
8/8-15/63	0.98	0.31	0.07	1.89	trace	0.08	2.99	1.29	0.33	1.45	0.15	0.93
8/15-22/63	0.77	0.33	0.61	0.06	dry	0.40	1.84	1.07	1.28	0.06	0.02	0.26
8/22-31/63	dry	0.75	0.12	0.50	dry	1.09	0.23	0.52	0.19	0.49	0.02	0.73
9/1-8/63	0.44	1.21	0.19	0.97	dry	0.45	0.49	2.00	0.15	0.58	0.04	0.60
9/8-15/63	0.58	1.39	0.09	0.21	0.18	0.20	0.64	0.86	0.26	0.19	0.21	0.97
9/15-22/63	0.47	0.51	dry	0.43	trace	0.19	0.72	0.65	0.04	0.19	0.12	0.36
9/22-30/63	3.20	0.70	0.66	0.20	dry	0.10	3.14	1.02	0.64	0.33	0.01	0.41
10/1-8/63	dry	0.01	dry	trace	dry	0.32	0.14	0.24	0.03	0.03	0.01	0.88
10/8-15/63	dry	dry	dry	trace	0.85	0.71	0.07	lost	0.05	0.02	0.34	0.25
10/15-22/63	dry	0.54	dry	0.16	0.14	1.39	0.05	1.40	0.02	0.30	0.12	1.25
10/22-31/63	0.92	0.07	dry	0.04	trace	1.77	1.22	0.28	0.03	0.09	0.05	1.73
11/1-8/63	3.98	trace	1.59	0.04	0.90	1.85	1.75	0.06	1.42	0.12	0.43	1.05
11/8-15/63	0.16	0.56	trace	dry	0.44	2.85	0.18	1.60	0.02	0.04	0.19	1.17
11/15-22/63	dry	1.13	0.07	1.95	1.40	1.61	0.05	0.87	0.06	0.98	0.18	0.69
11/22-30/63	2.08	trace	5.16	trace	trace	1.61	0.36	0.06	1.17	0.02	0.44	0.60
12/1-8/63	0.14	0.34	0.40	dry	dry	0.75	0.34	0.54	0.24	0.02	0.02	0.49
12/8-15/63	1.13	0.06	2.24	0.64	dry	0.62	0.80	0.07	0.36	0.24	0.06	0.43
12/15-22/63	0.15	0.11	dry	0.02	trace	1.11	0.11	0.06	0.02	0.07	0.08	0.92
12/22-31/63	0.09	0.06	2.06	0.01	dry	2.27	0.71	0.12	0.44	0.05	0.02	0.93
1/1-8/64	0.11	0.06	0.88	dry	dry	0.44	0.06	0.04	0.54	0.01	0.02	1.00
1/8-15/64	2.02	0.05	1.40	trace	trace	1.27	0.48	0.22	0.64	0.01	0.16	0.94
1/15-22/64	0.70	0.01	0.22	dry	3.14	3.44	0.64	0.10	0.37	0.02	{1.84}	0.99
1/22-31/64	0.65	0.92	3.13	0.67		2.24	1.35	0.94	1.52	0.38		1.51
2/1-8/64	0.79	0.02	0.79	1.92	dry	0.11	1.02	0.05	0.64	2.38	0.01	0.19
2/8-15/64	0.01	0.10	2.11	0.03	dry	0.32	0.07	0.21	2.07	0.22	0.14	0.71
2/15-22/64	1.06	dry	1.96	0.03	dry	0.62	1.17	0.02	0.63	0.15	0.03	0.26
2/22-29/64	0.03	0.04	0.64	trace	0.04	0.20	0.03	0.06	1.35	0.04	0.10	0.34
3/1-8/64	0.23	0.88	2.32	0.11	0.26	1.24	0.06	1.35	0.83	0.30	0.15	0.83
3/8-15/64	1.08	0.18	4.79	0.68	0.39	0.54	1.89	0.41	2.37	0.32	0.19	1.06
3/15-22/64	0.23	dry	1.06	0.49	0.33	0.91	0.14	0.22	2.02	1.90	0.18	1.08
3/22-31/64	0.70	0.60	3.20	0.06	0.43	0.28	1.22	0.21	2.46	0.51	0.67	0.80
4/1-8/64	2.26	0.69	{4.58}	1.50	dry	0.54	2.14	0.24	{3.25}	1.46	0.03	0.98
4/8-15/64	1.18	0.08		dry	dry	0.38	1.10	0.41		0.06	0.02	1.54
4/15-22/64	1.53	0.79	dry	0.24+	dry	0.26	1.56	0.87	0.03	0.66	0.02	0.78
4/22-30/64	1.17	1.04	5.24	0.36+	0.04	0.15	1.85	lost	4.82	1.27	0.05	0.72
5/1-8/64	dry	2.53	3.47	0.80+	0.13	0.30	0.03	7.50	2.07	1.13	0.23	1.20
5/8-15/64	0.92	1.07	0.15	1.47+	dry	0.20	1.12	2.60	0.41	2.93	0.01	0.72
5/15-22/64	0.13	0.77	dry	0.01	dry	0.57	0.56	1.26	0.05	0.50	0.06	1.76
5/22-31/64	dry	0.95	1.32		0.39	0.32	0.06	2.38	1.46		0.26	1.00
6/1-8/64	-	-	-	0.44	trace	0.80	-	-	-	1.25	0.10	1.33
6/8-15/64	-	-	-	trace	0.54	0.27	-	-	-	0.07	0.17	0.36
6/15-22/64	-	-	-			2.00	-	-	-			1.48
6/22-30/64	-	-	-			dry	-	-	-			0.03

Period	mc Sr^{89}/mi^2 (1): Westwood	Appleton	Chattanooga	Midwest City	Palo Alto	Seattle	Sr^{89}/Sr^{90}: Westwood	Appleton	Chattanooga	Midwest City	Palo Alto	Seattle
7/1-8/63	7.07			0.98	0.09		2.6			3.6	3.2	
7/8-15/63	7.43			5.89	0.05		2.5			3.6	3.2	
7/15-22/63	6.35			0.05	0.03	1.73	1.1			2.6	2.8	2.6
7/22-31/63	5.67	4.09	7.87	6.28	0.03	1.60	2.0	2.2	1.7	3.1	2.0	2.6
8/1-8/63	1.35	1.82	0.12	0.30	0.16	0.15	2.5	2.1	1.3	3.2	3.3	1.8
8/8-15/63	5.18	3.01	0.66	4.50	0.43	1.51	1.7	2.3	2.0	3.1	2.8	1.6
8/15-22/63	3.62	1.72	1.80	0.19	0.05	0.42	2.0	1.6	1.4	3.4	2.2	1.6
8/22-31/63	0.34	2.04	0.24	1.13	0.06	0.95	1.5	3.9	1.2	2.3	2.6	1.3
9/1-8/63	0.71	2.42	0.16	1.22	0.09	0.73	1.4	1.2	1.1	2.1	1.9	1.2
9/8-15/63	0.87	1.13	0.19	0.40	0.38	0.89	1.4	1.3	1.3	2.1	1.8	0.9
9/15-22/63	0.92	0.71	≤0.04	0.32	0.24	0.31	1.3	1.1	*	1.7	2.0	0.8
9/22-30/63	3.93	0.98	0.63	0.50	0.02	0.49	1.2	1.0	1.0	1.5	2.3	1.2
10/1-8/63	0.12	0.26	≤0.04	0.05	0.02	0.87	0.8	1.1	*	1.8	1.9	1.0
10/8-15/63	0.06	lost	≤0.07	0.03	0.44	0.34	0.9	lost	*	1.3	1.3	1.3
10/15-22/63	0.06	1.32	≤0.03	0.15	0.15	0.51	1.3	0.9	*	0.5	1.2	0.4
10/22-31/63	1.49	0.29	0.03	0.03	0.03	0.54	1.2	1.0	1.1	0.3	0.5	0.3
11/1-8/63	1.40	≤0.05	1.13	0.07	0.43	0.47	0.8	*	0.6	0.6	1.0	0.4
11/8-15/63	0.14	1.17	≤0.03	0.04	0.10	0.31	0.8	0.7	*	1.0	0.5	0.3
11/15-22/63	0.04	0.50	0.04	0.79	0.11	0.13	0.8	0.6	0.7	0.8	0.6	0.2
11/22-30/63	0.36	≤0.03	0.70	0.02	0.35	0.27	1.0	*	0.6	1.2	0.8	0.4
12/1-8/63	0.24	0.25	0.16	0.01	0.01	0.38	0.7	0.5	0.7	0.3	0.9	0.8
12/8-15/63	0.48	0.04	0.26	0.19	0.03	0.13	0.6	0.5	0.7	0.8	0.5	0.3
12/15-22/63	≤0.08	0.03	≤0.05	0.02	0.02	0.29	*	0.5	*	0.3	0.3	0.3
12/22-31/63	0.29	0.06	1.11	0.02	0.01	0.26	0.4	0.5	0.4	0.4	0.4	0.3
1/1-8/64	0.04	≤0.18	0.21	<0.01	0.02	0.18	0.6	*	0.4	*	0.9	0.2
1/8-15/64	0.19	0.06	≤0.03	0.01	0.07	0.08	0.4	0.3	*	0.8	0.4	0.1
1/15-22/64	0.10	≤0.02	0.07	0.01	{0.74}	0.34	0.2	*	0.2	0.7	{0.4}	0.4
1/22-31/64	0.46	0.28	0.31	0.13		<0.06	0.3	0.3	0.2	0.3		*
2/1-8/64	≤0.32	≤0.06	0.26	2.14	<0.01	0.05	*	*	0.4	0.9	<0.3	0.3
2/8-15/64	≤0.05	0.08	0.20	≤0.01	0.04	0.09	*	0.4	0.1	*	0.3	0.1
2/15-22/64	0.17	≤0.03	0.15	0.03	<0.01	<0.01	0.1	*	0.2	0.2	<0.2	*
2/22-29/64	≤0.02	≤0.03	0.25	0.02	<0.01	0.10	*	*	0.2	0.4	<0.1	0.3
3/1-8/64	≤0.01	0.20	0.10	0.04	<0.15	0.25	*	0.1	0.1	0.1	*	0.3
3/8-15/64	0.33	0.04	0.58	0.06	0.06	0.05	0.2	0.1	0.2	0.2	0.3	<0.1
3/15-22/64	≤0.05	≤0.05	0.28	0.10	<0.01	<0.03	*	*	0.1	0.1	*	*
3/22-31/64	0.15	≤0.05	0.20	<0.01	<0.01	<0.02	0.1	*	0.1	*	*	*
4/1-8/64	0.26	≤0.02	{0.40}	0.18	<0.01	0.09	0.1	*	{0.1}	<0.1	<0.2	0.1
4/8-15/64	≤0.02	0.04		<0.01	0.01	<0.06	*	0.1		<0.1	0.5	*
4/15-22/64	0.23	0.14	≤0.02	0.09	<0.01	<0.02	0.1	0.2	*	0.1	<0.4	*
4/22-30/64	≤0.06	lost	≤0.15	0.10	<0.01	<0.01	*	-	*	<0.1	<0.1	*
5/1-8/64	≤0.03	0.34	≤0.14	0.05	0.03	0.03	*	<0.1	*	<0.1	0.1	*
5/8-15/64	≤0.04	<0.13	≤0.13	0.28	<0.01	<0.02	*	*	*	<0.1	<0.3	*
5/15-22/64	≤0.06	<0.05	≤0.04	<0.01	0.01	0.08	*	*	*	<0.1	0.2	<0.1
5/22-31/64	≤0.03	<0.03	≤0.04		0.03	<0.02	*	*	*		0.1	*
6/1-8/64	-	-	-	0.15	0.02	<0.12	-	-	-	0.1	0.2	*
6/8-15/64	-	-	-	<0.01	0.04	<0.02	-	-	-	*	0.2	*
6/15-22/64	-	-	-			<0.09	-	-	-			*
6/22-30/64	-	-	-			<0.01	-	-	-			*

(1) Sr-89 result as of midpoint of collection period.
(2) Rain gauge blew over during severe thunderstorm.
* Sr-89 undetectable.

1.3 Sr-90 in World-Wide Soils Collected in 1963-1964

To assess the cumulative world-wide deposition of strontium-90 on the earth's surface following a period of intense nuclear testing, soil samples were collected in 1963 and early 1964 and analyzed for this fission product radionuclide.

The sampling was carried out under the direction of Dr. Lyle T. Alexander and staff of the Soil Conservation Service, U.S. Department of Agriculture, Beltsville, Md. The soils were dried, weighed and blended at Beltsville and duplicate blind aliquots were then sent to HASL for analysis. Forty-one (41) of the one hundred and eight samples collected were also analyzed at the Soil Survey Laboratory at Beltsville. With each set of twenty blind samples sent to HASL a check and blank soil were included to serve as time controls on the analytical and counting procedures. A statistical analysis of these data is in progress to determine the analytical reproducibility at HASL and between HASL and Beltsville.

The data are presented in Table 1e, pages 30 through 39 by site latitude from north to south. The cumulative precipitation figures listed cover the period January 1, 1953 to the date of sampling. The strontium-90 activity measurements have been calculated for decay to the sampling date. Locations of the soil sampling sites are shown on the United States and World maps following the table.

An interpretation of these strontium-90 measurements in terms of the general features of global fallout and strontium-90 inventory is currently in preparation. This will take the form of a TID report similar to those previously issued which covered the 1960-1961[1] and 1955-1959[2] results.

This is the first public release of the 1963-1964 results.

References

(1) TID-17090, Strontium-90 on the Earth's Surface II, November 1962.
(2) TID-6567, Strontium-90 on the Earth's Surface, February 1961.

TABLE 1e

Strontium-90 in Soils, 1963-1964

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Strontium-90 Avg.
Alaska, Barrow							
1. 3 mi. south of A.F. Field	71.3°N	156.8°W	20	7-26-63	60	21.2 20.9	21.0
2. 2 mi. east of A.F. Field	71.3°N	156.8°W	20	7-26-63	60	27.4 25.2	26.3
Norway, Vadso	70.1°N	29.6°E	30	6-27-63	189	51.8 45.3	48.6
Norway, Ekkeroy	70.1°N	30.1°E	30	6-27-63	189	53.9 50.9	52.4
Norway, Bardufoss							
1. Virgin woodland near weather station	69.2°N	18.5°E	80	6-28-63	286	93.4 86.4	89.9
Canada, Inuvik	68.3°N	133.5°W	124	8-26-63	97	40.1 39.8 41.2*	40.6
Norway, Bodo							
1. Across road from weather station	67.3°N	14.4°E	70	6-28-63	416	87.4 82.2 84.5*	84.6
Alaska, Fairbanks							
1. Agricultural Experiment station	64.8°N	147.9°W	440	7-23-63	115	53.1 50.4	51.8
Iceland, Reykjavik							
1. Hay field 5 mi. S.E. of Reykjavik	64.1°N	22.0°W	60	8-14-63	336	111 115	113
Alaska, Palmer							
1. Agricultural Experiment station	61.6°N	149.3°N	150	7-29-63	171	59.6 56.6	58.1
Canada, Whitehorse	60.7°N	135.1°W	2303	8-12-63	105	43.1 44.5 45.1*	44.4

* Analysis by Beltsville Soil Survey Laboratory, USDA.

Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Avg.
Norway, Bergen							
1. Nygards Park	60.4°N	5.3°E	140	6-25-63	784	134	132
						131	
Norway, Oslo							
1. Residential Area	59.9°N	10.8°E	320	6-24-63	305	92.2	90.2
						85.8	
						91.5*	
Norway, Utsira	59.3°N	4.9°E	50	6-30-63	451	110	108
						105	
Canada, Ft. Churchill	58.8°N	94.1°W	75	7-30-63	184	90.2	90.2
						90.0	
						90.2*	
Canada, Calgary	51.1°N	114.0°W	3557	8-2-63	180	117	116
						114	
						117*	
France, Longueville	49.8°N	1.1°E	295	4-16-63	280	68.2	67.9
						69.6	
						66.9*	
Canada, Vancouver	49.2°N	123.2°W	9	8-2-63	466	114	117
						120	
						117*	
France, Paris							
1. Residential Area	49.0°N	2.4°E	170	12-11-63	216	83.5	80.2
						76.8	
France, Bretigny	48.6°N	2.3°E	318	4-1-63	200	58.9	58.4
						56.9	
						58.9*	
Canada, Ft. William	48.4°N	89.3°W	653	7-17-63	292	156	160
						163	
						160*	
Washington, Puyallup							
1. Western Washington Experiment station	47.2°N	122.3°W	50	8-4-63	451	103	106
						104	
						107*	

* Analysis by Beltsville Soil Survey Laboratory, USDA.

Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Strontium-90 Avg.
North Dakota, Mandan							
1. Northern Great Plains Field Station	46.8°N	100.9°W	1750	10-8-63	176	163 158	160
France, St. Laurent	46.3°N	4.9°E	623	10-30-62	304	79.6 79.2 78.7*	79.0
Montana, Bozeman							
1. Montana State College Campus	45.7°N	111.0°W	4860	10-7-63	180	164 171 162*	165
Canada, Ottawa							
1. Airport	45.4°N	75.7°W	374	8-19-63	342	135 130 128*	130
Minnesota, St. Paul							
1. Univ. of Minnesota Campus	45.0°N	93.1°W	920	10-10-63	278	161 158 156*	158
Maine, Orono							
1. Univ. of Maine, Athletic Field	44.9°N	68.7°W	120	9-25-63	399	108 111	110
Oregon, Corvallis							
1. Oregon State College Campus	44.6°N	123.2°W	220	8-5-63	444	101 104 100*	101
Vermont, Burlington							
1. Univ. of Vermont Campus	44.5°N	73.2°W	330	9-24-63	361	135 128	132
Canada, Halifax	44.6°N	63.6°W	104	8-8-63	546	91.5 91.7 94.6*	93.1
South Dakota, Rapid City							
1. 2.3 mi. south of cemetery	44.1°N	103.2°W	3260	10-9-63	196	187 191 186*	188

* Analysis by Beltsville Soil Survey Laboratory, USDA.

Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Strontium-90 Avg.
Italy, Florence							
1. Farm	43.8°N	11.2°E	160	12-9-63	339	160	165
						170	
France, Lauris	43.7°N	5.3°E	689	10-29-62	237	63.6	64.6
						65.1	
						64.7*	
Idaho, Boise							
1. Veterans Hospital	43.6°N	116.2°W	2840	8-3-63	121	115	117
						119	
Japan, Sapporo							
1. Experiment Station	43.0°N	141.3°E	60	8-19-63	488	123	125
						127	
New York, Ithaca							
1. Univ. of Cornell Campus	42.4°N	76.5°W	950	11-9-63	381	113	110
						107	
Massachusetts, Amherst							
1. Univ. of Mass. Campus	42.4°N	72.5°W	210	9-26-63	457	119	118
						117	
						119*	
Canada, Windsor							
1. Airport	42.3°N	83.0°W	622	8-2-63	339	114	113
						111	
						114*	
Utah, Logan							
1. Utah State Univ. A.H. Farm	41.8°N	111.8°W	4610	8-2-63	156	75.5	80.3
						80.3	
						82.7*	
Iowa, Des Moines							
1. Municipal Airport	41.5°N	93.6°W	950	7-28-63	311	156	155
						148	
						158*	
Rhode Island, Kingston							
1. Univ. of Rhode Is., Athletic Field	41.5°N	71.5°W	100	9-26-63	523	174	172
						168	
						174*	

* Analysis by Beltsville Soil Survey Laboratory, USDA.

Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Strontium-90 Avg.
New York City							
1. Fordham Univ. Campus	40.8°N	73.9°W	180	10-22-63	431	146 146	146
Utah, Salt Lake City							
1. Univ. of Utah Golf Course	40.8°N	111.8°W	4730	8-1-63	170	186 189	188
Ohio, Columbus							
1. Ohio State Univ. Campus	40.0°N	83.0°W	720	7-27-63	343	148 146 138*	142
Turkey, Ankara							
1. Residential Area	40.0°N	32.9°E	2940	12-5-63	167	121 125	123
Colorado, Derby							
1. Government Reserve	39.8°N	104.9°W	5290	7-30-63	158	120 119 127*	124
Delaware, Newark							
1. Univ. of Delaware Experiment station	39.7°N	75.7°W	90	9-27-63	456	133 131	132
California, Healdsburg							
1. Residential Area	38.6°N	122.9°W	100	8-6-63	439	115 116	116
Utah, Cedar City							
1. Campus Lawn	37.7°N	113.1°W	5618	9-23-63	99	82.6 83.3 88.4*	85.7
Virginia, Norfolk							
1. Experiment Station	36.9°N	76.2°W	26	2-10-64	523	149 146	148
Oklahoma, Tulsa							
1. Municipal Airport	36.2°N	95.9°W	670	9-5-63	398	166 154 164*	162

* Analysis by Beltsville Soil Survey Laboratory, USDA.

Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Avg.
Japan, Tokyo							
1. Residential Area	35.7°N	139.8°E	10	8-16-63	632	125 128	126
2. Botanic Garden	35.7°N	139.8°E	10	8-16-63	632	128 138 129*	131
South Carolina, Florence							
1. Experiment Station	34.2°N	79.8°W	136	2-11-64	492	152 152 151*	152
California, Los Angeles							
1. Hollywood Park Race Track	33.9°N	118.4°W	125	8-8-63	114	36.0 35.4	35.7
Lebanon, Beirut							
1. Residential Area	33.8°N	35.5°E	80	12-3-63	360	132 133	132
Georgia, Altanta							
1. College Park Golf Course	33.6°N	84.4°W	980	2-21-64	523	136 144	140
Japan, Fukuoka							
1. Experiment Station	33.6°N	130.4°E	10	8-17-63	795	129 130	130
Syria, Damascus							
1. Residential Area	33.5°N	36.2°E	2380	12-2-63	88	55.4 54.8	55.1
California, El Centro							
1. Meloland Field Station	32.8°N	115.6°W	(-)50	9-2-63	20	33.0 29.3 32.5*	31.8
Mississippi, Newton							
1. Coastal Plains Experiment Station	32.3°N	89.1°W	350	2-21-64	583	120 123	122
Bermuda, Paget East							
1. Botanic Gardens	32.3°N	64.8°W	100	1-24-64	726	150 153	152

* Analysis by Beltsville Soil Survey Laboratory, USDA.

Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Avg.
Arizona, Tucson							
1. Residendial Area	32.2°N	111.0°W	2410	9-3-63	110	48.2 48.4 50.0*	49.2
Georgia, Tifton							
1. Experiment Station	31.5°N	83.5°W	370	2-19-64	497	114 114	114
Florida, Jacksonville							
1. Imeson Airport	30.4°N	81.6°W	20	2-12-64	563	138 133	136
Louisiana, New Orleans							
1. Moisant Airport	30.0°N	90.2°W	33	2-20-64	646	120 118	119
India, New Delhi	28.6°N	77.2°E	708	3-19-64	312	87.I 92.5*	89.8
Florida, So. Miami							
1. Univ. of Miami Campus Experimental Area	25.8°N	80.3°E	10	2-13-64	688	101 100	100
India, Indore	22.7°N	75.8°E	1860	3-9-64	417	67.3 66.3*	66.8
Hawaii, Is. of Oahu							
1. Kahuku Golf Course	21.7°N	158.0°W	20	8-12-63	448	130 127	128
2. Leilehua Golf Course	21.5°N	158.0°W	920	8-12-63	580	137 142	140
3. Kawailoa Girl's School	21.4°N	157.8°W	370	8-12-63	658	151 148	150
Puerto Rico, Fort Buchanan	18.4°N	66.1°W		1-20-64	~ 770	124 119	122
British West Indies							
1. Barbuda	17.4°N	61.8°W		1-23-64	~ 410	70.8 69.9	70.4

* Analysis by Beltsville Soil Survey Laboratory, USDA.

Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. In.	Strontium-90 mc/square mile	Avg.
India, Hyderabad	17.4°N	78.5°E	1788	3-14-64	338	56.3 53.2*	54.8
Senegal, Bambey	14.7°N	16.6°W	56	11-19-63	290	20.3 20.1	20.2
Philippines, Manila							
1. Residential Area	14.6°N	121.0°E	7	8-21-63	847	28.7 28.2	28.4
India, Bangalore	13.0°N	77.6°E	3021	3-12-64	396	38.9 38.8*	38.8
Panama Canal Zone							
1. Ft. Clayton Golf Course	9.0°N	79.6°W	110	11-18-63	892	37.2 35.8	36.5
2. Ft. Amador Golf Course	9.0°N	79.6°W	100	11-18-63	794	29.0 29.8	29.4
Colombia, Bogota							
1. Residential Area	4.6°N	74.1°W	8400	11-20-63	~ 420	16.8 16.6	16.7
Malaysia, Singapore							
1. Leedon Park	1.4°N	103.9°E	20	8-23-63	897	12.4 12.7	12.6
2. Residential Area	1.4°N	103.9°E	20	8-23-63	897	12.1 11.3	11.7
Kenya, Muguga							
1. Weather Station	1.2°S	36.6°E	7000	11-28-63	416	42.2 42.4 44.1*	43.2
Republic of the Congo, Leopoldville							
1. Residential Area	4.3°S	15.2°E	1210	11-21-63	596	13.3 14.7	14.0
Peru, Huancayo							
1. Instituto Geofisico	12.0°S	75.2°W	10990	11-24-63	317	11.4 10.8	11.1

* Analysis by Beltsville Soil Survey Laboratory, USDA.

Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Strontium-90 Avg.
Australia, Katherine							
1. Katherine Research Station	14.3°S	132.3°E	360	9-25-63	388	10.5 11.8	11.2
Southern Rhodesia, Salisbury							
1. Experiment Station	17.8°S	31.0°E	4830	11-27-63	383	8.8 9.6 10.1*	9.6
2. Botanic Gardens	17.8°S	31.0°E	4830	11-27-63	383	14.0 14.3	14.2
Australia, Townsville							
1. 30 miles south of Townsville at Woodstock	19.6°S	146.8°E	750	10-4-63	415	11.2 12.2	11.7
Chile, Antofagasta							
1. 11 miles north	23.4°S	70.5°W	390	11-27-63	trace	1.3 1.2	1.2
Australia, Alice Springs							
1. Experiment Station	23.8°S	133.9°E	1800	12-5-63	90	9.2 8.4	8.8
Paraguay, Asuncion							
1. Golf Course	25.4°S	57.6°W	300	12-11-63	642	18.7 21.9	20.3
Australia, Brisbane							
1. Experiment Station	27.5°S	153.0°E	130	10-10-63	474	30.6 30.7	30.6
South Africa, Durban							
1. Residential Area	29.8°S	31.0°E	20	11-25-63	448	27.9 23.4	25.6
2. Natal University Campus	29.8°S	31.0°E	20	11-25-63	448	20.5 23.9	22.2
Australia, Perth							
1 Avondale Research Station, Beverley	32.2°S	117.0°E	651	10-9-63	165	11.2 12.8	12.0
Chile, Santiago							
1. 14 miles west	33.5°S	70.7°W	1710	11-29-63	136	11.4 10.9	11.2

* Analysis by Beltsville Soil Survey Laboratory, USDA.

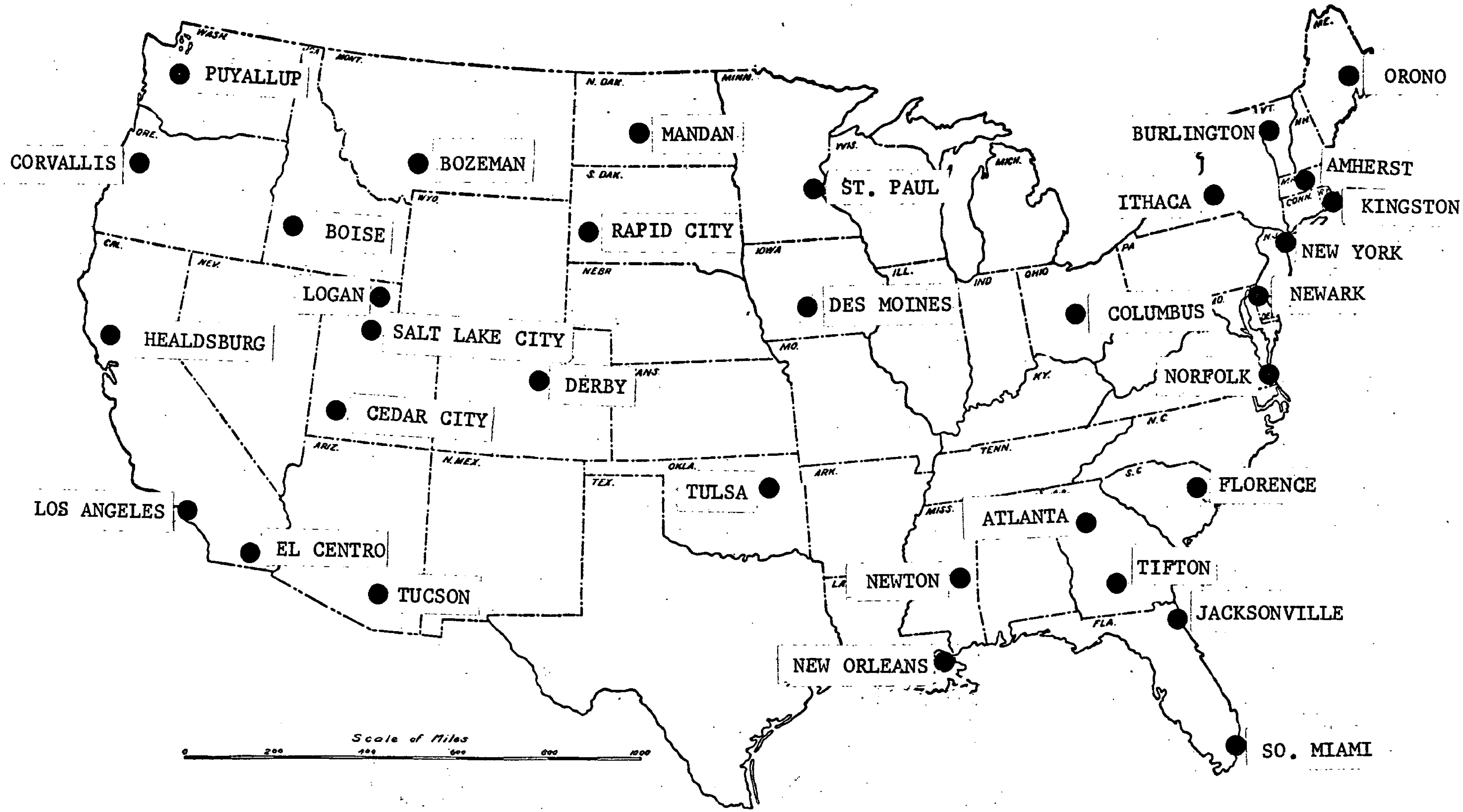
Strontium-90 in Soils, 1963-1964 - cont'd.

Location	Lat.	Long.	Elev. ft.	Sampling Date	Cum. Precip. in.	Strontium-90 mc/square mile	Strontium-90 Avg.
Argentina, Buenos Aires							
1. Residential Area	34.6°S	58.5°W	80	12-10-63	469	24.2	23.1
						22.0	
Australia, Adelaide							
1. Experiment Station	34.9°S	138.6°E	140	8-26-63	218	21.0	21.5
						22.0	
New Zealand, North Auckland							
1. Kakapu Settlement Block	35.8°S	174.2°E	400	2-16-64	787	26.1	26.4
						26.3	
						26.6*	
New Zealand, Wellington							
1. W.H. Lee farm, Judgeford	41.3°S	174.8°E	420	1-11-64	552	26.6	27.2
						27.8	
2. Taita	41.3°S	174.8°E	420	1-17-64	553	23.9	23.3
						24.8	
						22.2*	
New Zealand, Greymouth	42.5°S	171.2°E		12-12-63	1081	41.2	43.2
						45.2	
						43.3*	
Tasmania, Hobart							
1. Experiment Station	42.9°S	147.3°E	180	9-25-63	302	23.2	22.4
						21.5	
New Zealand, South Canterbury	44.4°S	171.2°E	200	11-21-63	251	16.4	16.4
						16.3	
Chile, Punta Arenas							
1. 68 miles north	53.2°S	70.9°W	30	12-3-63	95	11.8	12.4
						13.0	

* Analysis by Beltsville Soil Survey Laboratory, USDA.

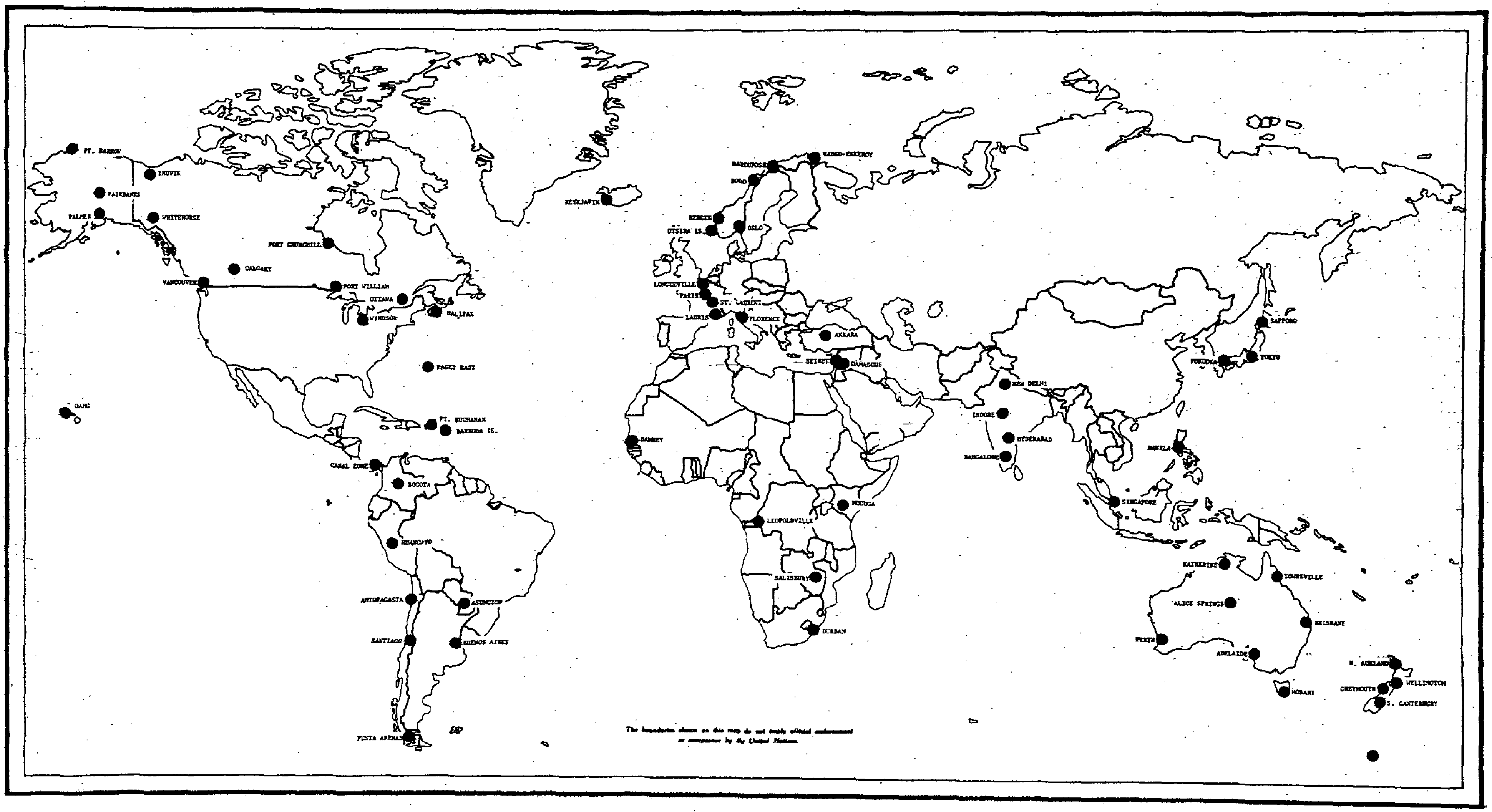
SOIL SAMPLING SITES - 1963-1964

FIGURE 3



SOIL SAMPLING SITES - 1963-1964

FIGURE 4



2. Radiostrontium in Milk and Tap Water

In 1954 the Health and Safety Laboratory began monitoring liquid whole milk in New York City for strontium-90 in order to estimate the dietary contribution from the ingestion of this radionuclide in milk. During the same year, tap water sampling was begun on a routine basis at the laboratory which receives its supply from one of the main reservoirs servicing New York City.

Powdered milk monitoring was intiated at a main processing plant in Perry, New York in 1954 and in 1955, sampling of powdered buttermilk from the Mandan, North Dakota area was begun. The powdered buttermilk is used as cattle feed and it was of interest to have a continuous record of the strontium-90 levels in this animal dietary supplement. Liquid milk from two large dairies serving Honolulu has been monitored since the summer of 1959. On the island of Oahu the dairy cows are on pasture throughout the year and it is of interest to know how well the strontium levels in milk in this area reflect changes in deposition rates.

Although a more complete study of the strontium-90 content of the diets in three major U.S. cities has been in process since March 1960, milk and tap water analyses at the above-mentioned sites have been continued in order to provide a detailed and continuous history of the contamination levels of these staples.

2.1 Milk

The New York City sample is a monthly composite of pasteurized milk purchased daily at retail stores. Five main dairies are represented in the sample. The Mandan and Perry samples are monthly composites of powdered milk collected in weekly five-pound lots. The Honolulu samples are monthly composites of quart samples collected weekly. During appropriate periods strontium-89, as well as strontium-90, has been analyzed in these milk samples. These data have been given in the quarterly reports but the monthly results for 1964 only are presented on pages 43 and 44 of this report. The strontium-90 data since the inception of the sampling programs are graphed in Figures 5, 6, 7, 8, on pages 46 through 49.

2.2 Strontium-90 in New York City Tap Water

Samples of New York City tap water are taken daily at HASL so that by the end of the month, approximately 100 liters have been collected. Strontium-90 and cesium-137 data for monthly samples collected in 1964 are shown on page 46. Tap water sampling and analyses were carried out at Richmond, California from 1959 through the first half of 1963. These data have been reported in previous quarterlies. A graphical presentation of New York City strontium-90 data is shown in Figure 9, p. 50.

Table 2a

Strontium-90 and Calcium in Milk

Year	Sampling Month	g Ca / liter	pc Sr^{90} per liter	pc Sr^{90} per g Ca
New York City - liquid				
1959	Average			11
1960	Average			8.0
1961	Average			6.7
1962	Average			12
1963	Average			26
1964	January	1.04	22.0	21.1
	February	1.08	25.8	23.9
	March	1.03	28.1	27.2
	April	1.03	26.9	26.1
	May	1.04	31.9	30.1
	June			
	July			
	August			
	September			
	October			
	November			
	December			

Year	Sampling Month	g Ca/liter dairy #1	g Ca/liter dairy #2	pc Sr^{90}/liter dairy #1	pc Sr^{90}/liter dairy #2	pc Sr^{90}/g Ca dairy #1	pc Sr^{90}/g Ca dairy #2
Honolulu, Hawaii - liquid							
8/59-12/59	Average					5.0	
1960	Average					3.2	
1961	Average					2.4	
1962	Average					3.5	5.0
1963	Average					6.9	9.1
1964	January	1.10	1.08	7.6	9.4	6.9	8.7
	February	1.23	1.07	8.8	9.9	7.2	9.2
	March	1.09	1.10	9.1	14.4	8.3	13.1
	April	1.09	1.06	9.2	11.8	8.4	11.1
	May	1.08	1.04	9.3	12.4	8.6	11.9
	June						
	July						
	August						
	September						
	October						
	November						
	December						

Table 2a - cont'd.

Strontium-90 and Calcium in Milk

Year	Sampling Month	g Ca / kg powder	pc Sr^{90} per kg powder	pc Sr^{90} per g Ca
Perry, New York - powdered				
1959	Average			8.0
1960	Average			6.5
1961	Average			6.2
1962	Average			11.1
1963	Average			21.6
1964	January	8.63	174	20.1
	February	8.78	191	21.7
	March	9.29	194	20.9
	April	8.69	183	21.0
	May	8.84	171	19.3
	June			
	July			
	August			
	September			
	October			
	November			
	December			
Mandan, North Dakota - powdered buttermilk				
1959	Average			26
1960	Average			15
1961	Average			9.4
1962	Average			25
1963	Average			58
1964	January	10.8	738	68.3
	February	10.6	863	81.8
	March	11.3	830	73.2
	April	11.5	936	81.2
	May	12.1	1207	100.0
	June			
	July			
	August			
	September			
	October			
	November			
	December			

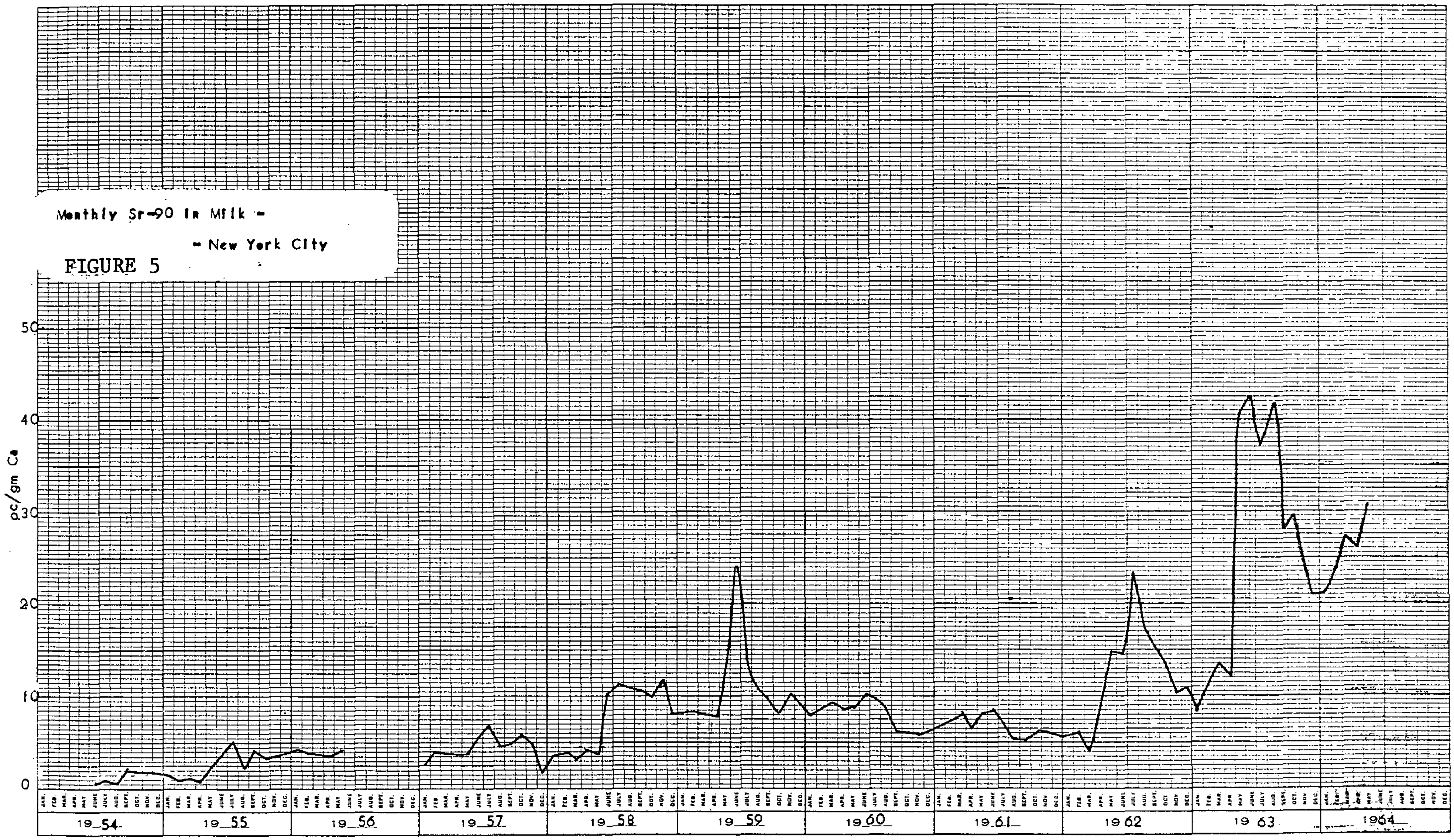
Table 2b

Radiostrontium in New York City Tap Water

Year	Sampling Month	pc Sr^{90}/liter (1)	Sr^{89}/Sr^{90} (2)	Cs^{137}/Sr^{90}
1959	Average	0.40		
1960	Average	0.47		
1961	Average	0.32		
1962	Average	0.72		
1963	Average	1.45		
1964	January	1.62	<0.1	0.20
	February	1.86		0.20
	March	1.59		0.24
	April	1.98		0.34
	May	1.96		
	June	1.98		
	July			
	August			
	September			
	October			
	November			
	December			

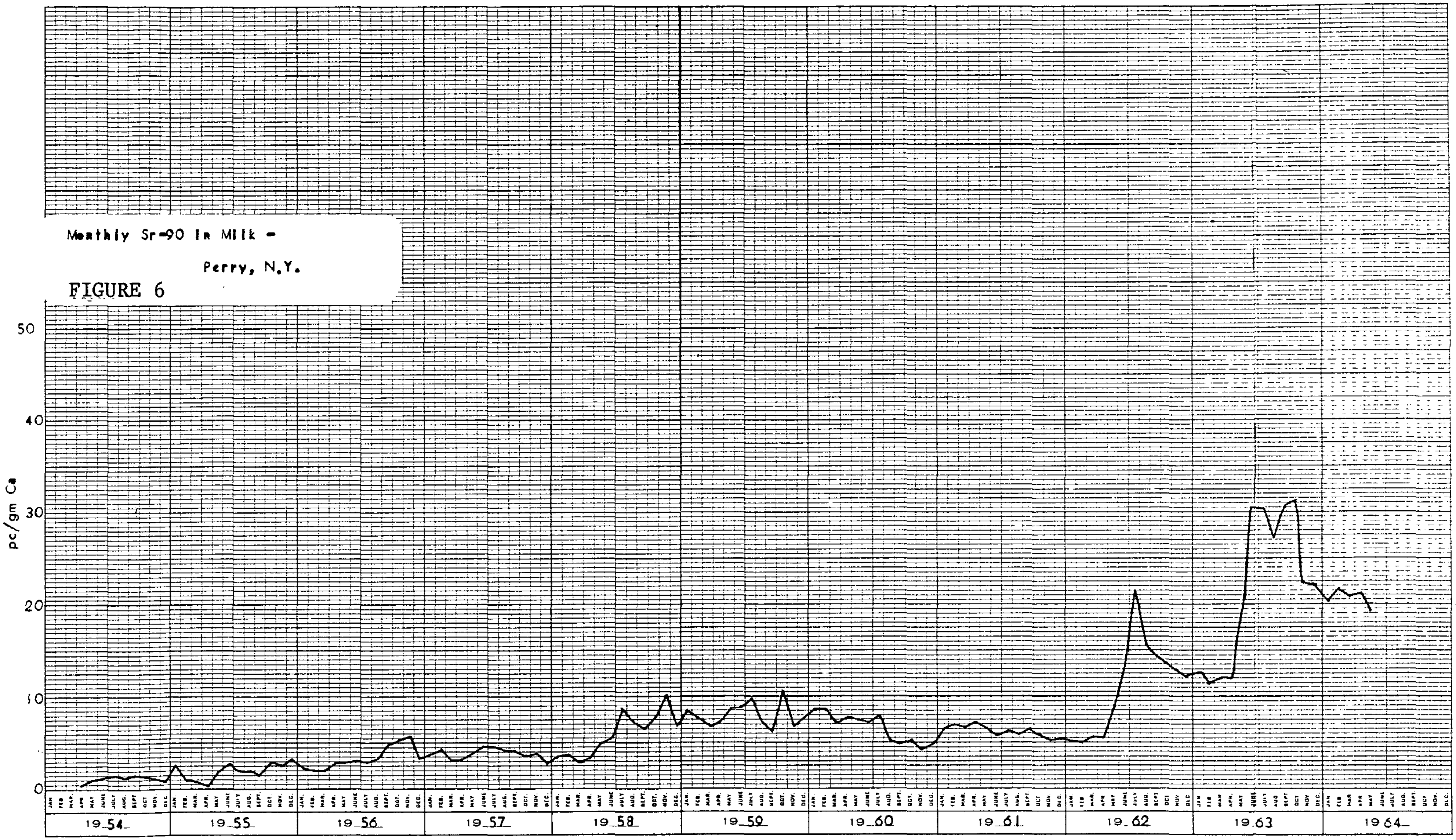
(1) From 100-200 liters per sample - sampling began August 1954.
(2) Sr-89 extrapolated to midpoint of sampling period. Sr-89 analyses discontinued after January 1964.

FIGURE 5



Monthly Sr-90 In Milk -
- New York City
pc/gm Ca
0
10
20
30
40
50
19 54
19 55
19 56
19 57
19 58
19 59
19 60
19 61
19 62
19 63
1964

FIGURE 6


Monthly Sr-90 In Milk -
Perry, N.Y.
pc/gm Ca
0
10
20
30
40
50
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964

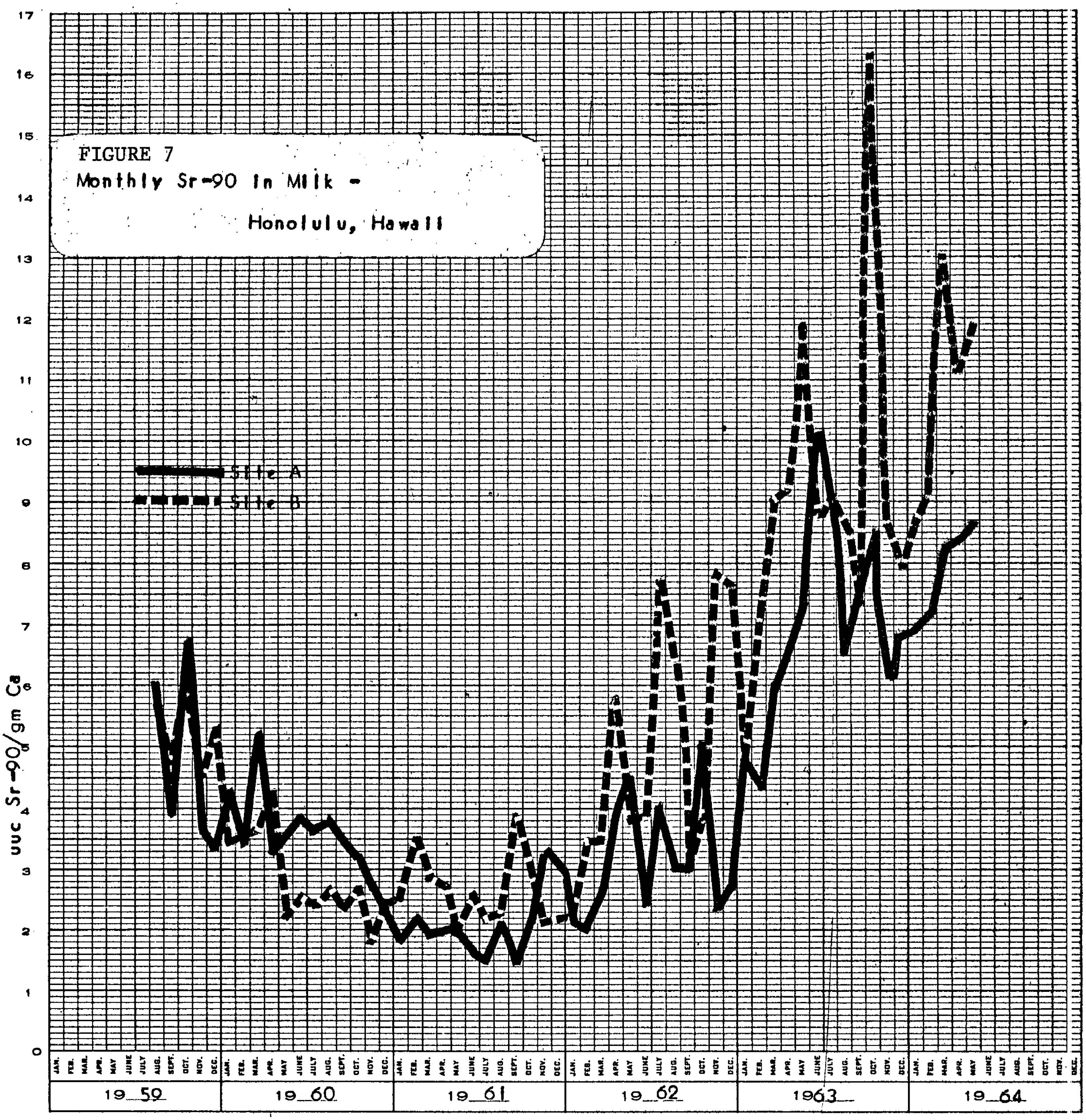


FIGURE 7
Monthly Sr-90 in Milk -
Honolulu, Hawaii
Site A
Site B
uuc Sr-90/gm Ca
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
1959
1960
1961
1962
1963
1964

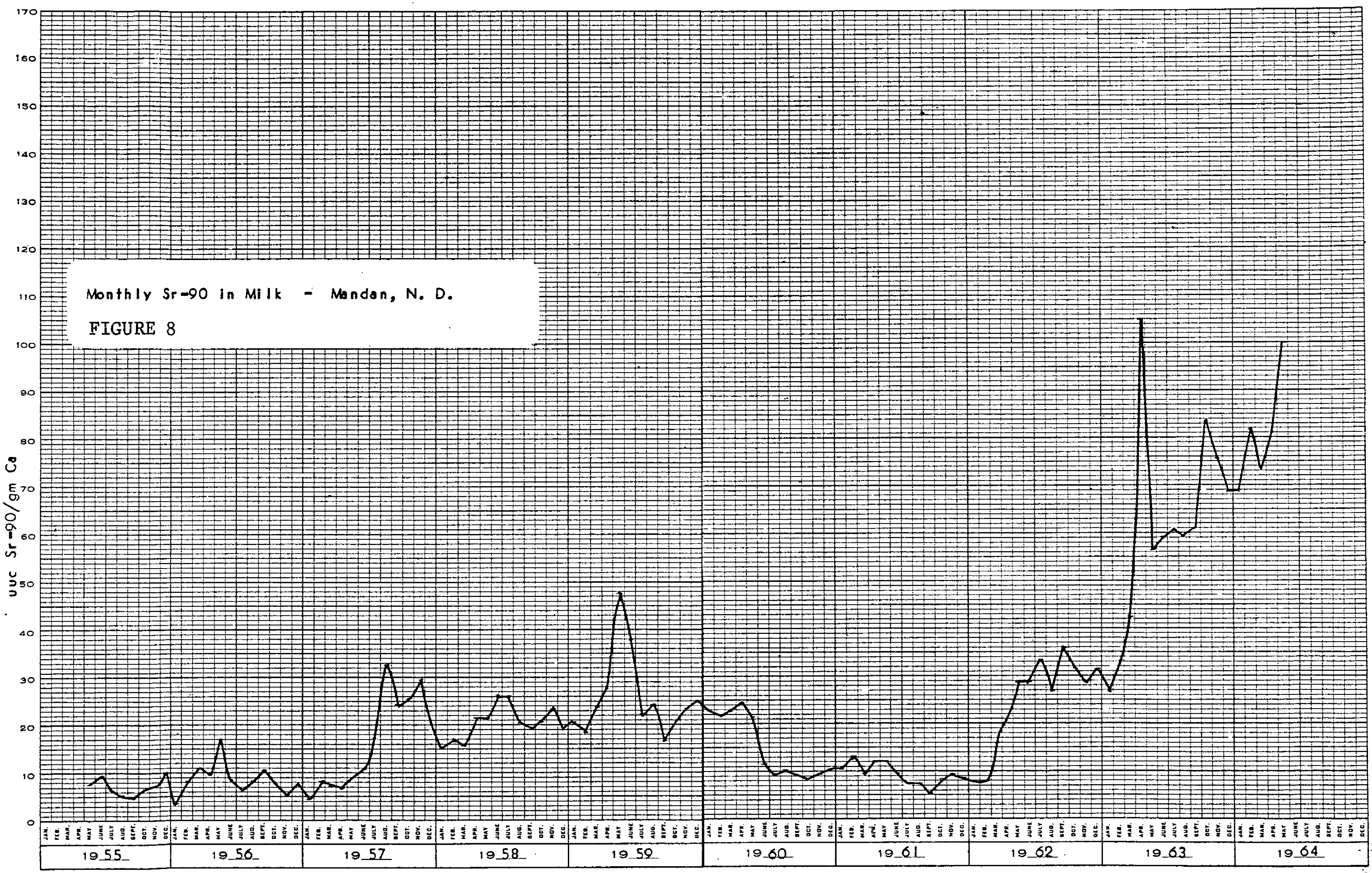
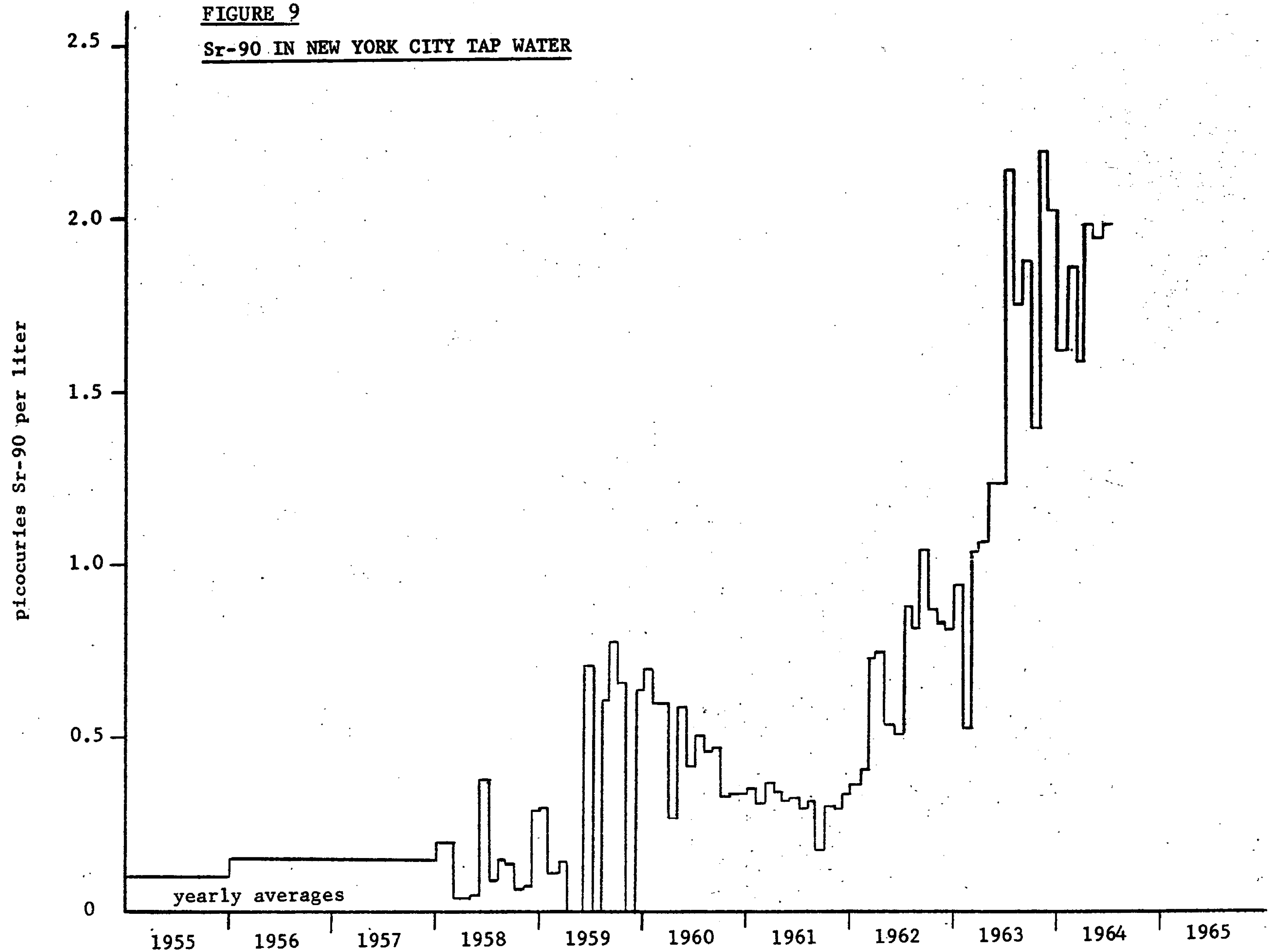

Monthly Sr-90 in Milk - Mandan, N. D.
FIGURE 8
uuc Sr-90/gm Ca
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
19 55
19 56
19 57
19 58
19 59
19 60
19 61
19 62
19 63
19 64

FIGURE 9

Sr-90 IN NEW YORK CITY TAP WATER



3. Tri-City Diet Studies - Sixteenth Sampling

The annual dietary intake of Sr-90 in New York City, Chicago and San Francisco has been estimated from measurements of the Sr-90 content of foods purchased at these cities every three months since March 1960. Details of the sampling system and a discussion of the results obtained up to the end of 1963, in this continuing program were summarized in HASL-147*

Results of the most recent set of analyses and estimates of the Sr-90/Ca ratio of the diet for the three cities are given in Table 3. The average daily intakes of Sr-90 at the three cities since the tri-city diet surveys began are plotted in Figure 10.

* HASL Contributions to the Study of Fallout in Food Chains, Joseph Rivera and John H. Harley, July 1, 1964 (HASL-147).

TABLE 3

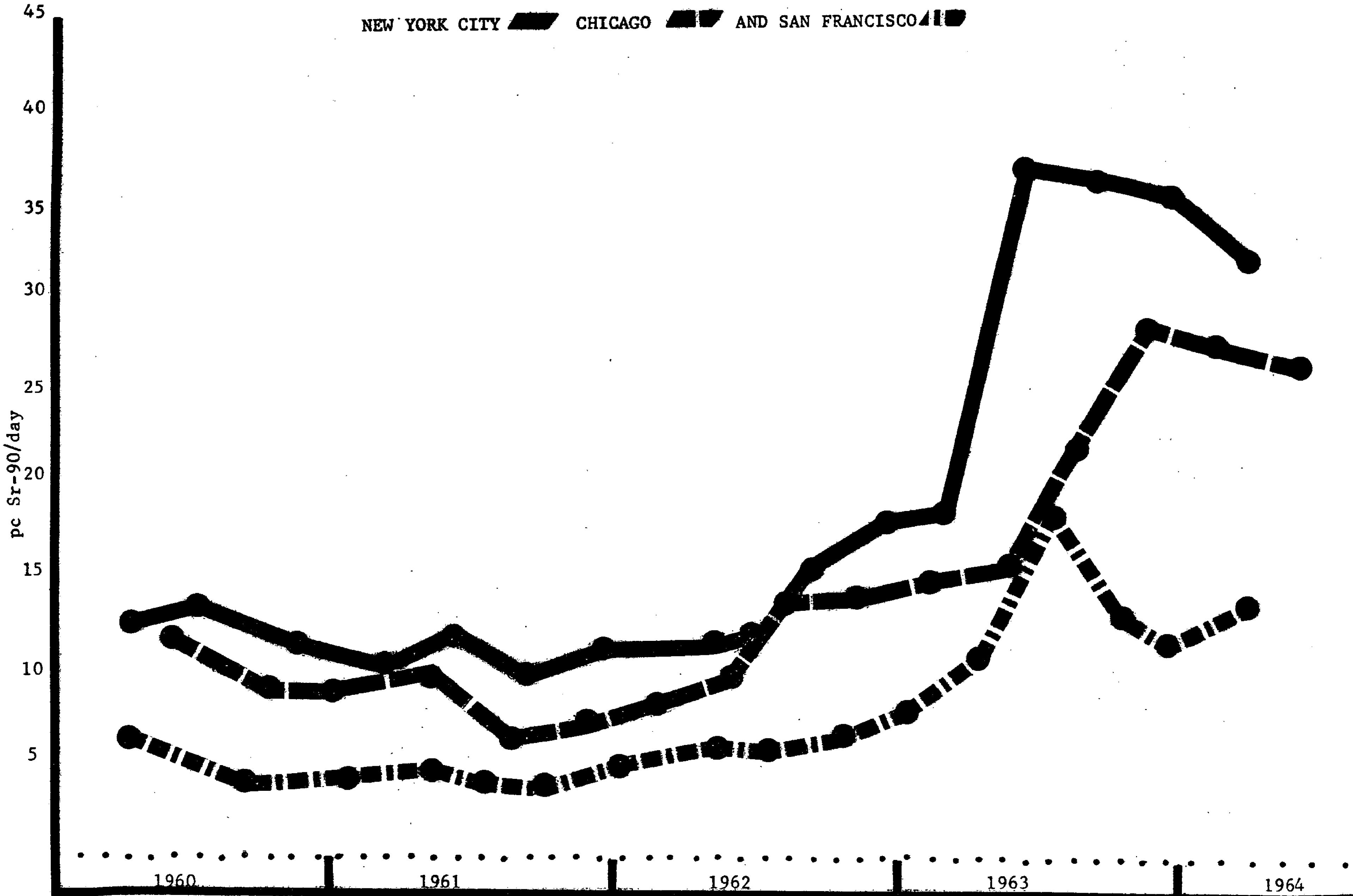
TRI-CITY DIET STUDIES
(Sixteenth Sampling)

Food Category	kg/yr	g Ca/yr	NEW YORK CITY -- 2/64		CHICAGO --- 4/64		SAN FRANCISCO -3/64	
			pc/kg	pc/yr	pc/kg	pc/yr	pc/kg	pc/yr
Bakery Products	37	37.0	26.3 ± 1.1	973	25.9 ± 1.3	958	25.0 ± 1.3	925
Whole Grain Products	11	10.0	101 ± 2.4	1111	81.5 ± 2.4	896	47.4 ± 2.1	521
Eggs	16	9.1	8.3 ± 0.3	133	9.8 ± 0.2	157	5.5 ± 0.2	88
Fresh Vegetables	43	15.0	13.9 ± 0.6	598	16.7 ± 0.5	718	3.2 ± 0.3	138
Root Vegetables	17	6.1	9.6 ± 0.5	163	9.8 ± 0.5	167	8.7 ± 0.5	148
Milk	221	234.3	25.9 ± 0.8	5724	18.0 ± 0.5	3974	15.2 ± 0.6	3359
Poultry	17	9.2	3.3 ± 0.2	56	1.7 ± 0.1	29	2.8 ± 0.1	48
Fresh Fish	8	10.8	0.9 ± 0.2	7	4.0 ± 0.2	32	0.7 ± 0.1	6
Flour	43	8.6	21.3 ± 0.4	916	23.6 ± 0.5	1015	10.9 ± 0.5	469
Macaroni	3	0.7	18.4 ± 0.5	55	24.4 ± 0.7	73	10.5 ± 0.4	32
Rice	3	1.1	4.8 ± 0.2	14	5.5 ± 0.3	16	4.8 ± 0.2	14
Meat	73	10.9	1.9 ± 0.1	139	1.5 ± 0.1	110	1.4 ± 0.8	102
Shellfish	1	0.8	3.9 ± 0.2	4	1.1 ± 0.1	1	3.0 ± 0.2	3
Dried Beans	3	2.9	36.0 ± 1.8	108	29.4 ± 1.8	88	10.2 ± 1.6	30
Fresh Fruit	68	12.6	9.8 ± 0.4	666	5.9 ± 0.4	401	2.6 ± 0.3	177
Potatoes	45	5.8	8.5 ± 0.7	382	6.9 ± 0.7	310	3.1 ± 0.3	140
Canned Fruit	26	1.3	3.6 ± 0.2	93	1.9 ± 0.2	49	1.9 ± 0.2	49
Fruit Juices	19	1.7	4.1 ± 0.3	78	4.1 ± 0.2	78	3.4 ± 0.2	65
Canned Vegetables	20	4.2	8.6 ± 0.6	172	10.1 ± 0.6	202	2.7 ± 0.3	54
ANNUAL INTAKE		383		11392		9274		6368
Sr-90/Ca in Total Diet				29.7		24.2		16.6

FIGURE 10

DAILY INTAKE OF STRONTIUM-90 IN

NEW YORK CITY, CHICAGO AND SAN FRANCISCO



4. High Altitude Balloon Sampling Program

by L. P. Salter (HASL)

The U. S. Atomic Energy Commission's program for measuring stratospheric nuclear debris collected by balloon-borne filtering devices has been in continuous operation since 1956. During 1963 and 1964 monthly collections have been made from several altitudes at two sites:

Location	Latitude	Flight Organization
San Angelo, Texas	31°N	Detachment 1, 6th Weather Squadron, Goodfellow Air Force Base
Mildura, Australia	34°S	Department of Supply, Commonwealth of Australia

Additional samples have been collected on special flights from Minnesota at 45°N, and Eilson Air Force Base, Alaska, at 65°N by General Mills, Electronic Division, and Detachment 1, 6th Weather Squadron, respectively.

Filters are shipped to HASL where gross gamma activity measurements and gamma spectra have been obtained for all samples collected since February 1962. Selected filters are then analyzed for fission products and other pertinent radionuclides at HASL and contractor laboratories.

The radionuclide assay data for 1963 and early 1964 are reported herein updating results given in HASL-144, p.184 (April 1964). Additional gross gamma activity results through August 1964 also are presented. The tables have been prepared via a data retrieval system using an IBM 1620 computer, IBM 407 tabulator, and peripheral units. The gamma activity results are summarized in Figures 11a and 11b. Data for samples collected prior to 1963 have been given previously in HASL-115, p.70 (October 1961); HASL-127, p.151 (July 1962); and HASL-140, p.166 (October 1963).

Sample Collection Data

HASL Number

A number is assigned by the Health and Safety Laboratory to each individual sample. Samples split for radiochemical assay, after gross gamma measurements were obtained, are designated by a letter suffix to the HASL number.

Altitude

All altitude data are obtained from barometric readings and refer to pressure-altitude in the ICAO Standard Atmosphere. The predominant sampling altitude is given in kilofeet (KFT). The entire sample was collected within a range of ±2 kilofeet of the predominant altitude except as indicated otherwise in NOTES on the bottom of the page.

Flight Date and Number

The date of flight and number assigned to the flight by balloon operations organizations are given. Two samples usually are collected from each flight.

Unit

Most 1963 and 1964 collections have been made with the "Direct Flow Sampler" which utilizes one square foot of I.P.C. No. 1478 filter paper. This system when routinely used with a Westinghouse motor and Torrington 704 blower is referred to as "D7". A discussion of this unit was presented by Rex Wood in HASL-115, p.155 (October 1961). The Direct Flow system has been used also with a Westinghouse motor and Torrington A14980 two-stage blower for a few samples taken above 110 kilofeet at San Angelo. This latter unit is referred to as "D14".

A few additional samples have been collected with an experimental unit which utilizes an air ejector pump. Two square feet of I.P.C. No. 1478 filter paper are used with this device. The sampler was developed by General Mills Electronic Division under Contract No. AT(11-1)-401 to the U. S. Atomic Energy Commission and is described in their Report No. 2277 (May 15, 1962). This unit is referred to as "AE".

When two samples are obtained on the same flight from similar units they are designated as -1 and -2.

Volume

The volume of air sampled is reported in thousands of standard cubic feet (KSCF) of air, computed at 1013 mb and 59°F (1 KSCF = 34.6 Kg of air). The method of determining the volume is indicated according to the following code listed under the reported volume:

F: Flowmeter
T: Radiotelemetry of blower speed
E: Estimated

The method currently preferred is that based on flowmeter measurements. In the absence of these data or when such data are suspect, a volume has been calculated on the basis of radiotelemetry of the instantaneous blower speed. Whenever the volume listed is estimated or doubtful, appropriate NOTES are given on the bottom of the page and the data are given in parentheses.

An evaluation of the volume data by K. Telegadas is presented in HASL-144, p.258 (April 1964).

Gamma Activity Measurements

The measured gamma activity concentration in counts per minute per 10^3 SCF (CPM/KSCF) are reported as of the counting date. These results are valid to three significant digits only[a]. The standard deviation due to counting is less than 5% except for those concentration values annotated according to the system given at the end of the descriptive text.

Counting Procedure

The filter samples are received in plastic bags from the collection sites and are counted without prior treatment one to two weeks after collection.

The bags containing the one square foot filters are folded into a plastic box 80 mm x 65 mm x 31 mm deep which is placed in the center of a heavily shielded 8" diameter x 4" NaI (Tl) crystal. The pulses from three phototubes, matched for pulse height response, are summed, amplified, and fed to a multichannel analyzer to obtain a gamma spectrum. The gross gamma activities are obtained by summing the data between 0.1 and 3.0 Mev and correcting for background.

Standardization

Because of the complexity involved in estimating the disintegration rate from the observed gamma counts per minute in a mixture of nuclides such as those present in composited weapons debris, such a conversion has not been attempted. The CPM results reported herein, therefore, are of significance on a relative basis only. The efficiency of the counting system has been compared, however, to a standard Cs-137 source counted under the same geometry. This source yields about 0.3 counts per emitted photon which is equivalent to about 0.25 counts per disintegration of Cs-137.

Precision

The degree of reproducibility for these gross gamma measurements has been studied and a value of about 0.013 found for the coefficient of variation (ratio of standard deviation to mean, or per cent standard deviation ÷ 100). This precision value includes the error from all sources

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a The additional digits given for the gross gamma and radionuclide results have no import and are recorded only because of the characteristics of the computational facilities upon which these data are processed.

of variation, exclusive of counting statistics, such as day to day fluctuations in response due to counting and factors relating to sample handling processes. The precision data are discussed in more detail in HASL-131, p.153 (October 1962).

Gamma Activity Concentration Figures

The gamma activity concentration data are shown by altitude on a log scale as a function of time in Figures 11a (31°N) and 11b (34°S). Altitudes are marked by special symbols if the associated concentration value or altitude has an abnormally large range or is otherwise in doubt. Lines are used to join monthly values for like altitudes. Broken lines are used when a concentration or altitude is in doubt, when predominant altitudes for consecutive months differ by 4 kilofeet or more, or to join successive values with a time span of two months or more.

Radiochemical Measurements

At least one sample collected from each successful flight through November 1963 has been radiochemically analyzed.

Six medium and longer-lived fission products have been assayed in most of these samples: Sr-89, Sr-90, Y-91, Zr-95, Cs-137, and Ce-144. When the presence of relatively fresh weapons debris (less than six months old) is suspected or background information on such debris is desired, the shorter-lived nuclides, Ba-140 and Ce-141, are sought. A quarterly profile of Pm-147 also has been obtained.

In addition to fission products, the presence of tracer nuclides associated predominatly with a single detonation or series of detonations has been investigated. These include Rh-102 from the U. S. high altitude Orange shot of August 1958 and Mn-54, Fe-55, Y-88, and Sb-124 produced in relatively large quantities in the 1961 and 1962 test series. Results for Sb-125, a fission product, have been obtained in conjunction with Sb-124 measurements. Some preliminary data for Pu-238 and Pu-239 are presented in Part III of this Quarterly Report. Later reports will include data for Cd-109 produced in the U. S. high altitude test over Johnston Island July 9, 1962.

The half lives and dominant radiations of these radionuclides are presented on the last page of this report.

Fraction

Some samples have been split prior to analysis to provide information on the precision of radionuclide results, analytical differences between laboratories, and other supplementary data. Since a precise physical division of the sample could not be made, the fraction in each portion was determined by comparison of gross gamma measurements taken after splitting. Stringent control in obtaining these measurements enabled the fraction to be determined with a precision error of about 1½%.

Analytical Laboratory

Samples analyzed under contract to the AEC are so indicated as follows:

II: Isotopes, Inc.

Radionuclide Concentrations

Results are reported in units of disintegrations per minute per 10^3 SCF (DPM/KSCF), corrected for fraction analyzed, and are listed in order of increasing mass number. As in the case of the gamma activity concentrations only the first three digits are significant. All fission products have been corrected to the collection date. Nuclides marked with an asterisk (*) have been corrected to the following dates:

Rh-102	August 12, 1958
Mn-54, Fe-55	October 15, 1961
Sb-124	December 31, 1962
Y-88	November 15, 1962

The standard deviation due to counting is less than 5% except for those concentrations annotated by the letters A, B, C, D, E or F appearing under the value. The counting errors in these cases and the definitions for other symbols used to further characterize the radioassays are listed in the notation system given on the following page.

Notation System

The following definitions apply to the symbols appearing under the concentration values:

A) Standard deviation due to counting 5-10%;

B) Standard deviation due to counting 10-20%;

C) Standard deviation due to counting 20-50%;

D) Standard deviation due to counting 50-100%;

E) Error value only is given, preceded by "±"; standard deviation due to counting 100-200%;

F) Error value only is given, preceded by "±"; standard deviation due to counting greater than 200%;

G) Gamma scan suggests presence of nuclide although radiochemical analysis did not affirm a positive value;

L) Nuclide lost;

W) Sample had a low counting rate approaching that for control samples but standard deviation due to counting was less than 20%;

X) Value or error limits inconsistent with values reported for other nuclides in sample;

Y) Chemical recovery less than 30%;

*) Value corrected by more than 5% from that previously reported.

Results obtained using data with suspect volumes, counting errors between 20-100% (C or D notation above) or questionable because of the conditions cited under W, X, and Y above are qualified by parentheses.

Table 4a

SAN ANGELO, TEXAS (31°N) JAN 1963

HASL A-	672A	672B	672C	673	664A	664B	665	658	659
ALT(KFT)	64	64	64	64	79	79	79	86	86
FLT DAY	15	15	15	15	8	8	8	2	2
FLT NO	T736	T736	T736	T736	T733	T733	T733	T729	T229
UNIT	D7-1	D7-1	D7-1	D7-2	D7-1	D7-1	D7-2	D7-1	D7-2
VOLUME	2.41	2.41	2.41	2.23	1.70	1.70	1.68	2.07	2.00
(KSCF)	F	F	F	F	T	T	T	F	F
GR GAMMA	JAN27	JAN27	JAN27	JAN27	JAN14	JAN14	JAN15	JAN 7	JAN 8
CPM/KSCF	114107	114107	114107	117937	8294	8294	9047	1855	1940
FRACTION	.523	.217	.260	1.000	.496	.504	1.000	1.000	1.000
ANAL LAB	II	II	II		II	II			II
MN- 54*	21818	20078	21400		1992				450
DPM/KSCF					A				A
FE- 55*	28958	26000	24300		3439				765
DPM/KSCF									
Y- 88*	785	±784	±3500		508				±65
DPM/KSCF		F	F						F
SR- 89	56013	60807	34600		3475				1015
DPM/KSCF			A						
SR- 90	2467	1989	1660		251				86
DPM/KSCF									
Y- 91	88065	87959	115000		5183				1845
DPM/KSCF									
ZR- 95	105520	(91783)	89400		6582				(1330)
DPM/KSCF		Y							Y
SB-124*	(363)	(302)	±4500		(39)				(14)
DPM/KSCF	C	CY	F		C				C
SB-125	4855	(2830)	3420		167				89
DPM/KSCF		AY			B				B
CS-137	3102	2830	2840		318				113
DPM/KSCF									
BA-140	8092	9867			968				515
DPM/KSCF									
CE-141	91239	±8222			(1648)				760
DPM/KSCF		F			C				B
CE-144	60059	63101	69700		4981				1055
DPM/KSCF									

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) FEB 1963

HASL A-	687	688A	688B	703	704A	704B	698	693	694A	694B
ALT(KFT)	65	65	65	76	76	76	79	88	88	88
FLT DAY	2	2	2	15	15	15	8	7	7	7
FLT NO	T741	T741	T741	T748	T748	T748	T746	T745	T745	T745
UNIT	D7-1	D7-2	D7-2	D7-1	D7-2	D7-2	D7-2	D7-1	D7-2	D7-2
VOLUME (KSCF)	2.09 F	2.22 F	2.22 F	1.91 F	1.91 F	1.91 F	1.64 F	1.94 F	2.03 F	2.03 F
GR GAMMA	FEB 5	FEB 5	FEB 5	FEB26	FEB27	FEB27	FEB14	FEB14	FEB14	FEB14
CPM/KSCF	60287	58558	58558	15392	15445	15445	15975	19329	18817	18817
FRACTION	1.000	.503	.497	1.000	.515	.485	1.000	1.000	.448	.552
ANAL LAB	II	II		II	II		II	II	II	
MN- 54* DPM/KSCF	18517			5969			7012	6804		
FE- 55* DPM/KSCF	(26411) Y			(6649) Y			7561	(6856) Y		
Y- 88* DPM/KSCF	L	314 B		L	578 B		L	L	967 A	
SR- 89 DPM/KSCF	22775	19612		5864	5378		4299	6289 B	6905	
SR- 90 DPM/KSCF	1742	1424		681	569		659	943	997	
Y- 91 DPM/KSCF	L	35821		L	(9932) Y		L	L	12975	
ZR- 95 DPM/KSCF	47560	33493		12094	8235		12439	15567	13635	
CS-137 DPM/KSCF	2254	2158		942	805		1067	1423	1407	
BA-140 DPM/KSCF	3416			1874			410	342		
CE-141 DPM/KSCF	12010 B	(13791) C		2901 B	±1423 F		±1159 F	±1649 F	(2782) D	
CE-144 DPM/KSCF	35646	34388		11780	11894		14451	18660	18803	
PM-147 DPM/KSCF	L	6797		6597	2135		6024	8041	3684	

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) MAR 1963

HASL A-	708	709	716	717	737	738	732	733	728	729
ALT(KFT)	66	66	80	80	88	88	(103)[a]	(103)[a]	120	120
FLT DAY	1	1	7	7	31	31	27	27	20	20
FLT NO	T753	T753	T756	T756	T765	T765	T764	T764	T758	T758
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D14-1[c]	D14-2[c]
VOLUME	2.06	2.07	1.81	1.65	1.83	1.56	(.70)[b]	(.60)[b]	.29	(.29)[d]
(KSCF)	F	F	F	F	F	F	E	E	F	E
GR GAMMA	MAR14	MAR14	MAR13	MAR14	APR 4	APR 5	APR 3	APR 4	MAR28	MAR29
CPM/KSCF	66990	65700	30662	34303	12568	12756	(5671)	(5983)	9034	(4379)
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB		II	II			II		II	II	
MN- 54*		16667	23094			4135	(1571)	(1487)	3724	
DPM/KSCF								A	B	
FE- 55*		19179	15580			4673		(1427)	1917	
DPM/KSCF								A	B	
Y- 88*		734	2917			487		(±433)	±1103	
DPM/KSCF		A				A		F	F	
SR- 89		31159	13757			(604)	(2500)	(2667)	3266	
DPM/KSCF						CX	A			
SR- 90		1565	1459			808	(321)	(342)	(315)	
DPM/KSCF									X	
Y- 91		45266	20994			5333		(4317)	5621	
DPM/KSCF										
ZR- 95		(53140)	(21878)			8077			(6966)	
DPM/KSCF		Y	Y					L	Y	
SB-124*		7826	107			(196)		(378)	1528	
DPM/KSCF			A			C		B	A	
SB-125		3329	1448			833		(435)	448	
DPM/KSCF								A	B	
CS-137		2362	1961			987	(414)	(440)	(955)	
DPM/KSCF									X	
BA-140		5942	359			335		(298)	714	
DPM/KSCF						B		A	B	
CE-141		±918	(3912)			±622		(±367)	(2166)	
DPM/KSCF		F	C			F		F	C	
CE-144		43285	29448			12436	(5571)	(6083)	7931	
DPM/KSCF										

a 60% of total volume collected at 103 kilofeet, 40% between 93-108 kilofeet; sample doors remained open during during descent to surface.
b Volume estimated from flowmeter data.
c Special sampling unit; see text.
d Flowmeter data lost, volume estimated from blower speed and flowmeter data for D14-1 unit.

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) APR 1963

HASL A- ALT(KFT)	750 65	751 65	756 80	757 80	767 [b] 90	768 [b] 90	748 [a] 102	749 102
FLT DAY FLT NO UNIT	8 T768 D7-1	8 T768 D7-2	13 T771 D7-1	13 T771 D7-2	29 T774 D7-1	29 T774 D7-2	8 T767 D7-1	8 T767 D7-2
VOLUME (KSCF)	2.06 F	2.01 F	1.39 F	1.42 F	1.57 F	1.38 F	--	.86 F
GR GAMMA CPM/KSCF	APR12 52912	APR12 53731	APR18 13812	APR19 13028	MAY 9 5528	MAY10 6978	--	APR18 3767
FRACTION ANAL LAB	1.000 II	1.000 II	1.000 II	1.000	1.000	1.000 II		1.000 II
MN- 54* DPM/KSCF	10777	14100	9209			3600		±337 F
FE- 55* DPM/KSCF	18932	21000	10288			2536		399
Y- 88* DPM/KSCF	607 A	±4100 F	1561			645 A		±233 F
SR- 89 DPM/KSCF	17524	(±3500) FX	2518			1720 A		1260
SR- 90 DPM/KSCF	1777	1910	806			739		129
Y- 91 DPM/KSCF	33058	76600	7842			4362		1965
ZR- 95 DPM/KSCF	29320	(42600) Y	9784			3978		2198
SB-124* DPM/KSCF	7621	±2000 F	1050 A			620 B		235 B
SB-125 DPM/KSCF	2383	(2640) C	727			447 A		177 B
CS-137 DPM/KSCF	2451	(2710) Y	1223			1051		171
BA-140 DPM/KSCF	961 A		512 B			(139) C		58 B
CE-141 DPM/KSCF	(18155) C		(1158) C			±1159 F		(533) C
CE-144 DPM/KSCF	36019	45500	14892			10942		2686

a Blower inoperative, sample invalid.
b Altitude ranged from 86-90 kilofeet.

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) MAY 1963

HASL A- ALT(KFT)	771 65	772A 65	772B 65	777 80	778 80	784 89	785 89	779 106 [a]	780 106 [a]
FLT DAY	7	7	7	11	11	27	27	14	14
FLT NO	T778	T778	T778	T780	T780	T786	T786	T781	T781
UNIT	D7-1	D7-2	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME (KSCF)	2.00 F	1.87 F	1.87 F	1.59 F	1.54 F	1.42 F	1.55 F	.79 F	.72 F
GR GAMMA CPM/KSCF	MAY15 42900	MAY15 43957	MAY15 43957	MAY24 15408	MAY25 15649	JUN 3 4190	JUN 4 3993	MAY23 2139	MAY24 1958
FRACTION ANAL LAB	1.000	.479 II	.521 II	1.000	1.000 II	1.000	1.000 II	1.000 II	1.000 II
MN- 54* DPM/KSCF		14178	14986		9416		2471		547 B
FE- 55* DPM/KSCF		(22886) Y	10983		7338		3039		539 B
Y- 88* DPM/KSCF		±770 FG	±616 FG		1643 A		±103 FG		±917 F
SR- 89 DPM/KSCF		12057	12214 A		4292		(±57) FX	619	528
SR- 90 DPM/KSCF		2065	1735		961		735	148	139
Y- 91 DPM/KSCF		25566	26276		8182		2123	1367	1261
ZR- 95 DPM/KSCF		(26905) Y	(38901		(8052) Y		(2155) Y	1456	997
SB-124* DPM/KSCF		10762 A	13241 B		6240		±123 F		±264 F
SB-125 DPM/KSCF		2557	2361		955		± 71 F		785
CS-137 DPM/KSCF		2992	3172		1584		L	243	L
BA-140 DPM/KSCF		601 A			126 B		115 B		229 B
CE-141 DPM/KSCF		(7513) C			22532		(4871) BY		±528 F
CE-144 DPM/KSCF		40861	44033		12987		(7419) Y	2595	2528
PM-147 DPM/KSCF		8060	7554		1422		1665		(4903) Y

a Altitude ranged from 102 to 106 kilofeet.

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) ; JUN 1963

HASL A-	788	789	786	787	790	791	801	802
ALT(KFT)	62	62	80	80	91	91	106	106
FLT DAY	6	6	4	4	11	11	27	27
FLT NO	T791	T791	T790	T790	T792	T792	T796	T796
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.15	1.42	1.53	1.52	1.59	1.72	.67	.68
(KSCF)	F	F	F	F	F	F	F	F
GR GAMMA	JUN14	JUN14	JUN 7	JUN 7	JUN19	JUN20	JUL 2	JUL 2
CPM/KSCF	26782	27816	10784	10460	2666	2540	1970	2260
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II			II		II	II	II
MN- 54*	11130			6447		1872	352	±588
DPM/KSCF							B	F
FE- 55*	10000			7105		1872	642	851
DPM/KSCF							A	B
Y- 88*	±191			1408		(±640)	1173	± 1912
DPM/KSCF	F			A		FGY	A	F
SR- 89	7278			2487		(327)	515	771
DPM/KSCF				A		CX	A	B
SR- 90	1557			836		469	175	193
DPM/KSCF								
Y- 91	16000			6151		(1965)	1110	1485
DPM/KSCF						Y		
ZR- 95	23391			(1132)		1541	(1582)	1721
DPM/KSCF				XY			AY	A
SB-124*	10000			(4441)		(115)	±448	
DPM/KSCF	A			C		C	F	
SB-125	1661			704		206	236	
DPM/KSCF				A		A	B	
CS-137	2487			(1026)		843	304	287
DPM/KSCF				Y				
CE-144	(33913)			14474		6512	3299	3750
DPM/KSCF	Y							

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) JUL 1963

HASL A-	813	814	809	810	811	812	828	829
ALT(KFT)	65	65	80	80	91	91	104	104
FLT DAY	8	8	1	1	2	2	20	20
FLT NO	T800	T800	T797	T797	T798	T798	T805	T805
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.65	2.05	1.79	1.64	1.29	1.34	.87	1.16
(KSCF)	F	F	F	F	F	F	F	F
GR GAMMA	JUL12	JUL12	JUL 8	JUL 9	JUL 8	JUL 8	AUG 6	AUG 7
CPM/KSCF	28484	26975	13966	14024	3364	3216	1643	1586
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II		II		II		II	
MN- 54*	12848		9274		3798	3300	4437	1140
DPM/KSCF								
FE- 55*	11939		(6257)		3442		(4218)	
DPM/KSCF			Y				Y	
Y- 88*	1103		1670		±698		±644	
DPM/KSCF					FG		F	
SR- 89	(2315)		(1302)		984	761	347	538
DPM/KSCF	BX		CX			A	B	A
SR- 90	1970		1251		642	567	295	231
DPM/KSCF								
Y- 91	15636		7486		1814		1195	
DPM/KSCF								
ZR- 95	27273		11397		2264		1437	
DPM/KSCF								
RH-102*	90		194		± 171		± 241	
DPM/KSCF	A		A		F		F	
SB-124*	21394		12961		±302		(516)	
DPM/KSCF	B		B		F		C	
SB-125	2236		1263		416		360	
DPM/KSCF					A			
CS-137	3545		1816		961		466	
DPM/KSCF								
CE-144	41697		22514		9845	8130	4609	3660
DPM/KSCF								

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) AUG 1963

HASL A-	839	840	837	838	835	836	857	858
ALT(KFT)	66	66	80	80	90	90	103	103
FLT DAY	7	7	6	6	1	1	21	21
FLT NO	T811	T811	T810	T810	T809	T809	T817	T817
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME (KSCF)	2.16 T	2.13 F	1.67 F	1.77 F	1.72 F	1.53 F	.91 F	.93 F
GR GAMMA	AUG19	AUG20	AUG19	AUG20	AUG19	AUG20	SEP10	SEP10
CPM/KSCF	20879	20704	11077	10508	2127	2444	1340	1365
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II	II		II		II		II
MN- 54* DPM/KSCF	15000	12864		7966		3856	1770 A	3172
FE- 55* DPM/KSCF	25000	7981		8757		3732		(2419) Y
Y- 88* DPM/KSCF	±2600 F	878 β		(±1469) FGY		±784 FG		±763 F
SR- 89 DPM/KSCF	(±830) FXY	4883		2672		463 A		587 A
SR- 90 DPM/KSCF	(2760) Y	1883		966		560	320	301
Y- 91 DPM/KSCF	20600	9577		(2797) Y		908		739 A
ZR- 95 DPM/KSCF	(16000) Y	16103		5164		1529		L
SB-124* DPM/KSCF	17900 A	19624 B		18927		(285) C		(13656) C
SB-125 DPM/KSCF	2940 B	2108		960		336 A		4355
CS-137 DPM/KSCF	2550	3085		1785		(869) Y		L
CE-144 DPM/KSCF	37600	37324		16328		(8170) Y	3750	4817
PM-147 DPM/KSCF	8750	6761		2192		1569		(786) Y

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) SEP 1963

HASL A- ALT(KFT)	866 66	867 66	863 82	864 82	860 91	861 91	868 105 [a]	869 105 [a]
FLT DAY FLT NO UNIT	9 T823 D7-1	9 T823 D7-2	5 T822 D7-1	5 T822 D7-2	4 T821 D7-1	4 T821 D7-2	11 T825 D7-1	11 T825 D7-2
VOLUME (KSCF)	(1.88)[b] T	(1.87)[b] T	1.50 F	1.41 T	1.49 F	1.47 F	.81 F	.78 F
GR GAMMA CPM/KSCF	SEP14 (22700)	SEP14 (24600)	SEP10 14500	SEP11 15800	SEP10 3830	SEP11 3740	SEP24 1710	SEP25 1590
FRACTION ANAL LAB	1.000	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000	1.000 II
MN- 54* DPM/KSCF		(14118)		(12837) Y	7520	(4925) AY		1346 B
FE- 55* DPM/KSCF		(19679)		(14610) Y		4912		1769
Y- 88* DPM/KSCF		(1979)		2099		1510		±859 F
SR- 89 DPM/KSCF		(4364) A		(1830) AY		(381) BY		322 B
SR- 90 DPM/KSCF		(1936)		(965) Y	778	(627) Y		396
Y- 91 DPM/KSCF		(13529)		10638		2218 A		1172
ZR- 95 DPM/KSCF		(14225)		7660		1694		(1282) Y
SB-124* DPM/KSCF		(35615) A		30709 B		(12313) C		±1141 F
SB-125 DPM/KSCF		(2380)		2092		4374		236 B
CS-137 DPM/KSCF		(3203)		2929		1279		651
CE-144 DPM/KSCF		(45561)		(29574) Y	9130	11224		5346

a Altitude ranged from 102 to 105 kilofeet.
b Flowmeter data appeared inconsistent; volumes computed from telemetry of blower speeds disagreed with flowmeter data by more than 15%.

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N)   OCT 1963

HASL A- ALT(KFT)	905 67	906 67	882 81	883 81	902 91	903 91	890 103	891 103
FLT DAY FLT NO UNIT	15 T834 D7-1	15 T834 D7-2	1 T828 D7-1	1 T828 D7-2	14 T833 D7-1	14 T833 D7-2	8 T829 D7-1	8 T829 D7-2
VOLUME (KSCF)	1.91 F	1.99 F	1.77 F	1.83 F	1.48 F	1.49 F	.90 F	.82 F
GR GAMMA CPM/KSCF	OCT24 14136	OCT25 14422	OCT 9 9887	OCT10 9890	OCT24 2101	OCT25 2120	OCT16 880	OCT17 862
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF	14346		7797		3764		1200 A	
FE- 55* DPM/KSCF	17749		10904		4872		1144	
Y - 88* DPM/KSCF	1314 A		(±4689) GFY		±811 GF		±1667 F	
SR- 89 DPM/KSCF	2225 A		2051 A		(± 57) FXY		166 B	
SR- 90 DPM/KSCF	1649		1237		(484) Y		232	
Y - 91 DPM/KSCF	5759		(2910) Y		650		431	
ZR- 95 DPM/KSCF	8429		6328		912		472	
RH-102* DPM/KSCF	148 A		129 A		±108 F		±156 F	
SB-124* DPM/KSCF	42932		31977		(1257) C		±1333 F	
SB-125 DPM/KSCF	2644 A		1610 A		484 A		238 A	
CS-137 DPM/KSCF	2696		1797		750		332	
CE-144 DPM/KSCF	31675		(20678) Y		7500		2844	

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) NOV 1963

HASL A-ALT(KFT)	965 65	966 65	956 83	957 83	958 90	959 90	969 101[a]	970 101[a]	980 104	981 104
FLT DAY	12	12	5	5	6	6	20	20	29	29
FLT NO	T843	T843	T838	T838	T839	T839	T845	T845	T850	T850
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME (KSCF)	2.51 F	2.69 F	1.38 F	1.44 F	1.82 F	1.69 F	1.31 F	1.09 F	(1.10)[b] F	(.89)[b] F
GR GAMMA	NOV19	NOV20	NOV13	NOV14	NOV13	NOV14	NOV27	NOV27	DEC11	DEC12
CPM/KSCF	9442	8921	3746	3715	1269	1289	743	838	(574)	(610)
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II		II		II		II			II
MN- 54* DPM/KSCF	11474		5616		1247 A		954 A			(552) A
FE- 55* DPM/KSCF	14143		5254		1088		1328			(545) C
Y - 88* DPM/KSCF	(± 797) GFY		±2174 GF		± 934 F		±1221 F			(±1685) F
SR- 89 DPM/KSCF	L		(199) AX		229 A		66 B			(52) B
SR- 90 DPM/KSCF	L		721		304		218 A			(99)
Y - 91 DPM/KSCF	(2482) Y		935		408		217			(188)
ZR- 95 DPM/KSCF	L		(1659) Y		(681) Y		258			(307)
SB-124* DPM/KSCF	25139 B		9565 B		± 604 F		±992 F			(±1910) F
SB-125 DPM/KSCF	2056 A		942		324 A		215 A			(190) B
CS-137 DPM/KSCF	2339		1065		444		315			(218)
CE-144 DPM/KSCF	25139		10580		4462		2771			(1854)
PM-147 DPM/KSCF	5339		2326		775		707			(433)

a Altitude ranged from 95 to 105 kilofeet.
b Blowers in operation for 57 minutes after sampler doors were closed.

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N)   DEC 1963

HASL A-	1002	1003	992	993	994	995	1000	1001
ALT(KFT)	65	65	82	82	89 a/	89 a/	103	103
FLT DAY	26	26	3	3	5	5	23	23
FLT NO	T859	T859	T852	T852	T854	T854	T858	T858
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.49	2.56	1.45	1.46	(1.34) b/	(1.35) b/	.71	.59
(KSCF)	F	F	F	F	T	T	F	F
GR GAMMA	JAN 2	JAN 3	DEC11	DEC12	DEC20	DEC19	JAN 2	JAN 3
CPM/KSCF	5381	5507	2331	2636	(828)	(896)	352	472
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II		II		II		II	
MN- 54*	9478	10703	6441		(940)		±1211	
DPM/KSCF							F	
FE- 55*	11486		5379		(1179)		414	
DPM/KSCF								
Y - 88*	±964		±2621		(±2537)		±2958	
DPM/KSCF	F		F		F		F	
SR- 89	478	688	194		(129)		(±52)	
DPM/KSCF	A	A	B		B		FY	
SR- 90	1201	1172	612		(258)		(77)	
DPM/KSCF							AY	
Y - 91	1598		800		(373)		84	
DPM/KSCF								
ZR- 95	2494		1103		(594)		112	
DPM/KSCF							A	
SB-124*	(20643)		(6110)		(±1194)		±3803	
DPM/KSCF	C		C		F		F	
SB-125	1586		609		(181)		±120	
DPM/KSCF					A		F	
CS-137	1703		959		(416)		126	
DPM/KSCF								
CE-144	18635	14609	7724		(3881)		1262	
DPM/KSCF								

a Altitude ranged from 86 to 90 kilofeet.

b Flowmeter units inoperative; blower speeds above normal at beginning of sampling period and unsteady thereafter; volumes estimated from telemetered blower speeds.

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) JAN 1964

HASL A-	1017	1018	1013	1014	1019	1020	1025	1026
ALT(KFT)	64	64	80	80	92	92	104	104
FLT DAY	7	7	5	5	10	10	16	16
FLT NO	T866	T866	T865	T865	T868	T868	T870	T870
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.10	2.04	1.86	1.48	1.22	1.42	.95	.96
(KSCF)	F	F	F	T	F	F	F	F
GR GAMMA	JAN21	JAN22	JAN15	JAN16	JAN21	JAN22	JAN28	JAN29
CPM/KSCF	3280	3745	1311	1486	618	628	332	327
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II		II		II		II	
MN- 54*	6524		3360		1221		649	
DPM/KSCF					A		A	
FE- 55*	8143		4065		1164		932	
DPM/KSCF					A		A	
Y - 88*	±1286		±1183		±1230		±1579	
DPM/KSCF	F		F		F		F	
SR- 89	271		170		(27)		± 7	
DPM/KSCF	A		A		C		F	
SR- 90	805		486		154		90	
DPM/KSCF								
Y - 91	848		273		152		76	
DPM/KSCF					A			
ZR- 95	1519		345		242		87	
DPM/KSCF							A	
SB-124*	(15381)		(1446)		±1721		±1895	
DPM/KSCF	C		C		F		F	
SB-125	1086		413		79		131	
DPM/KSCF					B		B	
CS-137	1190		688		319		172	
DPM/KSCF								
CE-144	11810		5753		2705		1368	
DPM/KSCF								

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) FEB 1964

HASL A-	1052	1053	1044	1045	1054	1055	1049	1050
ALT(KFT)	65	65	78	78	89	89	104	104
FLT DAY	14	14	6	6	16	16	11	11
FLT NO	T880	T880	T874	T874	T881	T881	T879	T879
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.27	2.33	1.92	1.83	1.77	1.72	.84	.88
(KSCF)	F	F	T	F	F	F	F	F
GR GAMMA	FEB25	FEB26	FEB13	FEB14	FEB25	FEB26	FEB18	FEB19
CPM/KSCF	3207	3442	760	748	351	366	173	181
							A	
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II		II		II		II	
MN- 54*	7974		2047		319		262	
DPM/KSCF					A		B	
FE- 55*	10529		2188		421		±115	
DPM/KSCF					A		F	
Y - 88*	(±2555)		±2240		±904		±3214	
DPM/KSCF	FY		F		F		F	
SR- 89	279		37		23		±19	
DPM/KSCF	A		B		B		F	
SR- 90	912		289		105		54	
DPM/KSCF								
Y - 91	(811)		146		65		40	
DPM/KSCF	Y		A					
ZR- 95	551		153		81		43	
DPM/KSCF							B	
SB-124*	24449		±2604		2774		±4524	
DPM/KSCF	B		F		B		F	
SB-125	1449		154				±73	
DPM/KSCF							F	
CS-137	(1529)				167		74	
DPM/KSCF	Y		L					
CE-144	12996		3276		1486		651	
DPM/KSCF								
PM-147	3286		865		531		226	
DPM/KSCF								

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31^{o}N) MAR 1964

HASL A-	1094	1095	1103	1104	1092	1093	1097	1098
ALT(KFT)	64	64	81	81	93	93	106	106
FLT DAY	11	11	26	26	10	10	17	17
FLT NO	T886	T886	T894	T894	T885	T885	T890	T890
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.23	2.20	1.80	1.84	1.40	1.28	.90	.89
(KSCF)	F	F	F	F	F	F	F	F
GR GAMMA	MAR18	MAR20	APR 8	APR 9	MAR18	MAR19	MAR24	MAR25
CPM/KSCF	2757	2581	520	506	284	322	166	194
							A	
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II	II	II		II		II	
MN- 54*	6906	7818	1261		556		± 456	
DPM/KSCF					A		F	
FE- 55*	9910	10545	1883		857		206	
DPM/KSCF							B	
Y - 88*	±1749		(± 3111)		±1929			
DPM/KSCF	F		FY		F			
SR- 89	(± 21)		(±4)		± 7			
DPM/KSCF	FX		FX		F			
SR- 90	1108	868	245		101		58	
DPM/KSCF								
Y - 91	507		(79)		36			
DPM/KSCF			AY		A			
ZR- 95	493		89		41			
DPM/KSCF			A		A			
SB-124*	11166		±1111					
DPM/KSCF	A		F					
SB-125	1152		162					
DPM/KSCF	B							
CS-137	1664	1414	341		163		89	
DPM/KSCF								
CE-144	11794	11318	2544		1393			
DPM/KSCF							L	

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) APR 1964

HASL A-	1112	1113	1118	1119	1116	1117	1127	1128
ALT(KFT)	67	67	80	80	90	90	108	108
FLT DAY	6	6	13	13	10	10	27	27
FLT NO	T895	T895	T898	T898	T897	T897	T902	T902
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.94	1.99	1.57	1.56	(1.48) a/	1.48	.71	.71
(KSCF)	F	F	F	F	E	F	F	F
GR GAMMA	APR14	APR15	APR21	APR22	APR21	APR21	MAY 5	MAY 6
CPM/KSCF	2773	2638	319	327	(203)	216	180 A	176
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II		II			II	II	
MN- 54*	(5773)		618			368	±592	
DPM/KSCF	Y		A			A	F	
FE- 55*	6804		790			420	325	
DPM/KSCF						A	B	
Y - 88*	±5670		±2675			±4730		
DPM/KSCF	F		F			F		
SR- 89	±46		(±3)			±16		
DPM/KSCF	F		FX			F		
SR- 90	928		143			76	73	
DPM/KSCF								
Y - 91	794		38			27		
DPM/KSCF						A		
ZR- 95	(515)		45			30		
DPM/KSCF	Y		A			A		
SB-124*	13144		±2420					
DPM/KSCF	A		F					
SB-125	(1232)		94					
DPM/KSCF	C		A					
CS-137	1634		204			118	112	
DPM/KSCF								
CE-144	11753		1299			905	824	
DPM/KSCF								

a Flowmeter and telemetry data lost; volume estimated from D7-2 unit.

Table 4a (cont'd.)

SAN ANGELO, TEXAS (31°N) MAY 1964

ALT(KFT)	80	80	90	90	106	106
FLT DAY	12	12	14	14	21	21
FLT NO	T904	T904	T906	T906	T911	T911
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.84	1.79	1.86	1.83	0.78	0.75
(KSCR)	F	F	F	F	F	F
GR GAMMA	MAY19	MAY20	MAY20	MAY21	MAY 26	MAY27
CPM/KSCF	449	452	219	222	159	163
					A	

SAN ANGELO, TEXAS (31°N) JUN 1964

ALT(KFT)	65	65	79	79	89	89	103	103
FLT DAY	15	15	3	3	4	4	27	27
FLT NO	T919	T919	T914	T914	T916	T916	T925	T925
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.59	2.46	1.78	1.63	1.65	1.66	0.75	0.76
(KSCF)	F	F	F	E	F	F	F	F
GR GAMMA	JUN23	JUN24	JUN 9	JUN10	JUN 9	JUN10	JUL 7	JUL 8
CPM/KSCF	1370	1450	1000	1070	272	290	175	184
							A	A

SAN ANGELO, TEXAS (31°N) JUL 1964

ALT(KFT)	65	65	80	80	91	91	104	104	102	102
FLT DAY	9	9	6	6	13	13	20	20	27	27
FLT NO	T931	T931	T928	T928	T932	T932	T936	T936	T940	T940
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	AE-1	AE-2
VOLUME	2.23	2.28	1.84	1.68	1.47	1.48	0.85	0.82	0.54	0.52
(KSCF)	F	F	F	F	F	F	F	F	F	F
GR GAMMA	JUL14	JUL15	JUL14	JUL15	JUL22	JUL23	JUL29	JUL30	SEP 3	SEP 1
CPM/KSCF	1286	1231	886	902	305	323	156	143	109	115
							A	A		

SAN ANGELO, TEXAS (31°N) AUG 1964

ALT(KFT)	81	81	90	90	106	106
FLT DAY	6	6	28	28	19	19
FLT NO	T943	T943	T952	T952	T947	T947
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.70	1.63	1.41	1.75	0.69	0.70
(KSCF)	F	F	F	F	F	F
GR GAMMA	AUG18	AUG19	SEP 9	SEP10	AUG25	AUG26
CPM/KSCF	745	758	424	372	187	160
					A	A

Table 4b

MILDURA, AUSTRALIA (34°S) JAN 1963

HASL A- ALT(KFT)	685 63	686 63	680 78	681 78	670 89	671 89
FLT DAY FLT NO UNIT	30 A125 D7-1	30 A125 D7-2	24 A124 D7-1	24 A124 D7-2	17 A122 D7-1	17 A122 D7-2
VOLUME (KSCF)	3.40 F	3.27 F	2.06 F	2.24 F	1.41 F	1.57 F
GR GAMMA CPM/KSCF	FEB 5 908	FEB 6 938	FEB 4 800	FEB 5 736	JAN21 460	JAN22 461
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000	1.000 II
MN- 54* DPM/KSCF	±126 F		229			215 A
FE- 55* DPM/KSCF	179 A		184 A			(141) AW
SR- 89 DPM/KSCF	248 A		271 A			132
SR- 90 DPM/KSCF	134		91			45
ZR- 95 DPM/KSCF	626		597			371
CS-137 DPM/KSCF	205		144			90
BA-140 DPM/KSCF						
CE-141 DPM/KSCF	±174 F		±74 F			±89 F
CE-144 DPM/KSCF	(121) X		942			453

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) FEB 1963

HASL A-	699	700	853[a]	691	692	695	696	701	702
ALT(KFT)	62	62	78	79	79	88	88	105	105
FLT DAY	12	12	15[a]	5	5	7	7	14	14
FLT NO	A128	A128		A126	A126	A127	A127	A129	A129
UNIT	D7-1	D7-2	--	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	3.48	2.87	6.91[a]	2.19	2.08	1.46	1.30	.59	.75
(KSCF)	F	F		F	F	F	F	F	F
GR GAMMA	FEB15	FEB15	--	FEB 8	FEB 8	FEB14	FEB15	FEB20	FEB21
CPM/KSCF	1135	1188		799	793	324	335	3542	4213
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II				II		II	II	
MN- 54*			164						
DPM/KSCF			A						
Y- 88*	(±101)				±77		±162	±220	
DPM/KSCF	FY				F		F	F	
SR- 89	417		(237)		284		98	1534	
DPM/KSCF			C		A				
SR- 90	126		81		94		45	225	
DPM/KSCF									
Y- 91	(730)				481		199	2424	
DPM/KSCF	Y							A	
ZR- 95	822				625		206	3169	
DPM/KSCF									
CS-137	187		106		126		74	283	
DPM/KSCF									
CE-141	±138				±82		±45	±288	
DPM/KSCF	F				F		F	F	
CE-144	1566		734		962		365	4288	
DPM/KSCF									
PM-147	(537)				400		46	1419	
DPM/KSCF	Y						A		

[a] Samples 681 from January 1963, 691 from February 1963, and 720 from March 1963 combined for analyses; results for fission products corrected to February 15, 1963; volume is the sum of volumes for the individual samples.

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) MAR 1963

HASL A- ALT(KFT)	724 67	725 67	720 77	721 77	712 90	713 90	718 105	719 105
FLT DAY FLT NO UNIT	21 A133 D7-1	21 A133 D7-2	19 A132 D7-1	19 A132 D7-2	5 A130 D7-1	5 A130 D7-2	15 A131 D7-1	15 A131 D7-2
VOLUME (KSCF)	2.49 F	2.28 F	2.48 F	2.31 F	1.13 F	1.39 F	.78 F	.75 F
GR GAMMA CPM/KSCF	MAR27 417	MAR28 429	MAR28 580	MAR27 571	MAR13 675	MAR20 582	MAR21 1384	MAR20 1360
FRACTION ANAL LAB	1.000	1.000 II	1.000	1.000 II	1.000 II	1.000	1.000 II	1.000
SR- 89 DPM/KSCF		110		123	288		392	
SR- 90 DPM/KSCF		76		(86) X	62		(131) X	
ZR- 95 DPM/KSCF		(205) Y		(244) BY	502		828	
CS-137 DPM/KSCF		150		(265) X	84		(471) X	
CE-141 DPM/KSCF		± 66 F		±35 F	±159 F		±231 F	
CE-144 DPM/KSCF		(65) X		792	947		1974	

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) APR 1963

HASL A- ALT(KFT)	746 77	747 77	739 91	740 91	760 104	761 104
FLT DAY FLT NO UNIT	4 A135 D7-1	4 A135 D7-2	2 A134 D7-1	2 A134 D7-2	23 A138 D7-1	23 A138 D7-2
VOLUME (KSCF)	2.07 F	2.08 F	1.29 F	1.28 F	.55 F	.54 F
GR GAMMA CPM/KSCF	APR17 367	APR18 368	APR10 1155	APR11 1187	MAY 1 1352	MAY 2 1237
FRACTION ANAL LAB	1.000	1.000 II	1.000 II	1.000	1.000	1.000 II
MN- 54* DPM/KSCF		129 B	837	205 B		± 463 F
FE- 55* DPM/KSCF		207 A	1380			1220 A
SR- 89 DPM/KSCF		(±3) FX	312	454 B		(91) CX
SR- 90 DPM/KSCF		76	126	110		130
ZR- 95 DPM/KSCF		 L	1202			1374
CS-137 DPM/KSCF		100	152	123		178
CE-144 DPM/KSCF		635	1922	1602		2241

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S)   MAY 1963

HASL A-	769	770	775	776	773	774
ALT(KFT)	66	66	78	78	104	104
FLT DAY	2	2	4	4	8	8
FLT NO	A139	A139	A140	A140	A141	A141
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.61	2.47	2.05	2.23	.82	.83
(KSCF)	F	F	F	F	F	F
GR GAMMA	MAY 9	MAY10	MAY15	MAY16	MAY15	MAY16
CPM/KSCF	409	421	590	591	1096	1093
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II		II		II	
MN- 54*						988
DPM/KSCF						A
Y - 88*	±253		± 234		± 756	
DPM/KSCF	F		F		F	
SR- 89	(±21)		(± 24)		194	
DPM/KSCF	FX		FX		A	
SR- 90	114		146		135	127
DPM/KSCF						
Y - 91	205		311		599	
DPM/KSCF						
ZR- 95	228		(590)		(1015)	
DPM/KSCF			Y		Y	
CS-137	202		201			
DPM/KSCF					L	
CE-144	870		(1210)		1963	2036
DPM/KSCF			Y			
PM-147	195		223		(207)	
DPM/KSCF					AY	

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S)   JUN 1963

HASL A- ALT(KFT)	799 67	800 67	797 77	798 77	807 86	808 86
FLT DAY FLT NO UNIT	27 A146 D7-1	27 A146 D7-2	24 A143 D7-1	24 A143 D7-2	26 A145 D7-1	26 A145 D7-2
VOLUME (KSCF)	2.40 F	2.30 F	2.17 F	2.18 F	1.64 F	1.89 T
GR GAMMA CPM/KSCF	JUL 1 450	JUL 1 452	JUN27 2884	JUN28 2848	JUL 2 2884	JUL 3 2417
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF	692 A		2986		(1902) X	
FE- 55* DPM/KSCF	950		(3613) AY		(8780) X	
Y- 88* DPM/KSCF	±163 F		227 B		±274 FG	
SR- 89 DPM/KSCF	128 B		(±74) FX		(±85) FX	
SR- 90 DPM/KSCF	130		618		598	
Y- 91 DPM/KSCF	198		963		1268	
ZR- 95 DPM/KSCF	L		1682		L	
SB-124* DPM/KSCF	±171 F		±60 F		±256 F	
SB-125 DPM/KSCF	103 A		219 A		456 A	
CS-137 DPM/KSCF	208		903		909	
CE-144 DPM/KSCF	1392		8756		8232	

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S)   JUL 1963

HASL A-	826	827	822	823
ALT(KFT)	85	85	103	103
FLT DAY	26	26	24	24
FLT NO	A149	A149	A148	A148
UNIT	D7-1	D7-2	D7-1	D7-2
VOLUME	1.18	1.16	.83	.89
(KSCF)	F	F	F	F
GR GAMMA	AUG 6	AUG 7	AUG 7	AUG 7
CPM/KSCF	1449	1534	328	313
FRACTION	1.000	1.000	1.000	1.000
ANAL LAB	II		II	
MN- 54*	1780		±506	
DPM/KSCF			F	
FE- 55*	2093		1011	
DPM/KSCF			B	
Y- 88*	±780		±1157	
DPM/KSCF	F		F	
SR- 89	202		175	
DPM/KSCF	B		A	
SR- 90	385		55	
DPM/KSCF				
Y- 91	810		286	
DPM/KSCF				
ZR- 95	907		467	
DPM/KSCF				
RH-102*	±169		±241	
DPM/KSCF	F		F	
SB-124*	±169		±217	
DPM/KSCF	F		F	
SB-125	311		60	
DPM/KSCF			A	
CS-137	613		102	
DPM/KSCF				
CE-144	5508		1078	
DPM/KSCF				

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) AUG 1963

HASL A-	843	844	841	842
ALT(KFT)	62	62	78	78
FLT DAY	9	9	8	8
FLT NO	A151	A151	A150	A150
UNIT	D7-1	D7-2	D7-1	D7-2
VOLUME (KSCF)	2.83 F	2.84 F	2.12 F	1.96 F
GR GAMMA	AUG20	AUG21	AUG20	AUG21
CPM/KSCF	575	559	1721	1750
FRACTION	1.000	1.000	1.000	1.000
ANAL LAB		II		II
MN- 54* DPM/KSCF		585		2321
FE- 55* DPM/KSCF		673		1546
Y- 88* DPM/KSCF		±423 F		±316 FG
SR- 89 DPM/KSCF		(27) DX		(±35) FX
SR- 90 DPM/KSCF		201		582
Y- 91 DPM/KSCF		221		617
ZR- 95 DPM/KSCF		284		(959) Y
RH-102* DPM/KSCF		±95 F		--
SB-124* DPM/KSCF		±67 F		±219 F
SB-125 DPM/KSCF		107		196 A
CS-137 DPM/KSCF		312		745
CE-144 DPM/KSCF		1810		6378
PM-147 DPM/KSCF		426		1235

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S)   SEP 1963

HASL A-	877	878	871	872	874	875	879	880
ALT(KFT)	68	68	79	79	90	90	105	105
FLT DAY	20	20	18	18	19	19	27	27
FLT NO	A155	A155	A153	A153	A154	A154	A156	A156
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.14	2.03	2.00	2.27	1.36	1.27	.81	(.22)[a]
(KSCF)	F	F	F	F	F	F	F	E
GR GAMMA	OCT 1	OCT 2	SEP24	SEP25	SEP24	SEP25	OCT 3	OCT 3
CPM/KSCF	1327	1467	1090	1030	372	365	233	(309) B
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II		II		II		II	
MN- 54*	(1897)		(1235)		± 301		1728	
DPM/KSCF	Y		Y		F		A	
FE- 55*	3112		1410		± 96		1383	
DPM/KSCF					F			
Y- 88*	±701		±385		±559			
DPM/KSCF	FG		F		F		L	
SR- 89	241		102		±31		(51)	
DPM/KSCF	A		B		F		CX	
SR- 90	368		280		26		183	
DPM/KSCF					A			
Y- 91	467		298		56			
DPM/KSCF			A		A		L	
ZR- 95							548	
DPM/KSCF	L		L		L			
SB-124*	±421		± 225					
DPM/KSCF	F		F		--		--	
SB-125	344		220					
DPM/KSCF	A				--		--	
CS-137	528		391		35		279	
DPM/KSCF								
CE-144	4575		3765		524		(3420)	
DPM/KSCF							Y	

a Motor burned out during collection; volume estimated from telemetry of blower speed.

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34oS) OCT 1963

HASL A- ALT(KFT)	900 68	901 68	907 80	908 80	897 90	898 90	910 106	911 106
FLT DAY FLT NO UNIT	15 A159 D7-1	15 A159 D7-2	17 A160 D7-1	17 A160 D7-2	10 A158 D7-1	10 A158 D7-2	24 A161 D7-1	24 A161 D7-2
VOLUME (KSCF)	2.11 F	2.38 T	1.72 F	1.84 F	1.27 F	1.32 F	.65 F	.63 F
GR GAMMA CPM/KSCF	OCT24 1037	OCT25 1029	OCT24 1081	OCT24 1054	OCT16 419	OCT17 425	OCT30 232	OCT30 222 A
FRACTION ANAL LAB	1.000 II	1.000 II	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF	1725 A		1953		± 449 F		± 754 F	
FE- 55* DPM/KSCF	2649		2500		383 A		147 B	
Y - 88* DPM/KSCF	± 521 F		± 576 F		±2126 F		±2615 F	
SR- 89 DPM/KSCF	199 A		(87) C		(±79) FY		(50) C	
SR- 90 DPM/KSCF	395		373		(79) AY		53	
Y - 91 DPM/KSCF	440		288 A		76 B		73 A	
ZR- 95 DPM/KSCF	461		385		(91) BY		135 B	
RH-102* DPM/KSCF	140 A		(±145) FY		±94 F		±200 F	
SB-124* DPM/KSCF	(±900) FY		(±2442) FY		L		±2308 F	
SB-125 DPM/KSCF	(324) Y		(261) AY		L		565 A	
CS-137 DPM/KSCF	578		515		109		75	
CE-144 DPM/KSCF	4066		3576		1110		791	

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) NOV 1963

HASL A- ALT(KFT)	963 68	964 68	954 78	955 78	961 87	962 87	967 107	968 107
FLT DAY FLT NO UNIT	12 A163 D7-1	12 A163 D7-2	8 A162 D7-1	8 A162 D7-2	14 A164 D7-1	14 A164 D7-2	20 A165 D7-1	20 A165 D7-2
VOLUME (KSCF)	2.20 F	2.20 F	2.10 F	1.97 F	1.38 F	1.29 F	.68 F	(.63)[a] E
GR GAMMA CPM/KSCF	NOV19 963	NOV20 950	NOV13 914	NOV14 903	NOV19 380	NOV20 362	NOV26 445	NOV27 (422)
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF	2800		1386 A		812 A		± 721 F	
FE- 55* DPM/KSCF	2336 A		2224		672		(115) C	
Y - 88* DPM/KSCF	±682 F		± 810 F		±1232 F		±2647 F	
SR- 89 DPM/KSCF	(42) CX		90 B		37 B		55 B	
SR- 90 DPM/KSCF	406		324		120		90	
Y - 91 DPM/KSCF	(228) Y		(201) Y		95		94	
ZR- 95 DPM/KSCF	350		265		112		218	
SB-124* DPM/KSCF	±305 F		± 667 F		(±1232) FY		±1912 F	
SB-125 DPM/KSCF	278		212 A		(91) BY		129 B	
CS-137 DPM/KSCF	591		438		157		124	
CE-144 DPM/KSCF	3745		3448		1449		1721	
PM-147 DPM/KSCF	1114		810		340		415	

a Faulty flowmeter equipment; volume estimated from ratio of blower speeds of D7-2 unit to D7-1 unit.

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) DEC 1963

HASL A- ALT(KFT)	996 67	997 67	984 (74)[a]	985 (74)[a]	998 78	999 78	988 87	989 87	986 105	987 105
FLT DAY FLT NO UNIT	12 A169 D7-1	12 A169 D7-2	5 A168 D7-1	5 A168 D7-2	12 A170 D7-1	12 A170 D7-2	4 A167 D7-1	4 A167 D7-2	3 A166 D7-1	3 A166 D7-2
VOLUME (KSCF)	2.28 F	2.27 F	(2.02)[b] T	(1.98)[b] T	1.88 F	2.01 F	1.64 F	1.47 F	.66 F	.69 F
GR GAMMA CPM/KSCF	DEC19 592	DEC20 607	FEB13 (584)	FEB14 (611)	DEC19 691	DEC20 651	DEC11 579	DEC12 565	DEC11 200 A	DEC12 226
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF	1614		(1718) A	(1662) A	1441		805 A		±727 F	
FE- 55* DPM/KSCF	1882		(2490)	(2217)	1638		1122 A		±303 F	
Y - 88* DPM/KSCF	±921 F			(±1162) F	±585 F		± 1280 F		±3182 F	
SR- 89 DPM/KSCF	(38) C			(73) B	52 B		(±20) FY		158 B	
SR- 90 DPM/KSCF	262		(334)	(312)	255		(181) Y		65	
Y - 91 DPM/KSCF	139			(272)	122		109		144	
ZR- 95 DPM/KSCF	176			(224)	154		103 A		107 A	
SB-124* DPM/KSCF	±79 F				±904 F		±1585 F		±3333 F	
SB-125 DPM/KSCF	197 A				197 A		173 A		±109 F	
CS-137 DPM/KSCF	368		(564)	(530)	372		280		87	
CE-144 DPM/KSCF	2803		(3297)	(3449)	2761		2268		724	

a Altitude ranged from 64 to 78 kilofeet.
b Volume estimated from telemetered blower speeds.

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) JAN 1964

HASL A- ALT(KFT)	1029 68	1030 68	1021 79	1022 79	1027 (80)[a]	1028 (80)[a]	1031[b] 87	1032 87
FLT DAY	22	22	16	16	21	21	23	23
FLT NO	A173	A173	A171	A171	A172	A172	A174	A174
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME (KSCF)	2.29 F	2.16 F	2.15 F	2.14 F	(2.40)[c] E	(2.50)[c] E	--	1.68 F
GR GAMMA CPM/KSCF	JAN28 550	JAN29 560	JAN21 520	JAN22 546	FEB13 (591)	FEB14 (528)	--	JAN28 480
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000 II	1.000	1.000 II
MN- 54* DPM/KSCF	1493		1260		(1475)	(1060) BY		988
FE- 55* DPM/KSCF	2017		1284		(1575)	(1812)		1286
Y - 88* DPM/KSCF	±1659 F		±2140 F		(±958) F			±2262 F
SR- 89 DPM/KSCF	(37) C		(21) C		(±22) F			(19) C
SR- 90 DPM/KSCF	272		209		(283)	(268)		193
Y - 91 DPM/KSCF	99		86		(92)			70 A
ZR- 95 DPM/KSCF	152		86 A		(105)			78
CS-137 DPM/KSCF	450		298		(438)	(408)		297
CE-144 DPM/KSCF	2668		2312		(2908)	(2660) Y		2292

a Altitude ranged from 75 to 86 kilofeet; 19% of total volume collected at 75 kilofeet, 78% between 75 and 85 kilofeet, and 3% at 86 kilofeet.
b Blower unit inoperable; no sample obtained.
c Volume estimated from flowmeter data.

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) FEB 1964

HASL A- ALT(KFT)	1056 66	1057 66	1042 78 [a]	1043 78 [a]	1040 91	1041 91	1058 106	1059 106
FLT DAY FLT NO UNIT	18 A177 D7-1	18 A177 D7-2	6 A176 D7-1	6 A176 D7-2	4 A175 D7-1	4 A175 D7-2	20 A178 D7-1	20 A178 D7-2
VOLUME (KSCF)	2.39 F	2.39 F	1.59 F	1.45 F	1.14 F	1.06 F	.68 F	.65 F
GR GAMMA CPM/KSCF	FEB25 564	FEB26 556	FEB12 518	FEB13 518	FEB11 281	FEB12 305	FEB25 128 A	FEB26 153 A
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF	1845		1270		336 B		± 1412 F	
FE- 55* DPM/KSCF	2084		1296 A		449 B		± 147 F	
Y - 88* DPM/KSCF	± 1004 F		±1824 F		± 1228 F		± 1471 F	
SR- 89 DPM/KSCF	37 B		63 B		±10 F		± 14 F	
SR- 90 DPM/KSCF	259		260		101		32	
Y - 91 DPM/KSCF	88		61		30 A		9 B	
ZR- 95 DPM/KSCF	92		72		37 B		(14) C	
CS-137 DPM/KSCF	423		355		130		48	
CE-144 DPM/KSCF	2929		1969		921		376	
PM-147 DPM/KSCF	1142		943		406		171	

a Altitude ranged from 74 to 79 kilofeet; about 50% of total volume collected from 74 to 79 kilofeet and 50% at 79 kilofeet.

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S)   MAR 1964

HASL A- ALT(KFT)	1099 71	1100 71	1064 81	1065 81	1061 90	1062 90	1069 107	1070 107
FLT DAY FLT NO UNIT	17 A182 D7-1	17 A182 D7-2	6 A180 D7-1	6 A180 D7-2	3 A179 D7-1	3 A179 D7-2	11 A181 D7-1	11 A181 D7-2
VOLUME (KSCF)	1.48 F	1.63 F	1.51 F	1.61 F	1.26 F	1.36 F	.64 F	.77 F
GR GAMMA CPM/KSCF	MAR24 367	MAR25 364	MAR10 390	MAR11 393	MAR10 255	MAR11 238	MAR17 231 A	MAR18 144 A
FRACTION ANAL LAB	1.000 II	1.000 II	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF		1344	1053		383 A		±313 F	
FE- 55* DPM/KSCF		1319	1470		413 A		406	
Y - 88* DPM/KSCF			±4636 F		±3810 F			
SR- 89 DPM/KSCF			(24) D		(28) C			
SR- 90 DPM/KSCF		166	198		90		85	
Y - 91 DPM/KSCF			65 A		37 B			
ZR- 95 DPM/KSCF			50		38 B			
CS-137 DPM/KSCF		242	277		150		135	
CE-144 DPM/KSCF		1589	1815		952		905	

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S)   APR 1964

HASL A- ALT(KFT)	1120 70	1121 70	1110 81	1111 81	1108 89	1109 89	1114 108	1115 108
FLT DAY FLT NO UNIT	16 A186 D7-1	16 A186 D7-2	10 A184 D7-1	10 A184 D7-2	7 A183 D7-1	7 A183 D7-2	15 A185 D7-1	15 A185 D7-2
VOLUME (KSCF)	1.69 F	1.76 F	1.53 F	1.70 F	1.54 F	.91 F	.65 F	.42 F
GR GAMMA CPM/KSCF	APR21 360	APR22 362	APR14 387	APR15 401	APR15 281	APR14 301	APR21 142 A	APR22 178 A
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF	1071		1026		721		± 708 F	
FE- 55* DPM/KSCF	(1308) Y		1634		1117		(106) C	
Y - 88* DPM/KSCF	± 2308 F		± 2288 F		± 2208 F			
SR- 89 DPM/KSCF	± 25 F		± 29 F		± 17 F			
SR- 90 DPM/KSCF	220		201		151		44	
Y - 91 DPM/KSCF	42		39		23 A			
ZR- 95 DPM/KSCF	49 A		42 A		33			
CS-137 DPM/KSCF	(321) Y		296		219		63	
CE-144 DPM/KSCF	2000		1706		1221		(±20) FX	

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) MAY 1964

HASL A-	1176	1177	1174	1175	1150	1151	1137	1138	1154	1155	1171	1172	1139	1140
ALT(KFT)	63	63	80	80	82	82	88	88	88	88	106	106	107	107
FLT DAY	29	29	28	28	18	18	5	5	20	20	27	27	7	7
FLT NO	A196	A196	A195	A195	A191	A191	A187	A187	A193	A193	A194	A194	A188	A188
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.33	2.26	1.70	1.69	1.53	1.40	1.46	1.60	1.52	1.47	.79	.73	.75	.81
(KSCF)	F	F	F	F	F	F	F	T	F	F	F	F	F	F
GR GAMMA	JUN 3	JUN 4	JUN 3	JUN 4	MAY21	MAY22	MAY12	MAY13	MAY26	MAY27	JUN 2	JUN 3	MAY12	MAY13
CPM/KSCF	326	328	262	244	278	280	184	171	201	200	200	172	162	158
												A	A	
FRACTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ANAL LAB	II				II		II		II		II		II	
MN- 54*					712		± 281		± 145		± 722		±560	
DPM/KSCF					A		F		F		F		F	
FE- 55*					863		275		463		494		337	
DPM/KSCF							A		B		B		B	
SR- 90 DPM/KSCF					135		68		97		79		57	
CS-137 DPM/KSCF					203		95		142		122		82	
CE-144 DPM/KSCF					1085		712		757		672		484	
PM-147 DPM/KSCF					369		208						144	

Table 4b (cont'd.)

MILDURA, AUSTRALIA (34°S) JUN 1964

ALT(KFT)	64	64	81[a]	81[a]	91	91	107	107
FLT DAY	5	5	2	2	4	4	10	10
FLT NO	A199	A199	A197	A197	A198	A198	A200	A200
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.12	2.19	2.50	2.16	1.19	1.26	0.76	0.76
(KSCF)	F	F	T	F	F	F	F	F
GR GAMMA	JUN10	JUN11	JUN 9	JUN10	JUN 9	JUN10	JUN19	JUN19
CPM/KSCF	398	384	200	229	339	328	113	138
							A	

MILDURA, AUSTRALIA (34°S) JUL 1964

ALT(KFT)	65	65	80	80	92	92	(104)[b]	(104)[b]
FLT DAY	29	29	9	9	27	27	30	30
FLT NO	A203	A203	A201	A201	A202	A202	A204	A204
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	2.04	2.07	1.57	1.56	1.11	1.19	(0.48)[b]	(0.47)[b]
(KSCF)	F	F	F	F	F	T	F	F
GR GAMMA	AUG 4	AUG 5	JUL14	JUL15	AUG 4	AUG 5	AUG 4	AUG 5
CPM/KSCF	378	349	273	266	196	176	196	185
							A	A

MILDURA, AUSTRALIA (34°S) AUG 1964

ALT(KFT)	67	67	82	82	92	92	108	108
FLT DAY	19	19	21	21	11	11	26	26
FLT NO	A206	A206	A207	A207	A205	A205	A208	A208
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.84	1.73	1.28	1.36	1.30	1.05	0.62	0.60
(KSCF)	F	F	F	F	F	F	F	F
GR GAMMA	AUG25	AUG26	AUG25	AUG26	AUG18	AUG19	SEP 1	SEP 2
CPM/KSCF	291	307	305	289	183	183	132	137
							A	A

a Altitude ranged from 78-84 kilofeet.

b 50% of sample collected between 96 and 106 kilofeet, 50% of sample collected at 106 kilofeet.

Table 4c

MINNESOTA (45°N) JUN 1963		
HASL A- ALT(KFT)	794 106	795 106
FLT DAY FLT NO UNIT	7 2618 AE-1[a]	7 2618 AE-2[a]
VOLUME (KSCF)	.52 F	1.08 F
GR GAMMA CPM/KSCF	JUN27 5173	JUN27 6120
FRACTION ANAL LAB	1.000 II	1.000 II
MN- 54* DPM/KSCF	±962 F	(487) AY
FE- 55* DPM/KSCF	 L	320 B
Y- 88* DPM/KSCF	±2885 F	(±2315) FY
SR- 89 DPM/KSCF	3096	3315 A
SR- 90 DPM/KSCF	512	449
Y- 91 DPM/KSCF	5231	(4852) Y
ZR- 95 DPM/KSCF	 L	(5750) Y
RH-102* DPM/KSCF	±462 F	191 B
SB-124* DPM/KSCF	±962 F	839 B
SB-125 DPM/KSCF	340 B	311 A
CS-137 DPM/KSCF	771	750
CE-144 DPM/KSCF	10577	9056
PM-147 DPM/KSCF	1263	1361

a Special sampling unit; see text.

Table 4d

ALASKA (65°) JUL 1963

HASL A- ALT(KFT)	832 80	833 80	830 88	831 88	824 106 [a]	825 106 [a]
FLT DAY FLT NO UNIT	29 AL-3 D7-1	29 AL-3 D7-2	28 AL-2 D7-1	28 AL-2 D7-2	25 AL-1 D7-1	25 AL-1 D7-2
VOLUME (KSCF)	1.75 F	1.71 F	1.84 F	1.76 F	.74 F	.80 F
GR GAMMA CPM/KSCF	AUG 2 3097	AUG 6 2918	AUG 6 2597	AUG 7 2551	AUG 6 6702	AUG 7 6187
FRACTION ANAL LAB	1.000 II	1.000	1.000 II	1.000	1.000 II	1.000
MN- 54* DPM/KSCF	(2194) Y		5870		2297 B	
FE- 55* DPM/KSCF	2291		2451		(777) BY	
Y- 88* DPM/KSCF	(±1943) FGY		(±1630) FGY		(± 3649) FY	
SR- 89 DPM/KSCF	937 B		587 A		1797 A	
SR- 90 DPM/KSCF	562		363		530	
Y- 91 DPM/KSCF	(1486) Y		(1016) Y		(4446) Y	
ZR- 95 DPM/KSCF	2011		1658		(5054) Y	
RH-102* DPM/KSCF	±109 F		±76 F		±297 F	
SB-124* DPM/KSCF	2806 A		1223 B		1581 B	
SB-125 DPM/KSCF	406 A		278 A		391 A	
CS-137 DPM/KSCF	806		620		864	
CE-144 DPM/KSCF	6457		5652		12324	
PM-147 DPM/KSCF	1074		1196		2189	

a Altitude ranged from 99 to 106 kilofeet.

Table 4d (cont'd.)

ALASKA (65°N) MAY 1964

ALT(KFT)	80	80	81[a]	81[a]	89[a]	89[a]	90	90
FLT DAY	23	23	5	5	2	2	21	21
FLT NO	AL-10	AL-10	AL-6	AL-6	AL-5	AL-5	AL-9	AL-9
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.52	1.46	1.57	1.34	1.49	1.55	1.08	1.64
(KSCF)	F	F	F	F	F	F	F	F
GR GAMMA	JUN 2	JUN 3	MAY 8	MAY 8	MAY 7	MAY 8	MAY28	MAY28
CPM/KSCF	543	570	459	440	490	459	219	226

ALASKA (65°N) JUN 1964

ALT(KFT)	80	80	88[b]	88	102	102
FLT DAY	21	21	20	20	18	18
FLT NO	AL-15	AL-15	AL-14	AL-14	AL-13	AL-13
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.61	1.56	--	1.86	0.56	0.47
(KSCF)	F	F		F	F	F
GR GAMMA	JUN30	JUL 1		JUN30	JUN23	JUN24
CPM/KSCF	427	408		247	177	191
					A	A

ALASKA (65°N) JUL 1964

ALT(KFT)	78	78	89	89	107[c]	107[c]
FLT DAY	14	14	14	14	13	13
FLT NO	AL-18	AL-18	AL-17	AL-17	AL-16	AL-16
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.74	1.82	1.55	1.48	0.56	0.62
(KSCF)	F	F	F	F	F	F
GR GAMMA	JUL22	JUL23	JUL22	JUL23	JUL22	JUL23
CPM/KSCF	337	320	204	203	168	168
					A	

ALASKA (65°N) AUG 1964

ALT(KFT)	78	78	88	88	105	105
FLT DAY	10	10	13	13	12	12
FLT NO	AL-19	AL-19	AL-22	AL-22	AL-21	AL-21
UNIT	D7-1	D7-2	D7-1	D7-2	D7-1	D7-2
VOLUME	1.78	1.87	1.78	1.72	(0.70)[d]	0.73
(KSCF)	F	F	F	F	E	F
GR GAMMA	AUG18	AUG19	AUG25	AUG26	AUG25	AUG26
CPM/KSCF	314	312	184	191	80	120
					B	A

a Samples landed in snow; filter papers wet when recovered.
b Sample destroyed on descent of balloon.
c Altitude ranged from 103-108 kilofeet.
d Flowmeter inoperative; volume estimated from ratio of blower speeds for D7-1 unit to D7-2 unit and flowmeter data for D7-2 unit.

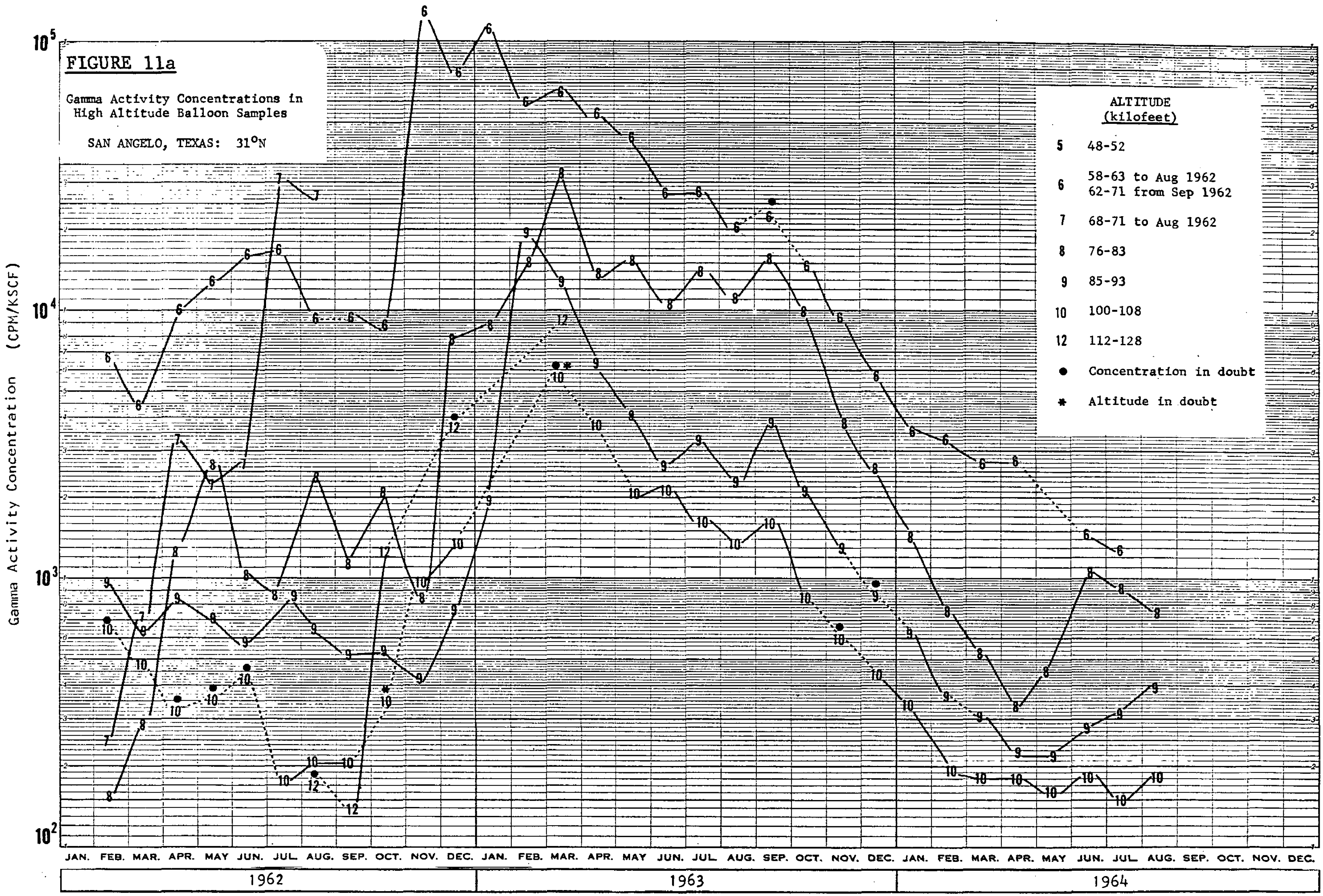

FIGURE 11a
Gamma Activity Concentrations in High Altitude Balloon Samples
SAN ANGELO, TEXAS: 31°N
ALTITUDE (kilofeet)
5 48-52
6 58-63 to Aug 1962
62-71 from Sep 1962
7 68-71 to Aug 1962
8 76-83
9 85-93
10 100-108
12 112-128
● Concentration in doubt
* Altitude in doubt
Gamma Activity Concentration (CPM/KSCF)
10^5
10^4
10^3
10^2
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
1962
1963
1964

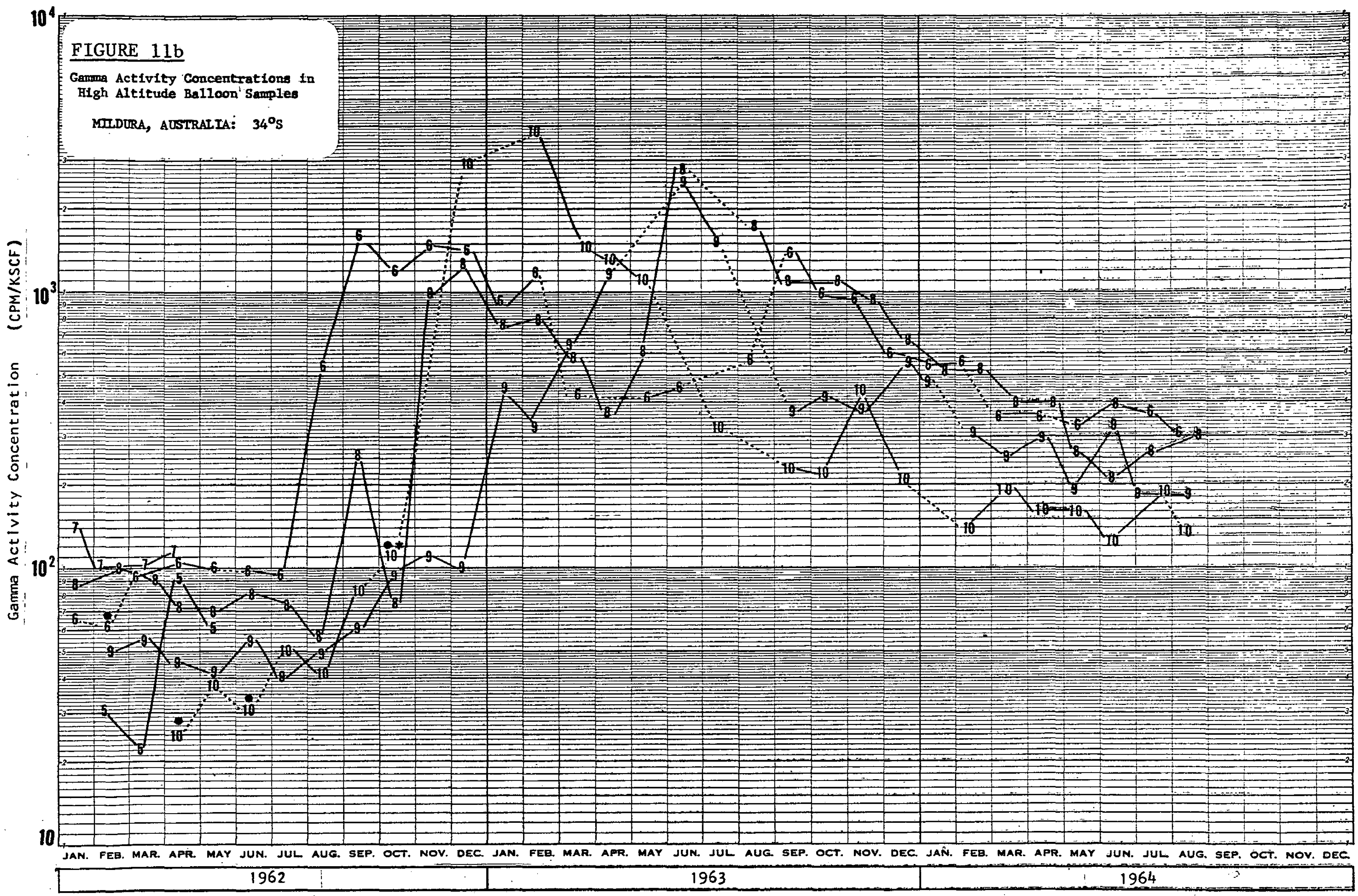
FIGURE 11b
Gamma Activity Concentrations in High Altitude Balloon Samples
MILDURA, AUSTRALIA: 34°S
Gamma Activity Concentration (CPM/KSCF)
10^4
10^3
10^2
10
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
1962
1963
1964

Part II - Data From Sources Other Than HASL

Numerous fallout studies are conducted by other organizations in the United States and abroad. Some of these data are sent to the editors for dissemination in these HASL quarterly reports. Submitted data are reproduced essentially as received and no interpretation by HASL is attempted.

1. The New Zealand Department of Scientific and Industrial Research

Since November 1958, precipitation collections at Lower Hutt have been analyzed for strontium-90, barium-140, and cesium-137. Beginning in September 1961, cerium-144 was also determined. Results for April 1964 are reported on page 101.

2. Division of Biological and Medical Research, Argonne National Laboratory

A report on cesium-137 gamma spectrometric measurements in Chicago food from April 1961 through April 1964 was presented in HASL-146, p. 225. The following data tabulation up-dates the previous one through July 1964. The report entitled, "Cs-137 in Various Chicago Foods" by S.S. Brar, P.F. Gustafson and S.E. Muniak is found on page 102.

1. RADIOISOTOPES IN RAINWATER

Report No. 54

Period: 31 March to 1 May 1964

STATION: Gracefield, Lower Hutt, New Zealand. S.41°14' E.174°55'

Polythene Collector 10.1 sq.ft.

Sampling Period		Activity: Microcuries/sq.mile				Ba^{140}/Sr^{90}	Cs^{137}/Sr^{90}	Cumulative Sr^{90} Millicuries/Sq.Mile	Rain Inches	Remarks
Start	Finish	Sr^{90}	Ce^{144}	Ba^{140}	Cs^{137}					
3-31	5 - 1	210 ± 4	1280 ± 30		440 ± 80		2.10	1.335	1.73	Monthly Pot Sample
3-31	5 - 1	220 ± 2	1330 ± 4						1.73	
Accumulated Total or Average for 1964		1335			3200		2.40		9.10	

2. Cs-137 in Various Chicago Foods, pc/kg

(Collection Month July, 1964)

S. S. Brar, P. F. Gustafson, and S. E. Muniak
Division of Biological and Medical Research
Argonne National Laboratory
Argonne, Illinois

White Bread (Dry)	152
Whole Grain Bread (Dry)	477
Eggs	25
Fresh Vegetables:	
Cabbage	10
Lettuce	10
Onions	T
Peas (Frozen)	59
Stringbeans	31
Tomatoes	18
Root Vegetables:	
Carrots	8
Milk (Fresh)	92
Poultry Muscle	77
Fresh Fish (Frozen):	
Fillet	1305
Halibut	53
Flour (White)	156
Macaroni	300
Rice	78
Meat Muscle:	
Beef	182
Pork	299

Shellfish:	
Oysters	44
Shrimps	23
Dried Beans	132
Fresh Fruits:	
Apples	60
Bananas	26
Berries	24
Melons	T
Oranges	47
Potatoes	T
Canned Fruits:	
Apple Sauce	49
Peaches	29
Pears	17
Pineapple	51
Canned Juices:	
Grapefruit	70
Orange	73
Pineapple	170
Tomato	19
Canned Vegetables:	
Peas	31
Stringbeans	24
Tomatoes	15
Baby Foods:	
Canned Milk	292
Formula Milk	261
Cereals	369
Fruits	43
Meats	164
Vegetables	28

T means trace (< 5 pc/kg)

Part III - Interpretive Reports and Notes

"Strontium-90 Levels in the Diets and Bones of Children - Progress Report 1962-1963", by D. Beninson, H. Migliori, and E. Ramos, Argentine Comision Nacional de Energia Atomica.

"Strontium-90 Levels in the Diets and Bones of Children - Progress Report 1964", by D. Beninson, E. Ramos, and R. Touzet, Argentine Comision Nacional de Energia Atomica.

"Strontium in Diet and Bone of San Juan, Puerto Rico Residents of Low Income", by J. Rivera, Health and Safety Laboratory, USAEC.

"Cesium-137, Stable Strontium and Radium-226 in Two Human Skeletons", by J. Rivera, Health and Safety Laboratory, USAEC.

"Possible Pu-238 Distribution from a Satellite Failure", by J.H. Harley, Health and Safety Laboratory, USAEC.

"Measured Levels of Pu-238 and Pu-239 in the Stratosphere", by L.P. Salter, Health and Safety Laboratory, USAEC.

"Cumulative Deposition of Strontium-90 Along a Mid-United States Constant Precipitation Transect", by L.T. Alexander, M. Meyer, and J.S. Allen, Soil Conservation Service, U.S. Department of Agriculture, and E.P. Hardy, Jr., Health and Safety Laboratory, USAEC.

"Reproducibility of Analyses of 1963-1964 Soils for Strontium-90", by F. Durkan and L.D.Y. Ong, Health and Safety Laboratory, USAEC.

Strontium-90 Levels in the Diets and Bones of Children

PROGRESS REPORT - 1962-1963

by D. Beninson, H. Migliori, and E. Ramos
Argentine CNEA*

Introduction

Since children have a high rate of bone formation their skeleton tends to follow readily the changes in levels of Sr-90 in the diet, this being especially true during the first year of life. Knowledge of correlating parameters between diet and bone in that period is therefore particularly important to estimate children's body burdens resulting from different environmental conditions.

These estimates are complicated by the fact that the diet of very young children is composed essentially of specially processed food items based on milk with several additions, and these materials cannot be easily correlated with adult alimentation which is normally surveyed in fallout programs. An additional incentive to study the Sr-90 content of diet and bones of children in Argentina was the need for systematic data in a region for which there is only scanty information on the subject.

The study was "a priori" facilitated by the fact that Sr-90 fallout in the Argentine Litoral Area has remained relatively constant during the last years(1)(2)(3) (1959 - 1.2 mc/Km^2; 1960 - 0.9 mc/Km^2; 1961 - 1.2 mc/Km^2; 1962 - 1.3 mc/Km^2); this being reflected also in the small variation of Sr-90 levels in several food items. The study could therefore be carried out over several years, simplifying the attempt to estimate discrimination factors.

The work carried out had two purposes: a) the estimation of representative average levels of Sr-90 in children's alimentation, and b) the determination of Sr-90 in bones from children whose "diet history" could be established with some reliability.

Sampling and Analytical Procedures

Specially produced baby food (formula and evaporated milks, etc.) were sampled at the comsumption point, at a rate of about 4 to 6 samples per month per brand. The samples of each brand were pooled approximately every month and processed. This time scheme was altered when convenient in relation with information from the producing companies.

Other food items were already being sampled by the regular CNEA survey, but the emphasis was shifted in connection with the reported work. The sampling was also carried out at the consumption point since no time trends of fallout food levels correlation studies were planned. The samples were obtained at random once a week and pooled and processed every month.

* Comision Nacional de Energia Atomica

Bone samples were obtained when available mainly from four Hospitals (Hospital de Niños de Buenos Aires, Casa Cuna, Hospital Rawson and Hospital Pirovano). Information was obtained from these hospitals on the alimentation in each case. In addition the family and the intervening medical practitioner were interviewed on the subject. Since sometimes the information was not available the number of bones with a corresponding "diet history" is smaller than the total number of bones processed.

All samples were processed using HASL radiochemical procedures[4]. Sr-90 was measured by counting its daughter Y-90 in low background β-counters (backgrounds ranging from 0.3 to 0.9 cpm). The chemical yields were determined by Sr-85 tracer and γ-counting; Ca contents were determined by gravimetric techniques.

Strontium-90 in Diets of Children

The survey covered different brands of baby foods in addition to diet items which are common to adult alimentation.

Table I presents averages and standard error of the mean for Sr-90 levels in baby foods based on milk products. The values are considered to be representative of the material available in the market in the period 1960 to 1962.

The scatter of values of individual samples was similar for the different brands, with standard deviations ranging from 20 to 40% of the average.

As some of the brands are "fortified" with mineral or animal calcium, and others include cereal products, no correlation can readily be obtained with the levels observed in cow milk of the Argentine Litoral Area. However, baby foods having higher calcium proportions in ash tend, as expected, to have lower Sr-90/Ca levels.

Values for other food items are shown in Table II. The table includes also prepared foods based on cereals. The scatter of values was higher than those of Table I, with standard deviations ranging from 30 to 70%. Potato levels are particularly variable and not too much significance should be attributed to the mean.

The estimation of Sr-90/Ca levels in the diet of children of different age groups requires information as to the proportions of Ca contributed by the food components. This information is not available for several regions in Argentina and could be obtained with a reasonable degree of reliability only for Buenos Aires Province[5][6]. Regional differences are probably of little importance in the case of infants as most of the dietary calcium is provided by specially prepared milk products (evaporated, formula, etc.) which are mostly of national distribution.

Table III shows the Sr-90 estimates for several age groups in Buenos Aires Province. Some uncertainity is introduced by the contribution of breast feeding, which is of particular importance in the 0-3 month group. The levels in this case were computed from those of the adult diet using an OR of 0.12. Meat was not included in the Table in view of its negligible contribution to the Ca intake even in the older age group.[9]

The data shows that during the first year of life milk and specially prepared formula and evaporated milks contribute about 80% of the calcium and 85% of the Sr-90 intake. A similar contribution was estimated elsewhere[7]. Table III shows that the average level of total diet during the first year of life was about 2.5 pc/g Ca, which is also the mean level measured in milk during the period of study.[2][3]

Sr-90 in Bones of Children

Experimental evidence suggests that the skeleton turn-over is very high in the first two years of life[8]; this means that no differences of Sr-90 levels should be expected among bones in very young children. This is important since the results reported corresponded generally to at most a few bones per child and the attempted correlations with diet depends on the assumption of uniform labeling.

Table IV presents bone level averages and standard errors of the mean for four age groups.

A large part (65%) of the samples were obtained from children only recently admitted to the supplying hospitals and coming from several regions of the country; it was therefore impossible to collect reliable information on their "integrated" diet. For the remaining 35% enough information could be collected, so as to estimate their average diet during different periods of their life (averaged over periods of 6 months).

Tables 5a, 5b, 5c and 5d present the information on these bones and the estimates of the past diets. The relevance of the estimates is different for the various age groups. While reliable information can be collected from mothers and doctors concerning alimentation during the first six months, the same does not apply to other age groups. Furthermore in the studied area most new born alimentation remain under medical supervision for only a few months.

The averages and scatter of Sr-90 levels for the groups presented in Tables 5a to 5d do not differ significantly from those obtained including all samples and therefore the group does not seem to be biased.

From these data an estimation of discrimination factors has been attempted. The Sr-90/Ca level in bone is related to that of the diets by the following general expression:

$$(Sr\text{-}90/Ca)_{Bone} = \frac{Ca_f \cdot L_M \cdot F_M + \sum \Delta\, Ca_i\, L_i\, F_i}{Ca_f + \sum i\ \Delta\, Ca_i}$$

where Ca_f is the amount of calcium from placental origin,
L_M is the Sr-90/Ca ratio in the mothers total diet,
F_M is the OR blood/diet in the mother (0.25),
F_p is the placental discrimination factor (0.5),
ΔCa_i is the amount of Ca incorporated into the bone in the period i,
L_i is Sr-90/Ca ratio in the diet of the child in the period i, and
F_i is the average OR bone/diet of the child during the period i.

From the data of Tables 5a to 5d the child discrimination factor (F_i) during the period of six months could "a priori" be calculated. However, it is clear that any of these estimations require the knowledge of all F up to F_{i-1}; the computations are therefore iterative and the uncertainty increases in every step. For this reason and since the "integrated" diet is known with some reliability for the 0-6 months group, the computation child by child has been restricted to this age period (Table 5a).

Other information is also needed for the calculation. The Ca content of new born children in the Argentine Litoral Area is estimated to be about 24 g[10]. Several calculations performed on published data[11][12] pointed to the fact that the increase of calcium in the child fits reasonably well the expression:

$$\frac{\text{Ca retained}}{\text{Ca ingested x Weight}} = \text{Constant}$$

From this relation calcium increment at different ages can be estimated and this was used in connection with Table 5a. Again a new and not readily assessed uncertainty is introduced here.

The approach presented leads to a value of 0.81 ± 0.27 for the OR bone/diet of the 0-6 months children group. This value gives the impression of being quite different from the adult discrimination factor, but all the uncertainties introduced here (and also present in the adult value of 0.25) would not allow any clearer conclusion.

Another approach has also been used with the data of Tables 5a to 5d. Since the skeleton Ca increased during each of the 6 months periods does not differ appreciably from linearity, the calculations could be carried out with an "average" child of each group. This has been done in Table 6.

The uncertainties involved in these calculations are substantially large and cannot be even estimated. The results should therefore be considered merely as a construction. It is suggestive, however, that the trend of change of the computed discrimination factors is similar to that estimated in other areas[8]. Although the actual values differ for the second year. It is also interesting that the value found for the older groups is the same as the accepted OR for adults.

It is clear that more data are needed to resolve differences of discrimination factors with age, the number required being larger as older age groups are considered. It seems also of interest to attempt a fractionation of the groups, again with more data, since the evidence suggests that discrimination changes considerably during the first year of life.

The same type of approach with stable strontium data would help considerably in the interpretation and would make the results clearly independent of changes in the contamination levels, which increase the difficulties of estimation.

Several methods of stable Sr measurement have been tried in our laboratory with erratic results. A simple method was finally developed and diets and bones are being measured. However, the amount of data obtained is so far insufficient for attempting the correlation.

References

(1) Achard, N.; Beninson, D.; Migliori, A., Fallout en la Republica Argentina durante 1959 - Informe CNEA 39, 1960.
(2) Beninson, D.; Kramer, J.; Mariano, E.; Ramos, E., Contaminacion por radioestroncio durante el ano 1959 - Informe CNEA 50, 1961.
(3) Beninson, D.; Ramos, E., Fallout en la Republica Argentina durante los años 1961 y 1962 - Informe CNEA, in publication.
(4) HASL: Manual of Standard Procedures NYO-4700 (1957).
(5) Instituto Nacional de la Nutricion - Private communication.
(6) Catedra de Pediatría, U. de Buenos Aires - Private communication.
(7) HASL Report 122 (1962).
(8) Loutit, J.; Bryant, F., Human Bone Metabolism Deduced from Strontium Assays, AERE-R-3716.
(9) Instituto Nacional de la Nutricion: Contenido en Calcio y Potasio de los Alimentos en la Republica Argentina (1957).
(10) Catedra de Pediatría, U. de Buenos Aires - Private communication.
(11) Sherman, H., Calcium and Phosphorus in Foods and Nutrition, (1947).
(12) Mitchell, H.; Stegerda, F.; Bean, H., J. of Biological Chemistry 153, p. 635, (1945).

TABLE I

Baby Foods

Brands	Ca (%/g ash)	Sr^{90}+ pc/g Ca
"Baberlac Compuesto"	28.30	1.05 ± 0.10
"Eledón con fécula"	16.17	1.75 ± 0.14
"Eledón con fécula y glúcido"	13.76	3.36 ± 0.25
"Baberlac simple"	11.56	3.52 ± 0.40
"Nestógeno"	9.96	3.06 ± 0.25
"Casenolín"	13.99	1.85 ± 0.16
"Secalbum"	27.52	0.82 ± 0.07
"Yogalmina"	14.90	2.96 ± 0.24
"Leche Nido"	10.84	2.17 ± 0.10
"Leche Kasdorf"	2.15	5.03 ± 0.38
"Leche S.M.A."	11.67	2.82 ± 0.22
"Leche Cyndor"	13.40	2.60 ± 0.21
"Osteolact"	10.00	3.03 ± 0.32

+ Values are means and standard errors of the mean.

TABLE II

Other Food Items

Food Items	Ca (mg/100 g food)	Sr^{90}+ (pc/g Ca)
Wheat flour	24.2	15.58 ± 1.74
Semolina	21.0	17.93 ± 0.16
"Farex" (flour with addition of animal bone calcium)	622.9	5.33 ± 0.48
"Maizena"	7.8	3.85 ± 1.05
"Quaker"	23.7	8.18 ± 0.73
Potatoe	6	14.85 ± 6.72
Calabash	20.8	5.15 ± 0.16
Onion	5.5	12.80 ± 0.05
Composite of Vegetables++ Onion Tomato Parsley Leek Carrot Lettuce	19.8	6.45 ± 0.26
Banana	27.2	5.90 ± 0.76
Apple	2.7	6.36 ± 0.14

\+ Values are means and standard errors of the mean.
++ Composited according to information on consumption by children[6].

TABLE III

Diet of Children

Age 0-3 months	Ca g/day	Sr-90 level	Sr-90 pc/day
Breast feeding	0.470	0.63	0.30
Milk	0.280	2.50	0.70
Formula and other special foods	0.250	2.68	0.67
TOTAL	1.000		1.67
			1.67 pc Sr-90/g Ca
Age 3-6 months			
Breast feeding	0.165	0.63	0.10
Milk	0.370	2.50	0.92
Formula and other special foods	0.003	14.85	0.04
TOTAL	0.538		1.06
			2.35 pc Sr-90/g Ca
Age 6-9 months			
Milk	0.400	2.5	1.00
Milk plus cereals	0.400	2.79	1.12
Potato	0.006	14.85	0.09
Calabash	0.003	5.15	0.02
Banana	0.004	5.90	0.02
Apple	0.002	6.36	0.01
Cereals	0.004	15.58	0.06
Eggs	0.020	5.25	0.10
TOTAL	0.839		2.42
			2.88 pc Sr-90/g Ca

TABLE III - cont'd.

Diet of Children

Age 9-12 months	Ca g/day	Sr-90 level	Sr-90 pc/day
Milk	0.400	2.5	1.00
Formula and other special foods	0.400	2.79	1.12
Potato	0.006	14.85	0.09
Calabash	0.002	5.15	0.01
Banana	0.006	5.90	0.04
Apple	0.004	6.36	0.03
Cereals	0.006	15.58	0.93
Eggs	0.040	5.24	0.21
TOTAL	0.864		3.43
			3.97 pc Sr-90/g Ca

Age 12-24 months	Ca g/day	Sr-90 level	Sr-90 pc/day
Milk	0.650	2.5	1.63
Potato	0.009	12.85	0.13
Calabash	0.002	5.15	0.01
Banana	0.006	5.90	0.04
Apple	0.004	6.36	0.03
Cereals	0.010	15.58	0.16
Egg	0.040	5.24	0.21
TOTAL	0.721		2.21
			3.07 pc Sr-90/g Ca

TABLE III - cont'd.

Diet of Children

Age 24-36 months	Ca g/day	Sr-90 level	Sr-90 pc/day
Milk	0.600	2.5	1.50
Potato	0.012	14.85	0.18
Calabash	0.002	5.15	0.01
Banana	0.006	5.90	0.04
Apple	0.004	6.36	0.05
Cereals	0.014	15.58	0.22
Egg	0.040	5.24	0.21
TOTAL	0.678		2.21

3.26 pc Sr-90/g Ca

TABLE IV

Sr-90 in Bone

Age Group	No. of samples	% Ca in ash	Sr^{90} pc/g Ca
0-6 months	43	33.9	0.81 ± 0.04
6-12 months	27	35.2	0.68 ± 0.03
1-2 years	38	34.9	0.70 ± 0.04
2-3 years	48	36.1	1.20 ± 0.09

TABLE 5a

Bone Samples with Diet Information

Age	Date of birth	Bone pc/g Ca	Diet 0-6 months pc/g Ca
15 days	8-1961	0.72 ± 0.08	1.53
22 days	8-1961	0.53 ± 0.05	1.00
25 days	7-1961	0.60 ± 0.06	1.04
33 days	6-1961	0.84 ± 0.08	0.97
45 days	7-1961	0.57 ± 0.09	0.63
48 days	9-1961	0.67 ± 0.10	1.71
60 days	4-1961	0.96 ± 0.12	2.00
62 days	8-1961	0.69 ± 0.08	0.93
90 days	3-1961	0.72 ± 0.11	1.53
90 days	6-1961	0.64 ± 0.11	1.83
90 days	12-1961	1.00 ± 0.07	2.14
140 days	7-1961	1.07 ± 0.20	0.75
180 days	6-1961	0.98 ± 0.10	2.22
180 days	6-1961	0.97 ± 0.12	2.56

Average diet of mother 5.1 pc/g Ca. Ca at birth 24 grams.

TABLE 5b

Bone Samples with Diet Information

(6-12 months)

Age	Date of birth	Bone pc/g Ca	Diet 0-6 months pc/g Ca	Diet 6-12 months pc/g Ca
6.3 mos.	2-1962	0.51 ± 0.09	0.97	1.82
8.0 mos.	3-1961	0.93 ± 0.06	1.18	2.76
8.0 mos.	7-1961	1.10 ± 0.08	1.18	2.76
8.0 mos.	3-1961	0.55 ± 0.10	1.23	2.50
8.8 mos.	6-1961	0.58 ± 0.06	1.14	2.66
10.0 mos.	1-1961	0.54 ± 0.08	0.64	2.35
10.0 mos.	4-1961	0.69 ± 0.09	1.22	2.90
10.5 mos.	10-1960	0.96 ± 0.10	1.32	2.34
12.0 mos.	9-1960	0.60 ± 0.07	1.57	2.42
12.0 mos.	7-1960	0.52 ± 0.07	1.01	2.61

TABLE 5c

Bone Samples with Diet Information
(12-24 months)

Age	Date of birth	Bone pc/g Ca	Diet 0-6 months pc/g Ca	Diet 6-12 months pc/g Ca	Diet 12-24 months pc/g Ca
14.0 mos.	8-1960	0.32 ± 0.09	0.51	1.00	2.18
14.0 mos.	11-1960	0.51 ± 0.10	1.20	2.13	3.62
15.0 mos.	8-1960	0.87 ± 0.10	1.20	2.13	3.62
15.0 mos.	12-1960	0.78 ± 0.07	1.20	2.13	3.62
16.0 mos.	2-1960	0.41 ± 0.09	1.20	2.13	3.68
20.0 mos.	1-1960	1.28 ± 0.07	1.20	2.13	4.23
17.5 mos.	12-1960	0.61 ± 0.04	1.20	2.13	3.62
22.5 mos.	4-1960	0.51 ± 0.06	1.20	2.13	4.08
24.0 mos.	7-1959	0.65 ± 0.06	1.20	2.13	3.66
24.0 mos.	8-1959	0.75 ± 0.04	1.20	2.13	3.88
24.0 mos.	9-1959	0.69 ± 0.09	1.20	2.13	3.29
24.0 mos.	7-1960	0.80 ± 0.13	1.60	2.05	3.53
24.0 mos.	7-1960	1.07 ± 0.07	0.90	1.47	3.68

TABLE 5d

Bone Samples with Diet Information
(24-36 months)

Age	Date of birth	Bone pc/g Ca	Diet 0-6 months pc/g Ca	Diet 6-12 months pc/g Ca	Diet 12-24 months pc/g Ca	Diet 24-36 months pc/g Ca
28.0 mos.	2-1959	0.53 ± 0.11	1.15	1.99	3.59	3.68
30.0 mos.	3-1959	1.10 ± 0.09	1.15	1.99	3.59	3.68
30.0 mos.	2-1960	0.91 ± 0.06	1.15	1.99	3.59	3.68
30.0 mos.	3-1960	0.61 ± 0.24	1.15	1.99	3.59	3.68
36.0 mos.	8-1958	0.83 ± 0.10	1.15	1.99	3.59	3.68
36.0 mos.	11-1958	0.55 ± 0.08	1.15	1.99	3.59	3.68

TABLE 6

Discrimination Factors for Age Groups

Group	Average Age (months)	Average Bone Sr^{90}/Ca, pc/g	L (0-6 mos.) pc/g Ca	L (6-12 mos.) pc/g Ca	L (12-24 mos.) pc/g Ca	L (24-36 mos.) pc/g Ca	L_M pc/g Ca	F
0-6	2.5	0.79	1.45	--	--	--	5.1	0.75
6-12	9.4	0.70	1.15	2.51	--	--	3.3	0.35
12-24	19.5	0.71	1.15	1.99	3.59	--	3.3	0.25
24-36	32.0	0.76	1.15	1.99	3.59	3.68	3.3	0.25

$\bar{\Delta}$ Ca 0-2.5 months - 12.5 grams

$\bar{\Delta}$ Ca 0-6 months - 30.4 grams; $\bar{\Delta}$ Ca 6-9.4 months - 17.3 grams

$\bar{\Delta}$ Ca 6-12 months - 30.4 grams; $\bar{\Delta}$ Ca 12-19.5 months - 25.0 grams

$\bar{\Delta}$ Ca 12-24 months - 39.6 grams; $\bar{\Delta}$ Ca 24-32 month - 17.9 grams

Strontium-90 Levels in the Diets and Bones of Children

PROGRESS REPORT - 1964

by D. Beninson, E. Ramos, and R. Touzet
Argentine CNEA*

Introduction

The 1962-1963 Progress Report summarized data on Sr-90 levels in bones and diets of children in Argentina and attempted an estimation of strontium to calcium discrimination factors as a function of age.

This report gives emphasis to subjects for which little or no information was included in the former report, namely:

a) Stable strontium levels in bones and diets and discrimination factors worked out from these data.

(With stable strontium, equilibrium conditions are insured.)

b) Up-dating information on Sr-90 in children's diet and estimation of changes in the 1962-1963 period.

c) Strontium-90 levels in stillbirth bones.

New data on bone from children having lived in the"controlled environment" are not included in the report, as they are at present being processed together with the corresponding individual dietary information, and only the raw results from measurements are available.

Detailed discussion and references on the material presented in the report can be found in a C.N.E.A. report now in publication. This paper, which gives due acknowledgement to A.E.C. support, will be shortly submitted as a complement of the present Progress Report.

Natural Strontium in Bones and Diets

a) Experimental Procedures

1. Measurements

Measurements were carried out with a modified Philips PW-1051 spectrometer, using a LiF monochromator, a W anticathode and a thin X-ray NaI detector with the corresponding electronics. The work was performed with an evacuated difraction chamber and a primary beam produced by 40 Kvolt and 20 mA.

Samples were placed on holders with a 30 mm diameter window. The primary beam definition was excellent, with an area of 240 mm^2. The goniometer was automatically driven and counting recorded between 20 and 30°. In our conditions strontium amounts are proportional to the 25.10° peak intensity, background subtracted.

* Comision Nacional de Energia Atomica

2. Standards

The matrix was PO_4HCa purified in our laboratory, to which Sr was added as PO_4HSr in variable concentrations (from 10 to 5000 ppm). Powders were reduced to 100-150 mesh and homogenized during 4 hours in a rotating blender. Several checks showed that measurements of different portions of the mixture were within the counting standard deviation.

3. Sample Preparation and Measurement

Samples were ashed and dissolved in nitric acid, and then insoluble phosphates were precipitated and dried and a graded powder prepared.

Strontium content in the phosphate powder is determined with the technique described; then the sample is redissolved, a calibrated amount of Sr is added and after reprecipitation the measurement is carried out again. This internal standard procedure has proved to be of importance in reducing interfering effects (blank effect, auto-absorption, etc.).

b) Natural Strontium in Bone

The results correspond to samples obtained in the Sr-90 survey during 1963.

Table I shows the stable strontium levels in stillbirths; standard deviation in the Sr/Ca results is estimated to range from 10 to 15%.

The average and standard error of the mean of the values are 0.23 ± 0.02 mg Sr/g Ca. The value is similar to others found in the literature. It is always puzzling to see that the scatter agrees well with that of parameters found for most environmental biological samples (standard error ~ 40%/Vn).

Table II presents results for children from 0 to 3 years of age. Values shown in Table II are means and standard errors for each age group.

Determinations in different bones from the same child show no significant variations within the skeleton. (Consistent with information available elsewhere.) The level of stable strontium appears to increase slightly with age.

Adult bones (ribs) were collected from several places in the country. The results are shown in Table III.

Although the corresponding diets are quite different, values do not show important scatter. No information is available at present on the Sr/Ca ratio in specific diets, but the average adult bone level (0.37 ± 0.01 mg Sr/g Ca) is in excellent agreement with the Buenos Aires diet value (~ 1.7 mg Sr/g Ca), assuming a discrimination factor of 0.23.

c) Natural Strontium in Diets and Discrimination Factors

Samples analyzed are suplicates of those used for the Sr-90 survey. The milk survey is quite extensive and the values are representative of the Buenos Aires milk-shed area. The coverage of formula milk and other preparations important in diets of children is also adequate.

Table IV shows the results for baby foods (means and standard errors).

We do not have at present good data on other individual food items; a large number of samples are under process. However, several composite diets have been analyzed. The composition of these samples were based on dietary information presented in the 1962-1963 Progress Report and results are shown in Table V.

The Sr/Ca ratio of bones can be related to those of diet with a crude model implied in the following expression:

$$(Sr/Ca)_{bone} = \frac{Ca_f \cdot R_M \cdot f_t + \sum_i Ca_i \cdot R_i \cdot f_i}{Ca_f + \sum_i Ca_i}$$

where Ca_f is the amount of fetal calcium (from placental origin),
R_M is the Sr/Ca ratio in the mother's diet,
f_t is the total discrimination-mother's diet to fetus,
Ca_i is the amount of calcium incorporated during period i,
R_i is the Sr/Ca ratio in the child's diet during period i,
f_i is the child's discrimination factor (diet-bone) during period i.

Data of Tables I, II, and V, together with information on the amounts of calcium involved, allows an estimation of the discrimination factors, as shown in Table VI. Calcium increments are those estimated in the 1962-1963 Report (based on 24 grams at birth and retention fitting the expression:

$$\frac{\text{Ca retained}}{\text{Ca ingested x Weight}} = \text{Constant}$$

which is fairly good in childhood).

Results agree quite well with those of the 1962-1963 Progress Report, derived from Sr-90 data. It should be pointed out that the calculation of discrimination factors shown above is iterative and that uncertainties pile up along the way. More significance, therefore, can be attached to values of D.F. for the younger age groups.

The total discrimination (mother's diet-fetal bone) is comparable to that observed in other species and to some published values for man.

<u>Strontium-90 in Diet</u>

Since the last Progress Report a considerable number of new data have become available. The principal aim pursued was to observe time-trends. Sampling and analytical procedures were those described in the 1962-1963 Progress Report.

a) Milk and Baby Foods Based on Milk Products

The milk survey is representative of the Argentine Littoral Area, Table VII gives the levels grouped by 6 month periods, together with fallout data.

Milk and fallout Sr-90 are believed to be related by the expression:

$$C = a D + b d,$$

where C is the average level of Sr-90 in milk (pc/g Ca),
D is the cumulative deposition (mc/Km^2),
d is the average Sr-90 fallout rate in the period (mc/Km^2/year),
and a and b are proportionality factors.

Using the data of Table VII, these proportionality factors, computed by multiple regression, are:

$$a = 0.27 \quad \text{and} \quad b = 0.42.$$

Using the expression shown above milk levels can be computed, the standard deviation of the estimate being ± 0.37 pc/g Ca.

Table VIII summarizes the results for special baby foods based on milk. As some brands are "fortified" with mineral or animal calcium and others contain cereal products, correlations with the levels of milk cannot easily be obtained. The scatter of individual samples was similar for the various brands, with standard deviations of 15 to 40% of the average.

b) Other Food Items

Values for other food items, including commercial preparations based on cereals, are shown in Table IX.

Scatter is larger than with milk products (sampling is poorer), and the standard deviations range from 20 to about 70%. Each entry corresponds to 10-50 samples.

Data of Tables VII, VIII, and IX, together with dietary information included in the last Progress Report, show that from 1961 to 1963 Sr-90/Ca in total children's diet has increased about 40% for all age groups.

At present a detailed calculation of Sr-90 daily intakes in different age groups (in the line of Table III of the last Report) is being prepared for 1962 and 1963, attempting a classification by regional diet types.

Strontium-90 in Stillborns

During 1963, 23 samples from stillbirths were analyzed for Sr-90. The group, which contained a few samples from subjects having lived up to 7 days, is well spread in time over the year. Table X summarizes the data.

The average level and its standard error are 0.77 ± 0.04 pc/g Ca. As the average Sr-90/Ca ratio in total adult diet in 1962-1963 was 7.1 pc/g Ca, a total discrimination (mother's diet-fetal bone) of 0.11 is computed. This value is in excellent agreement with the one derived from natural strontium measurements.

TABLE I

Stable Strontium in Stillbirths

Sample code		Ca % (in ash)	Sr ppm (in ash)	mg Sr / g Ca
S/Sr-1963	4	27.5	70	0.25
	23	31.8	30	0.10
	25	34.1	40	0.12
	27	32.0	60	0.19
	30	34.6	30	0.23
	31	34.2	70	0.21
	34	35.7	70	0.20
	35	32.0	50	0.17
	39	34.4	70	0.20
	40	33.2	70	0.21
	41	32.3	50	0.16
	56	21.7	100	0.46
	57	31.7	70	0.22
	58	33.0	70	0.21
	59	24.9	120	0.48
	69	35.7	82	0.23
	70	32.7	83	0.25
			MEAN ± S.D.	0.23 ± 0.10

TABLE II

Stable Strontium in Children's Bones

Age group	Number of samples	Mean of age	Ca % (in ash)	Sr ppm (in ash)	mg Sr / g Ca
0-3 mos.	19	30 days	28.5	77	0.25 ± 0.02
3-6 mos.	16	114 days	30.0	87	0.29 ± 0.04
6-9 mos.	12	243 days	35.7	85	0.24 ± 0.02
9-12 mos.	15	349 days	31.9	71	0.31 ± 0.02
12-24 mos.	3	18 mos.	36.0	110	0.32 ± 0.05
24-36 mos.	5	34 mos.	34.7	142	0.41 ± 0.07

TABLE III

Adults Bones (Ribs)

(Age 20 and Up)

Sample Code	Age	Ca % (in ash)	Sr ppm (in ash)	mg Sr / g Ca
S/Sr-1963				
10	37	32.0	130	0.41
11	48	34.2	160	0.47
12	47	31.8	110	0.35
13	65	33.0	120	0.36
14	37	31.2	140	0.45
15	62	34.0	180	0.53
16	49	33.7	150	0.44
18	51	30.9	120	0.39
19	72	32.8	100	0.31
20	29	30.2	100	0.33
42	37	34.3	130	0.38
43	51	35.3	100	0.28
44	69	36.0	130	0.36
45	68	34.0	130	0.38
46	67	35.0	140	0.40
47	54	34.0	140	0.41
49	42	34.0	130	0.38
50	57	30.4	80	0.27
52	58	35.0	140	0.40
72	20	33.1	70	0.21
74	34	33.5	110	0.33
75	72	32.5	100	0.31
77	57	34.2	170	0.50
81	23	33.1	120	0.36
83	58	34.1	150	0.44
84	60	32.5	80	0.25
			MEAN ± S.D.	0.37 ± 0.08

TABLE IV

Mean Stable Strontium in Baby Foods

	Number of samples	Ca % (in ash)	Sr ppm (in ash)	mg Sr / g Ca
Milk	24	15.0	140	0.95 ± 0.08
Baberlac comp.	10	11.8	123	0.85 ± 0.09
Milk Nido	10	11.3	140	1.26 ± 0.21
Eledón con fécula y glúcidos	10	15.6	116	0.92 ± 0.06
Baberlac simple	10	11.3	171	1.50 ± 0.20
Biberol	9	14.2	70	0.48 ± 0.08
Yogalmina	10	15.2	90	0.59 ± 0.09
Levulosa	10	17.4	200	1.15 ± 0.05
Osteolact	10	15.3	110	0.72 ± 0.06
Secalbum	10	25.2	551	2.28 ± 0.38
Nestógeno	10	13.7	140	1.02 ± 0.15
Nestún	10	6.4	170	2.65 ± 0.40
Eledón con fécula	10	14.6	100	0.69 ± 0.05
Quaker	7	3.13	310	9.91 ± 1.10
Farex	10	25.0	200	0.80 ± 0.06

TABLE V

Stable Strontium in Total Diet[1]

Age Group	mg Sr/g Ca	Calcium intake (g/day)	Strontium intake (mg/day)
0-3 mos.	0.69[2]	1.00	0.69
3-6 mos.	0.97[3]	0.99	0.96
6-9 mos.	1.21	0.84	1.02
9-12 mos.	1.24	0.86	1.07
12-24 mos.	1.31	0.72	0.94
24-36 mos.	1.35	0.68	0.92
Adults	1.75	0.70	1.22

(1) Diet composition based on Table III of 1962-1963 Progress Report.
(2) The value is computed from measured diet and 47% of breast feeding calcium contribution, assuming an OR (diet mother-milk) of 0.12.
(3) The value includes breast feeding (17% of calcium intake) in the way shown above.

TABLE VI

Discrimination Factors

Age Group	D. F.
stillbirth	0.13*
0-3 months	0.81
3-6 months	0.49
6-9 months	0.50
9-12 months	0.28
12-24 months	0.30
24-36 months	0.22

* This is the total discrimination mother's diet-fetal bone.

TABLE VII

Fallout and Sr-90 in Milk

Period	Cummulative deposition (mc/Km^2)	Average Fallout Rate (mc/Km^2 year)	Average level in milk (pc/g Ca)
1st semester 1960	6.8	0.60	1.63
2nd semester 1960	7.1	1.02	2.14
1st semester 1961	7.7	0.96	1.85
2nd semester 1961	8.0	1.40	3.22
1st semester 1962	8.8	0.70	3.05
2nd semester 1962	9.4	2.68	3.54
1st semester 1963	10.6	1.15	3.31
2nd semester 1963	11.5	2.21	4.17

TABLE VIII

Baby Foods (pc Sr^{90}/g Ca)

Brand	1961	1962	1963
Baberlac compuesto	1.05	1.47	2.32
Eledón con fécula	0.85	2.65	2.37
Eledón con fécula y glúcido	4.02	2.37	2.41
Baberlac simple	3.52	3.48	3.72
Nestógeno	3.19	3.68	3.00
Casenolín	1.85	0.49	1.51
Secalbum	0.82	0.51	0.26
Yogalmina	2.96	2.98	2.23
Leche Nido	2.17	1.88	2.37
Leche Kasdorf	5.03	4.61	5.20
Leche S.M.A.	3.14	3.13	2.82
Leche Cundor	2.60	2.60	2.83
Osteolack	3.03	3.79	3.32

TABLE IX

Other Foods (pc Sr^{90}/g Ca)

	1961	1962	1963
Flour	15.58	19.91	18.20
Semolina	17.93	22.41	20.11
Farex	0.80*	0.95	0.64
Maizena	3.85	2.75	--
Quaker	8.18	8.18	10.26
Potato	14.85	18.47	18.24
Calabash	3.15	8.44	5.31
Onion	12.80	16.07	14.63
Tomato	23.95	28.94	25.95
Pool of vegetables**	6.45	8.06	8.60
Banana	5.90	6.42	6.04
Apple	6.26	7.77	7.40
Eggs	5.24	6.55	7.01

* The 1962-1963 Progress Report has an incorrect value for the 1961 level.
** Pooled according to consumption (1962-1963 Progress Report).

TABLE X

Strontium-90 in Stillborn

Sample Code	pc/g Ca	% Ca in ash	Month of death
213	0.58	45.7	2
215	0.62	27.5	5
216	0.62	34.1	5
233	0.55	34.5	6
240	0.59	35.0	6
241	0.50	34.0	8
244	0.46	31.8	6
246	0.61	34.0	8
248	0.57	34.0	8
249	0.88	29.4	8
254	0.71	34.6	8
254A	0.62	34.0	8
255	0.86	34.2	8
218	0.33	32.8	6
245	0.55	33.8	8
258	0.74	35.7	8
266A	1.04	34.4	9
266	1.19	36.0	9
267	1.15	33.2	9
268	0.83	32.2	10
268A	1.12	32.3	10
275	1.30	21.7	10
276	1.21	31.7	11

Strontium-90 In Diet and Bone of San Juan, Puerto Rico Residents Of Low Income

by J. Rivera - (HASL)

The results of the Sr-90 analyses of specimens of human vertebrae from New York City, Chicago, and San Francisco for 1962 and 1963 were presented in HASL-146[1]. The relations between the observed Sr-90/Ca levels in the specimens and the estimated dietary intakes of Sr-90 and Ca at the three cities was described.

In addition to obtaining vertebrae at the above mentioned cities, HASL has also been obtaining specimens from accident victims who resided in San Juan, Puerto Rico prior to death. Results of the analyses of these samples are presented in Table 1. A comparison of average Sr-90/Ca ratios found in specimens from New York City and those from San Juan is shown below:

Average pc Sr-90/g Ca in Human Vertebrae

	1961		1962		1963	
Age	NYC	SJ	NYC	SJ	NYC	SJ
4-20	1.24 (35)	1.14 (23)	1.64 (37)	1.47 (33)	1.97 (27)	2.18 (69)
> 20	0.83 (7)	0.82 (33)	0.90 (14)	1.33 (12)	1.55 (23)	1.62 (26)

( ) = number of samples.

It is evident that the concentrations of Sr-90 in bones obtained in Puerto Rico have been about the same as those from New York City. Based on the considerations discussed in HASL-146, the Sr-90/Ca ratio of the diet in San Juan can therefore be assumed to have been about the same as that in New York City i.e., 10, 13, and 30 pc/g Ca for 1961, 1962 and 1963 respectively[3].

To verify the similarity of Sr-90/Ca ratios in the New York City and San Juan diets, an estimate of the intake of Sr-90 and Ca by San Juan residents of low income was made in June 1961[2]. It was found that although Sr-90 intake was about half that in New York City at that time, Ca intake was also half as great and, therefore, the Sr-90/Ca ratio of the diet was close to that estimated for New York City.

To further substantiate these findings, another sampling and analyses of foods from San Juan was done in August 1962. The results of the two surveys are presented in Table 2. Once again it was found that on a pc/day basis the intake of Sr-90 for the low income San Juan residents was lower than that for the New York City population, but the Ca intake was correspondingly lower so that the Sr-90/Ca ratio of the diets from the two cities were again about the same.

The food samples listed in Table 2 have also been analyzed for stable strontium. The estimated Sr/Ca ratio of the diet based on these analyses is 1.71 mg/g[3]. Stable strontium determinations have been also made on 12 adult bone specimens from San Juan. The average Sr/Ca ratio found is 0.42 ± 0.24 mg/g. The diet-bone observed ratio calculated from these results is 0.25. This result is in excellent agreement with the accepted value of the diet-bone Observed Ratio[4] and suggests therefore that the actual diet composition of the population studied is similar to that estimated.

The results presented here, emphasize the importance of obtaining information on Ca intake as well as Sr-90 intake to estimate the potential hazards of fallout to a given population.

References

(1) USAEC Report No. HASL-146, p. 236, July 1, 1964.
(2) USAEC Report No. HASL-122, p. 183, April 1, 1962.
(3) USAEC Report No. HASL-147, HASL Contributions to the Study of Fallout in Food Chains, Joseph Rivera and John H. Harley, July 1, 1964.
(4) Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Supplement No. 16, (A/5216), p. 312, (1962).

TABLE 1

pc Sr^{90}/g Ca in Human Vertebrae of Low Income Residents Of San Juan, Puerto Rico

Age	1961	1962	1963
4-6	0.93	1.80 (2)	2.85 (3)
6-8	1.38	--	1.75 (2)
8-10	0.80	1.54 (3)	2.61 (10)
10-12	1.06 (5)	1.19	2.26 (7)
12-14	1.12 (2)	1.42 (2)	2.39 (7)
14-16	1.69	1.45 (9)	2.30 (12)
16-18	1.41 (3)	1.20 (5)	1.89 (14)
18-20	1.07 (9)	1.56 (11)	1.84 (14)
20-40	0.93 (12)	1.33 (12)	1.61 (24)
40-60	0.69 (16)	--	1.68 (2)
> 60	0.96 (5)	--	--
Weighted Averages			
0-4	--	--	--
4-20	1.14 (23)	1.47 (33)	2.18 (69)
> 20	0.82 (33)	1.33 (12)	1.62 (26)

( ) = number of samples.

TABLE 2

ANNUAL Sr-90 AND Ca INTAKE OF SAN JUAN P. R. RESIDENTS OF LOW INCOME

CATEGORY	ITEMS IN COMPOSITE	kg/yr	g Ca/yr	-- pc Sr-90/yr -- 6/61	8/62
Dairy Products	Liquid milk	68	66.6	183	313
Rice	Rice	65	52.6	85	286
Beans	Beans	22	22.2	374	147
Codfish	Codfish	10	9.1	10	1
Vianda	Plantains, bananas, and yautia	55	9.9	457	1012
Vegetables	Pumpkins, onions	6	2.6	11	34
Fruits	Mangos, oranges, guanabana and mamey	25	5.8	150	95
Bakery Prod.	Bread	20	16.2	70	172
TOTAL			185	1340	2060
			pc/day	3.7	5.6
			pc/g Ca	7.2	11.1

Cesium-137, Stable Strontium and Radium-226 in Two Human Skeletons

by J. Rivera - (HASL)

To estimate the total amount of a given nuclide in the whole skeleton from its concentration in a single bone, the intraskeletal distribution of the nuclide must be known. For bone seeking nuclides present in the diet at the same levels since birth, it is reasonable to assume that the concentrations in every bone of the skeleton per gram of calcium will be the same. On the other hand for nuclides whose level in the diet has not been constant, the concentrations in different bones within the skeleton can be expected to be different due to differences in the rates of metabolic processes taking place in each bone.

In HASL-144[1] the distribution of Sr-90 in the skeletons of two adult Milwaukee, Wisconsin residents who died in 1960 and 1961 were reported[2]. It was found that Sr-90 was present in higher concentrations in spongy bone such as vertebrae or ribs, than in cortical bone such as the skull or the shafts of long bones. These findings were as expected, since spongy bone has a higher turnover rate than cortical bone and therefore is closer to equilibrium with mineral levels in the current diet than is cortical bone.

Portions of the ashed components of the two skeletons previously analyzed for Sr-90 and Ca were also analyzed for Cs-137, stable strontium and Ra-226. The results of these analyses and the estimated amounts of these nuclides in the skeletal components are summarized in Table 1.

Cesium-137

The intraskeletal distribution of Cs-137 was quite variable in each of the two skeletons. In skeleton #1 the highest Cs-137 concentrations were found in the rib and "other bones" components. This might have been due to the higher metabolic activity of these bones as compared to that of the other skeletal components with more cortical bone. Skeleton #2 also had a relatively high Cs-137 concentration in the rib component but the skull also had a high concentration. Since the skull presumably consists of primarily cortical bone this result was surprising. One possible explanation is that the entire skull was not obtained and a non-representative part may have been ashed and analyzed.

Anderson and Gustafson[3] have reported Cs-137 concentrations in human rib of the order of 0.5 pc/g ash for Chicago residents who died during the period from April to August 1961. The observed concentration of 0.32 pc/g ash in the rib component of skeleton #2 is in good agreement with their results.

From whole body counting measurements the average Cs-137 body burdens of eight Chicago residents in July 1960 and April 1961 were about 6000 and 4000 pc respectively[4]. If these values are assumed to have been the body burdens of subjects #1 and #2 prior to death, then the fraction of the burden in their skeleton was about 2 and 5% respectively. The latter estimate is probably on the high side since as has been mentioned the observed concentration in the skull of this subject was anamolously high. From these results and taking into account the possibility that some Cs-137 may have been lost due to volatilization, the fractional Cs-137 content of the skeleton is estimated to be about 3%.

Nay, Stahlhofen, and Kaul[5] have reported preliminary results indicating that in the spring of 1964 the relative fraction of Cs-137 in the skeleton was about 1%. This estimate is probably a little on the low side since they assume that the Cs-137 concentration in the skeleton as a whole is the same as that found in femur shafts. Their findings are therefore also consistent with an estimate of a skeletal Cs-137 content of from 1 to 5% of the whole body burden.

Stable Strontium and Radium-226

The intraskeletal distribution of stable strontium in the two skeletons was fairly constant. Skeleton #2 had concentrations of stable strontium similar to those previously reported[6, 7], but skeleton #1 had much higher concentrations.

Radium-226 was also fairly uniformly distributed within the two skeletons, with levels similar to those previously found in adult vertebrae[8].

It has been shown that the Sr/Ca discrimination factor from diet to bone is about 4[9] while the Ra/Ca discrimination factor is about 64[8]. The average diet Sr/Ca ratio in the United States is probably about 1.8 mg/g and the average Ra-226/Ca ratio in the diet is about 1.9 pc/g[10], hence expected skeletal ratios for these nuclides are 0.45 mg Sr/g Ca and 0.03 pc Ra-226/g Ca.

The observed skeletal ratios in skeleton #1 were 2327/937 = 2.48 mg Sr/g Ca, and 70.3/937 = 0.075 pc Ra-226/Ca. Skeleton #2 had ratios of 575/1225 = 0.47 mg Sr/g Ca and 49.0/1225 = 0.04 pc Ra-226/g Ca. These data suggest that subject #2 probably had a diet similar to the estimated United States average diet while subject #1 had a diet probably below average in Ca and above average in stable strontium and Ra-226.

It would be improper to overestimate the validity of conclusions drawn from the analyses of only two skeletons. The data presented here, however, support the following beliefs:

1. There are not large ($>$ than a factor of 2) differences in the concencentrations of stable strontium or radium-226 from one bone to another within an individual skeleton.

2. For nuclides whose concentration in the diet has varied considerably during the life of the subject, such as Sr-90 or Cs-137 differences in concentrations from bone to bone within the skeleton greater than a factor of two are likely to exist.

3. The skeletal content of Cs-137 was probably about 3% of the whole body burden, during the period 1960 to 1964.

References

(1) USAEC Report No. HASL-144, p. 278, April 1, 1964.

(2) The specimens were from dissected cadavers which had been stripped of soft tissues, but not thoroughly cleaned. The stripped cadavers were soaked in isopropal alcohol for dehydration and in Stoddard's solution to remove all fat before being sent to HASL. Upon receipt each skeleton was divided into seven parts and each part was then ashed in silica trays in a muffle furnace overnight at 500°C.

(3) Anderson, R.W. and Gustafson, P.F., "Concentration of Cesium-137 in Human Rib Bone", Science 137, p. 668, February 26, 1962.

(4) Miller, C.E. and Corcoran, J.B., In Vivo Measurement of Cs-137: Summary Of Observations Up to June 1961, Argonne National Laboratory Semi-annual report January through June 1961, ANL-6398.

(5) Nay, Stahlhoven, W. and Kaul, A., Distribution of Caesium-137 in Samples Consisting of Soft Tissue, Bone and Bone-marrow, (Preliminary results); Presented at the symposium at Heidelberg on the Assessment of Radioactive Body Burdens in Man, May 1964.

(6) USAEC Report No. HASL-138, p. 235, July 1, 1963.

(7) USAEC Report No. HASL-140, p. 303, October 1, 1963.

(8) Hallden, N., Fisenne, I., and Harley, J.H., "Ra-226 in Human Diet and Bone", Science 140, p. 1327, June 21, 1963.

(9) Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Supplement No. 16, (A/5216), p. 336, (1962).

(10) USAEC Report No. HASL-147, Contributions to the Study of Fallout in Food Chains, July 1, 1964.

Table 1

Cesium-137, Stable Strontium, and Radium-226 Distribution in Two Adult Human Skeletons

	g/ash	Cs^{137} pc/g	Cs^{137} pc	Sr mg/g	Sr mg	Ra^{226} pc/g	Ra^{226} pc
1. 60 Year Old Male, Died 7/60, Wisconsin							
Hands & Feet	216	0.037	7.9	1.00	216	0.034	7.24
Skull	375	0.036	13.6	0.77	289	0.030	11.3
Vertebrae	246	0.046	11.2	1.34	330	0.023	5.58
Ribs	159	0.077	12.3	0.89	141	0.024	3.74
Long Bone - shafts	338	0.032	10.7	0.82	278	0.028	9.57
Long Bone - ends	766	0.023	17.4	0.80	611	0.032	24.5
Other Bones (Sternum, Pelvis, etc.)	357	0.082	29.2	1.23	462	0.023	8.35
TOTAL SKELETON	2457	0.042	102	0.95	2327	0.029	70.3
2. 40 Year Old Male, Died 4/61, Wisconsin							
Hands & Feet	285	0.041	11.6	0.19	54.9	0.019	5.42
Skull	499*	0.234	117	0.20	97.9	0.013	6.37
Vertebrae	327*	0.004	1.5	0.14	44.5	0.018	5.85
Ribs	187	0.320	59.8	0.15	28.8	0.017	3.24
Long Bone - shafts	453	0.023	10.2	0.21	94.6	0.012	5.53
Long Bone - ends	1012	0.009	9.1	0.18	185	0.014	13.7
Other Bones (Sternum, Pelvis, etc.)	490	0.022	11.0	0.14	69.3	0.018	8.92
TOTAL SKELETON	3253	0.068	220	0.18	575	0.015	49.0

*Estimated by comparison with I.

Possible Pu^{238} Distribution from a Satellite Failure

by John H. Harley (HASL)

In April of 1964, an isotope-powered satellite failed to orbit and apparently re-entered the atmosphere over the Southern Indian Ocean. The power unit contained about 17,000 curies of plutonium-238 and therefore had a mass of about a kilogram. It is apparent that the tracing of this material is of extreme interest, both for satellite re-entry burnup studies and for fallout studies.

Possible Fate of the Debris

The complete burnup of the capsule could result in conversion of the isotope fuel to submicron particles of plutonium oxide, possibly mixed with material from other parts of the satellite. If burnup did not occur, the capsule would have disappeared into the Indian Ocean. Intermediate cases, such as partial burnup and formation of large particles would most likely result in rapid fallout over a limited area.

Considering only the problems of tracing the debris, the best conditions would be the complete burnup to submicron particles at an altitude of perhaps 150,000 feet. Our experience with the rhodium-102 released in 1958 and the cadmium-109 released in 1962 would then allow us to make some estimates of the possible fate of the debris.

If we assume that the material is distributed uniformly throughout the entire atmosphere, the resulting concentration would be about 0.2 dpm/1000 standard cubic feet. If, however, the material is pictured as mixing downward from an altitude of 150,000 feet to the tropopause so as to give a uniform concentration per unit mass of air, we can make an estimate of the concentrations at various altitudes in the stratosphere. Then if the past data on strontium-90 and other nuclides are indicative we can assume that the concentration in the troposphere is about 1/200 to 1/500 the concentration in the lower stratosphere. Based on our experience with high altitude nuclear tests, it is possible to estimate the arrival time of the debris. These predictions of concentrations and arrival times at different altitudes are given in Table 1.

Preliminary cadmium-109 data from balloon and aircraft sampling confirm the order of magnitude of the estimated concentrations given in Table 1. The total cadmium-109 radioactivity produced in 1962 was about ten times as great as the Pu^{238} radioactivity from the satellite. Cadmium-109 appeared in balloon samples taken at 105,000 feet over Mildura, Australia about five months after injection and remained at the level of about 100 dpm/1000 standard cubic feet for a few months. It appeared later at lower altitudes over Mildura and at lower concentrations over San Angelo, Texas. The first detection by aircraft was indicated to be about one year after the injection.

If the altitude of burnup was below 150,000 feet, the debris should be detected earlier, perhaps as soon as two months after injection. Nonuniformity of distribution would give increased concentrations in the region containing the debris but would also mean that the plutonium would be harder to detect outside this particular region.

<u>Sampling Systems</u>

The AEC balloon sampling program is designed to make collections up to 105,000 feet at San Angelo, Texas and Mildura, Australia. Experimental flights have been carried out to almost 130,000 feet but they are not fully operational. Sampling at Mildura was doubled at the higher altitudes in

May to assist in detection. Balloon samplers collect duplicate filters of 500 to 1000 standard cubic feet at 105,000 feet and larger volumes at lower altitudes. Thus, one to two dpm of Pu^{238} per thousand standard cubic feet would be readily detectable.

Stardust, the aircraft sampling conducted by the Defense Atomic Support Agency, collects filter samples up to about 70,000 feet. The volume sampled ranges from 10,000 to 100,000 standard cubic feet and as little as 0.01 dpm/1000 standard cubic feet should be detectable. A special series of daily flights was conducted for one week following the loss of the satellite. Sampling was carried out from Australia to about 10° South latitude to increase the probability of detection of larger particles resulting from partial burnup. No significant levels above background were found. Sampling flights are continuing.

Ground level sampling along the 80th Meridian West is carried out under HASL. Weekly filter samples of about 10,000 cubic meters (250,000 cubic feet) are taken. The predicted level of Pu^{238} which will eventually appear at ground level should be detectable. Other laboratories have ground level air filters which collect up to ten times as much sample.

The possibility of detecting Pu^{238} in deposition collectors is much more doubtful. It is possible that some measurements on composites or large area samples will be made.

Background Levels

There is no widespread network that has been collecting data on plutonium-238 in the atmosphere from past weapons tests. There are, however, some measurements which allow us to calculate the possible Pu^{238} concentrations that existed before the satellite loss. First we have the widespread data on strontium-90 which is the basis for most fallout studies. Many measurements of Pu^{239} concentrations indicate that this nuclide is present at about two percent of the level of strontium-90 in the atmosphere. A smaller number of measurements indicate the Pu^{238} concentrations to be a few percent of the Pu^{239} levels. These data allow us to make the estimates of inventories and concentrations given in Table 2.

Conclusions

If the burnup conditions occurred as described here, it is very likely that the Pu^{238} from the satellite failure will be detected by existing sampling systems. It is intended that a sufficient number of measurements be made to allow a broad evaluation of the transfer of this material from the place of burnup to the surface of the earth.

Acknowledgement

A considerable amount of this material, including the calculations, was collected by Mr. J. Z. Holland from the Division of Biology and Medicine, U. S. Atomic Energy Commission, Washington.

Table 1

Estimates of Pu^{238} Distribution

Altitude (feet)	Concentration dpm/1000 scf	Approximate Arrival Time
150,000	100	- -
100,000	10	Late 1964
70,000	4	Early 1965
40,000 (Mean Tropopause)	1	Late 1965 to Early 1966
Ground Level	0.01	Early 1966

Table 2

Background Levels - Early 1964

	Sr^{90}	Pu^{239}	Pu^{238}
Total atmospheric inventory (curies)	5×10^6	1×10^5	1 to 7×10^3
Stratospheric Concentrations (dpm/1000 scf):			
Northern Hemisphere	200-1500	4-30	0.04 - 2
Southern Hemisphere	50-500	1-10	0.01 - 0.5
Ground Level air concentration (dpm/1000 scf):			
Northern Hemisphere	1-2	0.02-0.04	2 to 30×10^{-4}
Southern Hemisphere	0.1-0.3	0.002-0.006	0.2 to $4 \times 10^{-}$

Measured Levels of Plutonium-238 and Plutonium-239 In the Stratosphere

by L.P. Salter - (HASL)

Since the failure of a satellite device containing about 17 kilocuries of plutonium-238 in April 1964[1], samples collected under the High Altitude Balloon Sampling Program have been analyzed for Pu-238 and Pu-239 + Pu-240. Additional samples collected before the incident also have been analyzed to obtain background information on the concentrations in the atmosphere due to past weapons testing.

Partial results of analyses from samples collected at 65°N, 31°N, and 34°S are now available and are summarized in Table 1. Pu-238 concentrations and the ratios of Pu-238/Pu-239 + Pu-240 and Pu-239 + Pu-240/Sr-90 are presented.

Radiochemical separations for plutonium isotopes and other radionuclides are performed by Isotopes, Inc. A small quantity of Pu-236 is added to determine the recovery on the plated plutonium sources. Alpha spectra are obtained by counting with a 450 mm^2 silicon surface barrier detector in conjunction with a multi-channel analyzer for pulse height analysis. The counts under the peaks at 5.14 Mev from Pu-239 + Pu-240, 5.48 Mev from Pu-238, and 5.75 Mev from Pu-236 are summed, normalized for 100% recovery of Pu-236 and corrected for counting efficiency.

Plutonium results reported in Table 1 for samples collected prior to the satellite failure were obtained by counting at Isotopes, Inc.; results for those collected after the incident, by counting at HASL. Intercalibration results given below indicate that little bias exists between the two laboratories:

Pu-238 (dpm)		Pu-239 + Pu-240 (dpm)	
II	HASL	II	HASL
0.72C	0.92C	35B	52C
0.38C	0.28B	6.7B	6.0B
0.31B	0.34B	7.3B	6.0
0 ± 0.1	0.08C	1.5B	1.2B
0 ± 0.1	0.05C	0.62B	0.61
0 ± 0.1	0.05C	0.16C	0.06B

Standard deviations due to counting less than 10% except as follows:

B: 10-20%
C: 20-50%

Data from several blank filters interspersed among the samples give an analysis background with a sample standard deviation of 0.05 ± 0.05 dpm for Pu-238 and 0.10 ± 0.10 dpm for Pu-239 + Pu-240. The following table presents the analysis background in concentration units for samples with typical volumes from 65, 80, 90, and 105 kilofeet:

Altitude (kilofeet)	Typical Volume (10^3 SCF)	Pu-238 (dpm/10^3 SCF)	Pu-239 + Pu-240 (dpm/10^3 SCF)
65	2.50	0.02 ± 0.02	0.04 ± 0.04
80	1.67	0.03 ± 0.03	0.06 ± 0.06
90	1.25	0.04 ± 0.04	0.08 ± 0.08
105	0.62	0.08 ± 0.08	0.16 ± 0.16

In view of the activity levels observed in these control samples, many of the Pu-238 and Pu-238/Pu-239 + Pu-240 ratios presented in Table 1 should be considered upper limits, especially at the higher altitudes.

The data for March and April indicate that measured levels of Pu-238 from weapons debris are at least a factor of 10-100 below those calculated on the assumption of complete burn-up of the satellite capsule at 150 kilofeet(1). For May, June, and July, the data show that there have been no significant increases in the Pu-238 concentrations or Pu-238/Pu-239 + Pu-240 ratios since the early spring. This suggests that through July no material from the device had arrived below 110 kilofeet at any of the three latitudes sampled.

Analyses for the plutonium isotopes will continue since the High Altitude Balloon network presents one of the best opportunities for early detection of the satellite fuel if complete burn-up did occur in the stratosphere.

Reference

(1) Harley, J.H., "Possible Pu-238 Distribution from a Satellite Failure", USAEC Report No. HASL-149, p. 138, October 1, 1964.

Table 1

Isotopic Plutonium Levels in High Altitude Balloon Samples

		1963 Dec	1964 Mar	Apr	May 1-15	May 16-31	Jun	Jul
65°N								
105	Pu-238 (dpm/10^3SCF)						0.06D	0.12C
	Pu-238/Pu-239[a]						0.05D	0.19C
	Pu-239/Sr-90						0.014	
90	Pu-238 (dpm/10^3SCF)				0.13C	0.09C	0.14C	0.08C
	Pu-238/Pu-239				0.06C	0.10C	0.10C	0.09C
	Pu-239/Sr-90					0.012	0.012B	
80	Pu-238 (dpm/10^3SCF)				0.19C	0.28B	0.25B	0.15B
	Pu-238/Pu-239				0.07C	0.08	0.10B	0.09B
	Pu-239/Sr-90					0.016	0.014B	
31°N								
105	Pu-238 (dpm/10^3SCF)		0.3D	0±0.5		(0.18D)[b]	0.09C	0.15C
	Pu-238/Pu-239		0.5D	0±0.6		(0.14D)[b]	0.08C	0.09C
	Pu-239/Sr-90	(0.022)[b]	0.012B	0.013B		(0.020B)[b]		
90	Pu-238 (dpm/10^3SCF)			0±0.2	0.02C		0.09C	0.13C
	Pu-238/Pu-239			0±0.2	0.02C		0.07C	0.08C
	Pu-239/Sr-90	0.019		0.016B	0.008		0.010B	0.010
80	Pu-238 (dpm/10^3SCF)			(0±0.3)[b]	0.22B		0.27	0.33B
	Pu-238/Pu-239			(0±0.2)[b]	0.12B		0.04	0.05B
	Pu-239/Sr-90	0.024		(0.014C)[b]	0.010		0.012	
65	Pu-238 (dpm/10^3SCF)	0.56B	0.18C		0.16C		0.25B	0.32C
	Pu-238/Pu-239	0.02B	0.01C		0.02C		0.02B	0.02B
	Pu-239/Sr-90	0.020	0.015	0.019				
34°S								
105	Pu-238 (dpm/10^3SCF)		0±0.2			0.07C	<0.1[c]	(0.10B)[d]
	Pu-238/Pu-239		0±0.3		0.02D	0.09C	<0.3[c]	0.08B
	Pu-239/Sr-90	0.021B	0.008C	0.011C		0.010	0.008	
90	Pu-238 (dpm/10^3SCF)			0±0.1		0.05C	0.11B	0.05C
	Pu-238/Pu-239			0±0.08	0.07C	0.07C	0.07B	0.04C
	Pu-239/Sr-90	(0.010)[b]		0.008B		0.007B	0.008	
80	Pu-238 (dpm/10^3SCF)		0±0.1	0±0.1		0.07C	0.05B	0.10C
	Pu-238/Pu-239		0±0.08	0±0.05	0.07C	0.07C	0.06B	0.07C
	Pu-239/Sr-90	0.013	0.008	0.009			0.008	
65	Pu-238 (dpm/10^3SCF)		0.11C	0.15C		0.09B	0.14B	0.11B
	Pu-238/Pu-239		0.08B	0.07C		0.04B	0.05B	0.04B
	Pu-239/Sr-90	0.013	0.009	0.010			0.010	

a Pu-239 + Pu-240 is referred to as Pu-239 throughout.
b Chemical recovery is less than 30%.
c Peak at ~5.4 Mev indicates a contaminating radionuclide in the Pu-238 region. Upper limits based on the total count under the Pu-238 peak are given.
d Volume uncertain.

Standard deviations due to counting are less than 10% except as indicated below:

B	10-20%
C	20-50%
D	50-100%

Cumulative Deposition of Strontium-90 Along a Mid-United States Constant Precipitation Transect

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Since precipitation is the most important single parameter responsible for the deposition of tropospheric nuclear debris, it was considered desirable to study strontium-90 fallout along a latitudinal transect where the variation in mean annual rainfall was minimal. In 1958, Dr. Lester Machta and staff of the U.S. Weather Bureau, Office of Special Projects, provided a list of precipitation measurement stations extending from the Gulf of Mexico, south of Houston, Texas to the south shore of Lake Superior in Michigan that could serve as suitable soil sampling sites for this investigation. During the spring of that year soil samples were taken at eighteen of the sites by Dr. Lyle T. Alexander. The samples were analyzed for strontium-90 at the Health and Safety Laboratory. Locations of the sampling sites are shown in Figure 1. Two additional samplings were carried out in 1961 and 1962, just prior to and during a period of intense nuclear testing.

The site locations, sampling dates and the results of cumulative strontium-90 deposition measurements are given in Table 1. The cumulative precipitation from January 1, 1953 to the sampling date for each site is also listed. Variability in mean annual rainfall along the latitudinal transect is shown in Figure 2 for three periods, namely, long term, during the period of sampling, and over the ten year period from 1953 through 1962. On the average, precipitation was slightly higher during the sample collection period but for the purposes of this study, variations between the three measurement intervals and along the transect were considered to exert a negligible effect upon the cumulative strontium-90 deposition values.

The cumulative strontium-90 levels for each sampling period are graphed as a function of latitude in Figure 3. The shaded areas encompass all of the analytical results for each sampling and were drawn to reflect as well as possible the deposition trend. It is at once clear that the heaviest fallout of strontium-90 has occurred in the mid-latitudes of the United States with the maximum at about 37°. There is a tapering off toward the northern and southern boundaries with the lowest deposition of strontium-90 occurring in the southern latitudes.

An attempt to relate incremental deposition with latitude quantitatively, proved inconclusive. It is anticipated that further sampling along this transect will be carried out during the testing moratorium. It should then be possible to see whether the strontium-90 fallout increment between 1962 and 1965 will show the same latitudinal pattern. This would yield information on the sources of the debris causing the observed increased fallout in the mid latitudes. For the time being, however, definitive conclusions from the available soil measurements cannot be drawn as to whether the debris from Nevada or from testing outside the continental United States has made the more significant contribution to the preferential deposition of strontium-90 in the mid-latitudes.

Figure 1 - Locations of Soil Sampling Sites Along a Mid-United States Constant Precipitation Transect

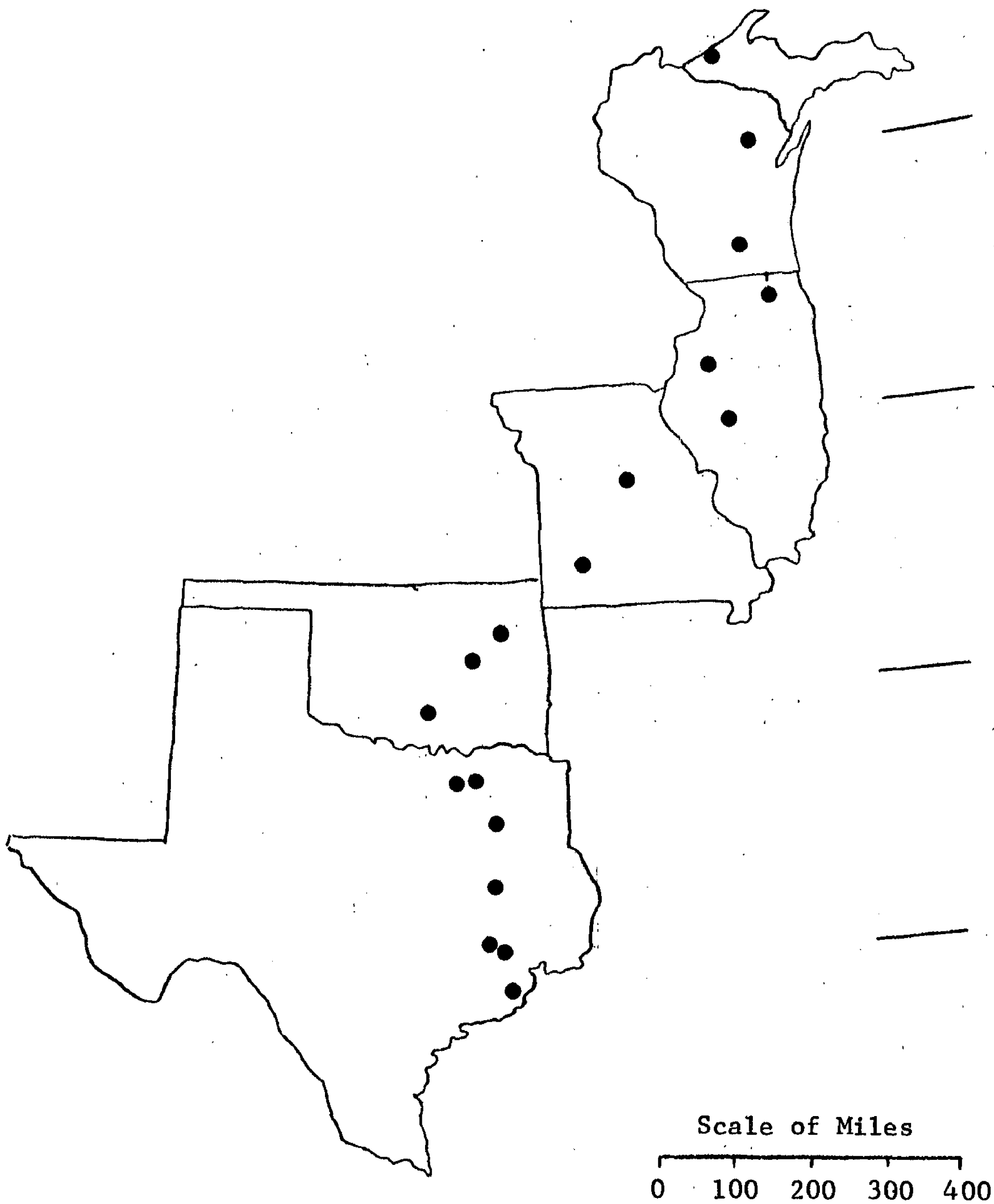


TABLE 1

Cumulative Deposition of Strontium-90 Along a Mid-United States Constant Precipitation Transect

Site	Lat. °N	Sampling Date	mc Sr^{90}/mi^2	Precip.* in inches
Ontonagon (Mich.)	46.9	6-5-58	33	166
		5-16-61	59	270
		10-8-62	89	310
Antigo (Wisc.)	45.2	6-5-58	32	152
		5-16-61	55	257
		10-9-62	75	310
Portage (Wisc.)	43.5	6-4-58	35	153
		5-15-61	71	247
		10-9-62	100	301
Marengo (Ill.)	42.2	6-3-58	37	165
		5-15-61	62	267
		10-10-62	85	319
Galva (Ill.)	41.2	6-3-58	39	171
		5-15-61	67	274
		10-10-62	81	331
Springfield (Ill.)	39.8	6-3-58	59	167
		5-14-61	77	277
		10-11-62	100	329
Columbia (Mo.)	39.0	6-2-58	47	166
		5-13-61	84	269
		10-11-62	96	324
Bolivar (Mo.)	37.6	6-2-58	42	178
		5-13-61	90	310
		10-12-62	106	360
Tulsa (Okla.)	36.2	5-29-58	49	177
		5-12-61	87	296
		10-12-62	102	368
Chandler (Okla.)	35.7	5-28-58	50	172
		5-12-61	84	275
		10-13-62	114	335

* From 1-1-53 to sampling date.

Table 1 - cont'd.

Site	Lat. °N	Sampling Date	mc Sr^{90}/mi^2	Precip.* in inches
Marlow (Okla.)	34.6	5-28-58	46	176
		5-12-61	80	272
		10-13-62	112	332
Slidell (Tex.)	33.4	5-28-58	47	179
		5-11-61	64	268
		10-14-62	88	319
Sanger (Tex.)	33.4	5-27-58	58	170
		5-11-61	64	254
		10-14-62	101	300
Ferris (Tex.)	32.6	5-27-58	44	189
		5-11-61	62	307
		10-15-62	86	360
Thornton (Tex.)	31.4	5-27-58	33	176
		5-11-61	61	296
		10-15-62	75	343
Dime Box (Tex.)	30.3	5-26-58	31	170
		5-10-61	60	295
		10-15-62	73	363
Brenham (Tex.)	30.2	5-26-58	23	172
		5-10-61	59	310
		10-15-62	63	369
Danevang (Tex.)	29.0	5-26-58	27	182
		5-10-61	43	335
		10-16-62	66	404

* From 1-1-53 to sampling date.

Figure 2 - Average Annual Precipitation at Soil Sampling Sites

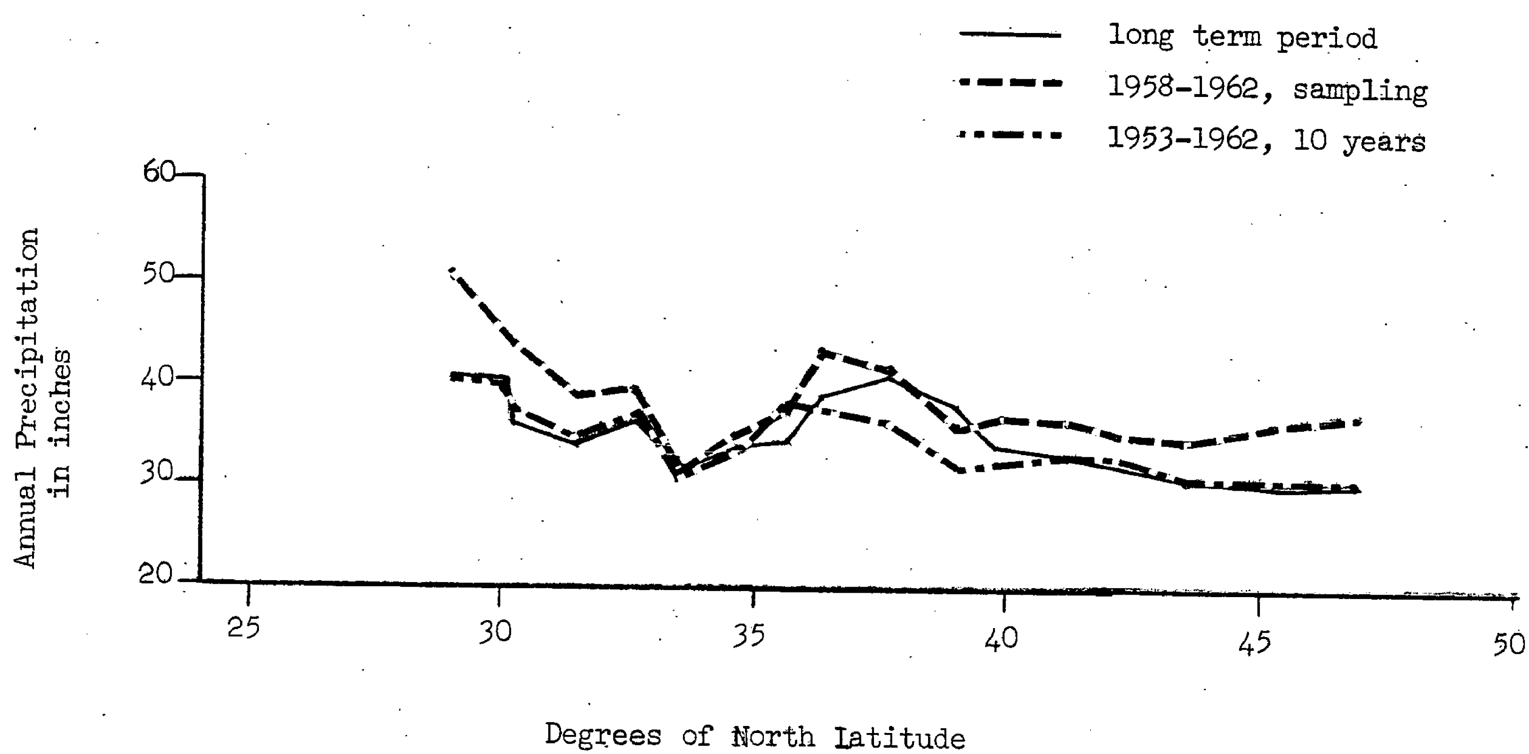
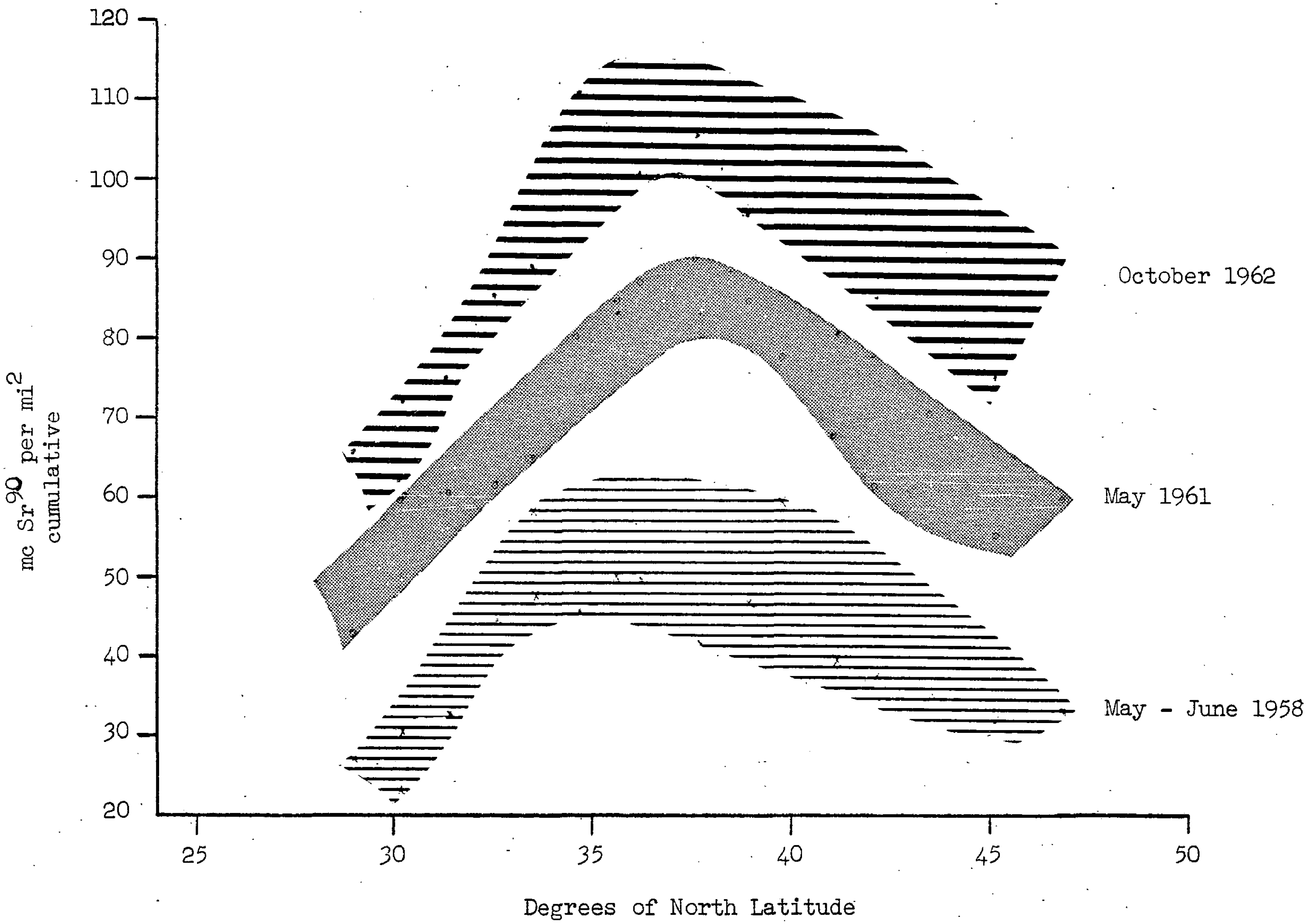


Figure 3 - Cumulative Deposition of Strontium-90 Along a Mid-United States Constant Precipitation Transect



Reproducibility of Analyses of 1963-1964 Soils for Sr-90

by F. Durkan and L.D.Y. Ong - (HASL)

Introduction

Statistical evaluations of the reproducibility of analyses of soils for Sr-90 by the Health and Safety Laboratory were presented in previous quarterly reports(1, 2). The present study provides additional information on this subject obtained using the results of the analyses of soils collected in 1963-1964.

Of the 108 soil samples collected, 103 were analyzed in duplicate. The 206 samples were analyzed "blind" by the chemist, that is the samples were identified only by code numbers. With each set of 20 samples, at least one unidentified standard or blank sample was also included to serve as a check of time quality control. Aliquots from 37 of the soil samples were also analyzed by the Beltsville Soil Laboratory for comparison purposes.

Time Independence Tests

Two standards and a blank sample served to check the time quality control of the radiochemical measurements made during the period August 9, 1963 through July 2, 1964. The blank soil standard was analyzed 14 times, the red soil standard was analyzed 10 times and the blank sample was analyzed 10 times during this period. Graphs of the results of the analyses of each sample versus time suggested the relationship:

$$y = a + b\,t$$
$$a = \bar{y} + b\,\bar{t} \qquad (1)$$

where y = activity of standard and t = time of analysis. A sign test for linearity described by Crow, et al.(3), was applied to the data and the validity of eq. 1 was established. A least squares fit to eq. 1 was then found for each standard (Figures 1, 2, 3). This study indicated that there were no variations with time in the results of analyses of a given sample. A statistical test verified that in each case the coefficient 'b' was not significantly different from zero(3) and that therefore y(t) was constant ($y(t) = \bar{y}$).

Precision

The pair differences (D_i) and the pair averages ($\bar{x}_i$) for each of the 103 samples analyzed in duplicate at HASL were calculated. The range of $\bar{x}_i$ was from 1.25 to 189 mc/mi^2 with a 12th percentile of 14, a 33rd percentile of 40, a median value of 86 and a 67th percentile of 118. The range of D_i was from 0 to 33 mc/mi^2 with a 12th percentile of 0.3, a 33rd percentile of 1.4, a median of 3 and a 67th percentile of 4. The pair differences were distributed normally about the average pair difference $\bar{D}$.

The standard deviation of a single measurement can be estimated from the pair difference using the following relations:(4, 5)

$$\sigma_i = \frac{\sqrt{\pi}\, D_i}{2} = 0.8862\, D_i \qquad (2)$$

Using this relation, confidence ranges for a single measurement or for the mean of a pair of measurements can be calculated at any desired confidence level, e.g., the 95 per cent confidence range for a single measurement is $x \pm 1.96\,\sigma$ and the 95 per cent confidence range for the mean of a pair of measurements is $\bar{x} \pm \frac{1.96}{\sqrt{2}}\,\sigma$.

A scatter plot of σ_i and $\bar{x}_i$ was drawn (Figure 4). A straight line fit to the data yielded the following equation:

$$\sigma_i = 0.8862\, D_i = 0.064 + 0.041\, \bar{x}_i \qquad (3)$$

The computed standard error of the estimate for this fit ($S_{\sigma_i, \bar{x}}$) was 3.7.

Using eq. 3 a graph of the relative error $\frac{\sigma_i}{\bar{x}_i} \cdot 100$ vs $\bar{x}_i$ was constructed, and is shown by the dashed curve of Figure 5. At levels greater than 10 mc/mi^2 a relative error or precision of about 4% is predicted.

Inter-Laboratory Comparison

An indication of the precision between two different laboratories is given by comparing HASL measurements with those obtained by the Beltsville Soil Laboratory (BSL) on aliquots from the same soil samples.

The Wilcoxon 'Paired' Replicate Rank test[6] was employed to determine if the analytical results obtained by BSL on aliquots from 37 of the soil samples, were significantly different from those obtained by HASL. This test takes into account the frequency with which the results from Beltsville were greater or less than the HASL results, weighted by the magnitudes of these differences. The result of the test was that there was no significant difference between HASL and BSL measurements.

A quantitative confirmation of this conclusion can be seen by stuyding Figure 5. The dashed curve in this figure is the relative error of pairs of samples analysed at HASL versus the pair average. The solid curve in the figure is the relative error between BSL and HASL results, versus the HASL average. Since the solid curve is always below the dashed curve, this suggests that the relative error in analyses between laboratories is smaller than between HASL duplicate measurements, i.e., about 4%.

Conclusions

Statistical analyses of the data obtained in the 1963-1964 Sr-90 in soil measurements indicated the following:

1. From measurements of standards and blank samples it is concluded that results of analyses did not depend on when the analyses were performed.

2. From the results of the 103 measurements made in duplicate, it is concluded that the precision of the analyses was about 4%.

3. An intercomparison of results of measurements made on 37 samples at HASL and the Beltsville Soil Laboratory showed no significant difference between the laboratories, suggesting that the precision of the inter-laboratory analyses was also about 4%.

References

(1) USAEC Report HASL-113, p. 75, July 1, 1961.
(2) USAEC Report HASL-117, p. 217, December 30, 1961.
(3) Crow, E., et al., Statistics Manual, New York, p. 56, (1960).
(4) Snedecor G.W., Statistical Methods, Iowa, p. 97, (1950).
(5) Volk, W., Applied Statistics for Engineers, New York, p. 113-115, (1958).
(6) Ibid., p. 329.

FIGURE 1. BLACK SOIL, BSL

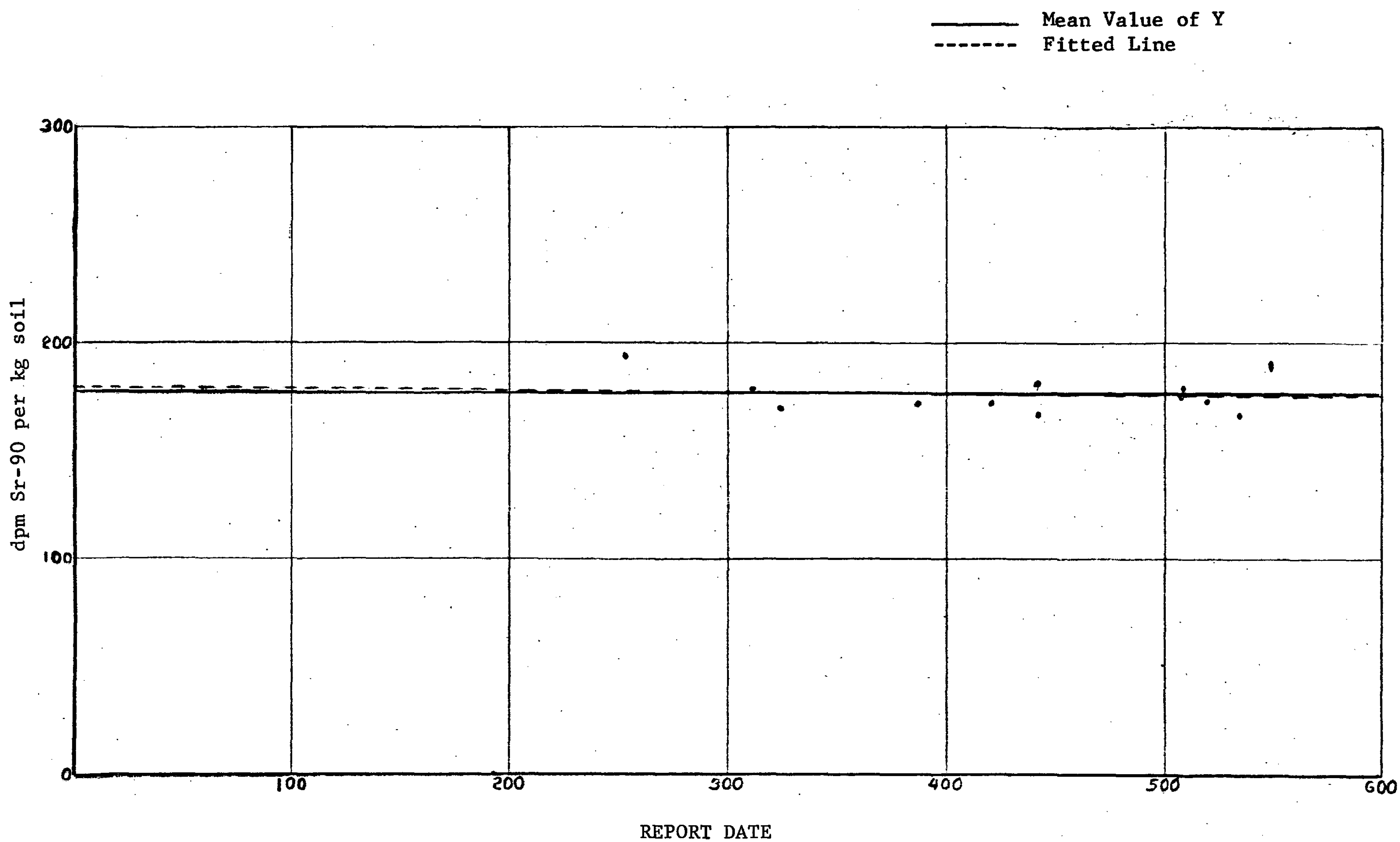


FIGURE 2. BLANK SOIL, HASL

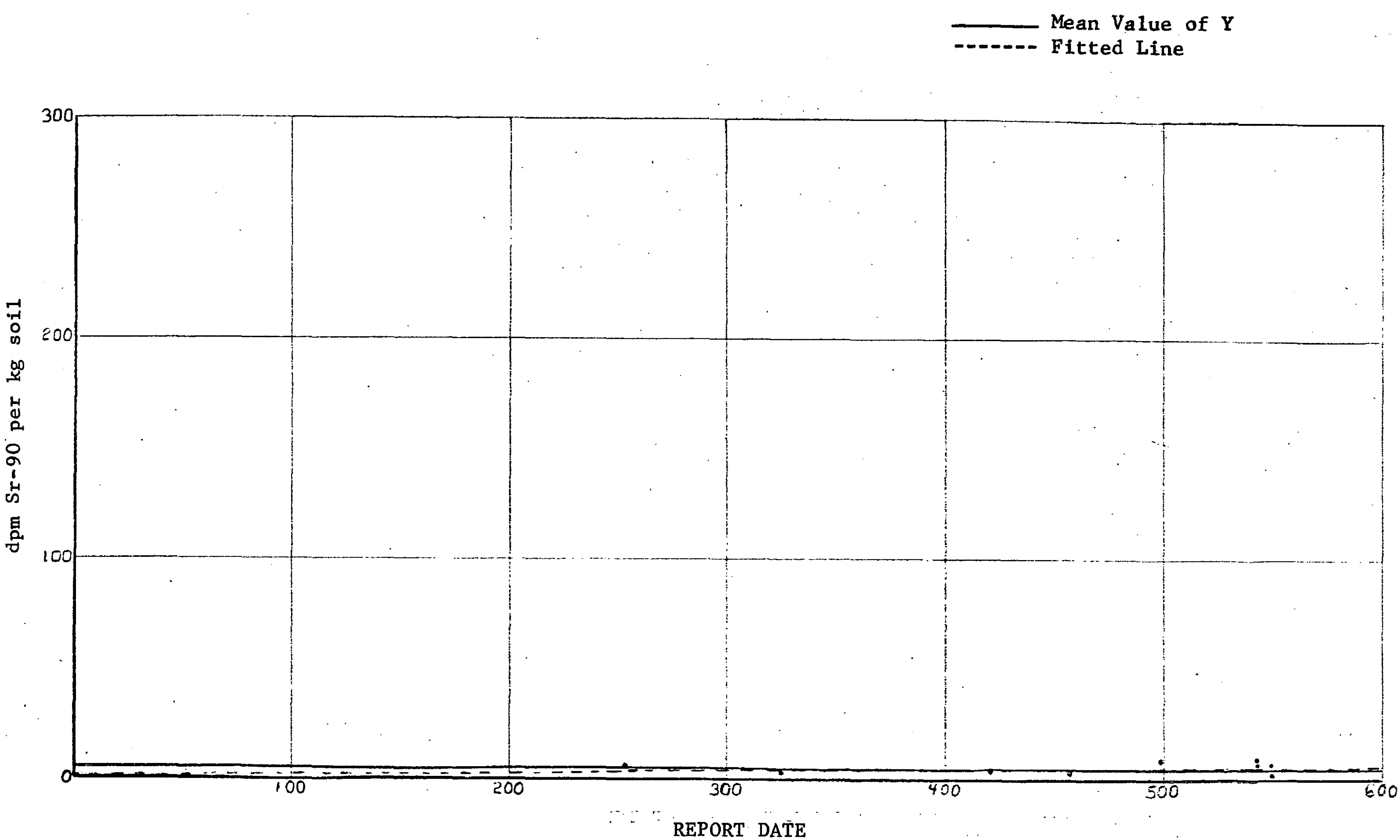


FIGURE 3. RED SOIL, BSL

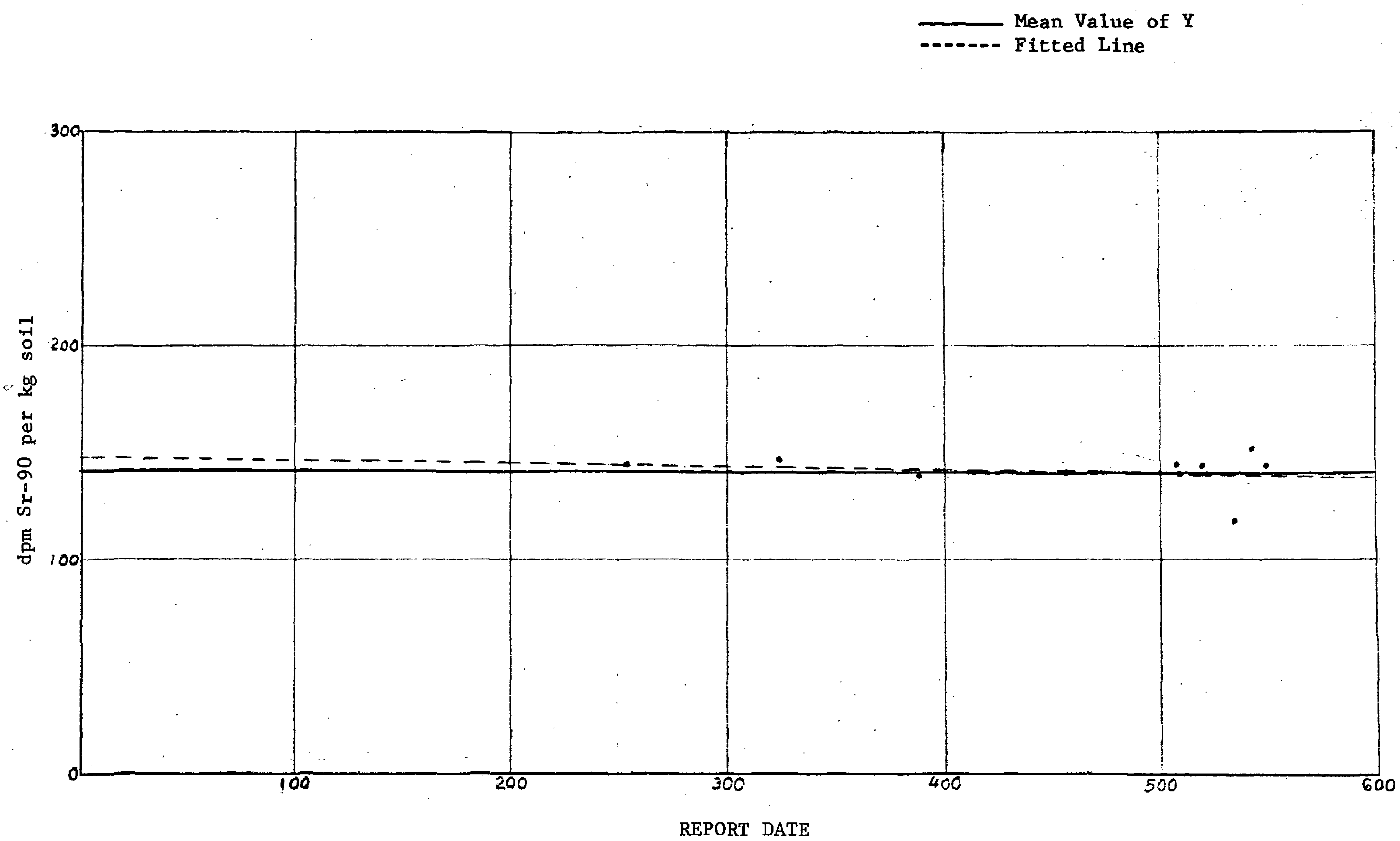


FIGURE 4. ESTIMATED STD. DEVIATION BETWEEN TWO DUPLICATE SOIL MEASUREMENTS

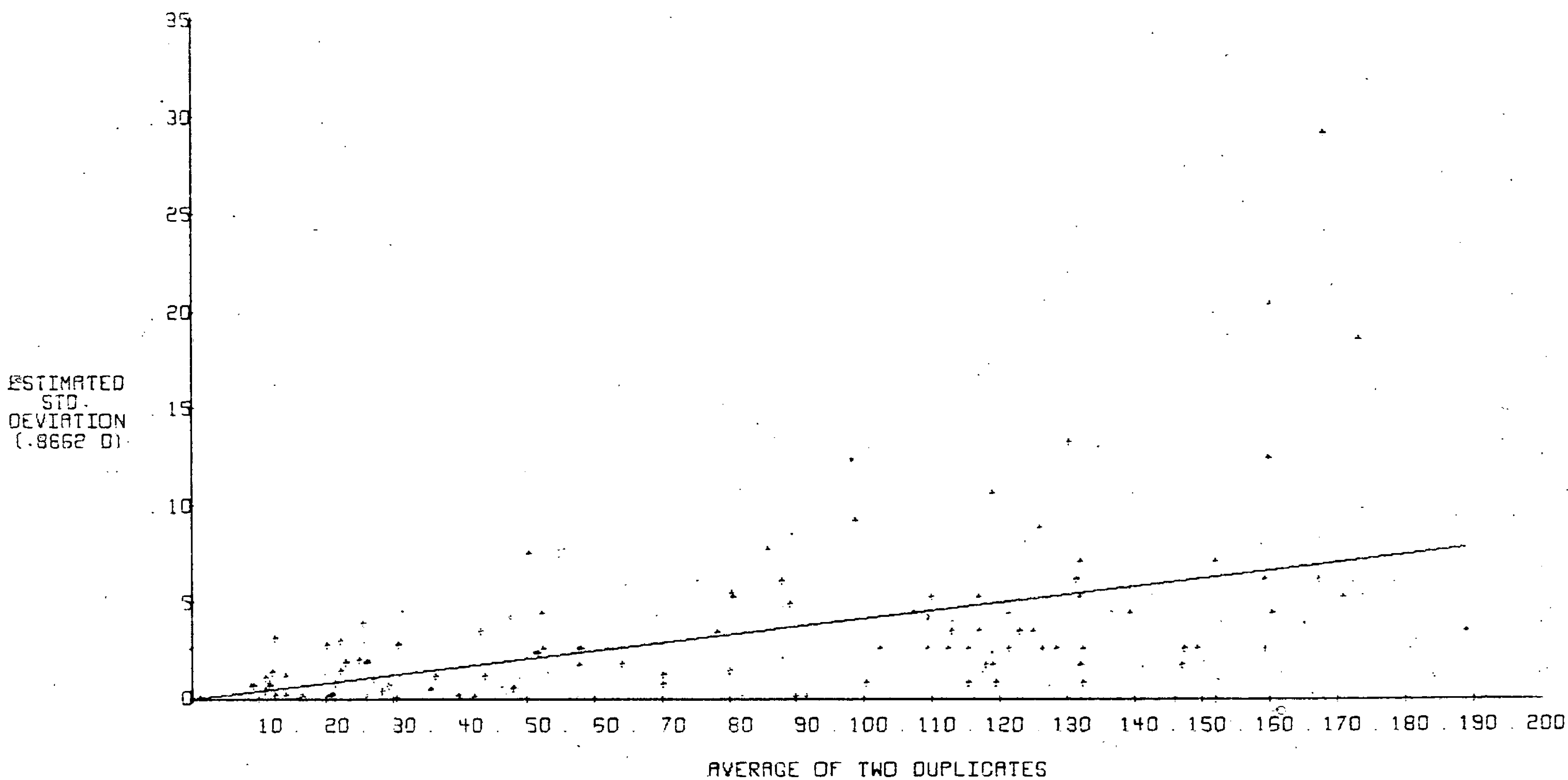
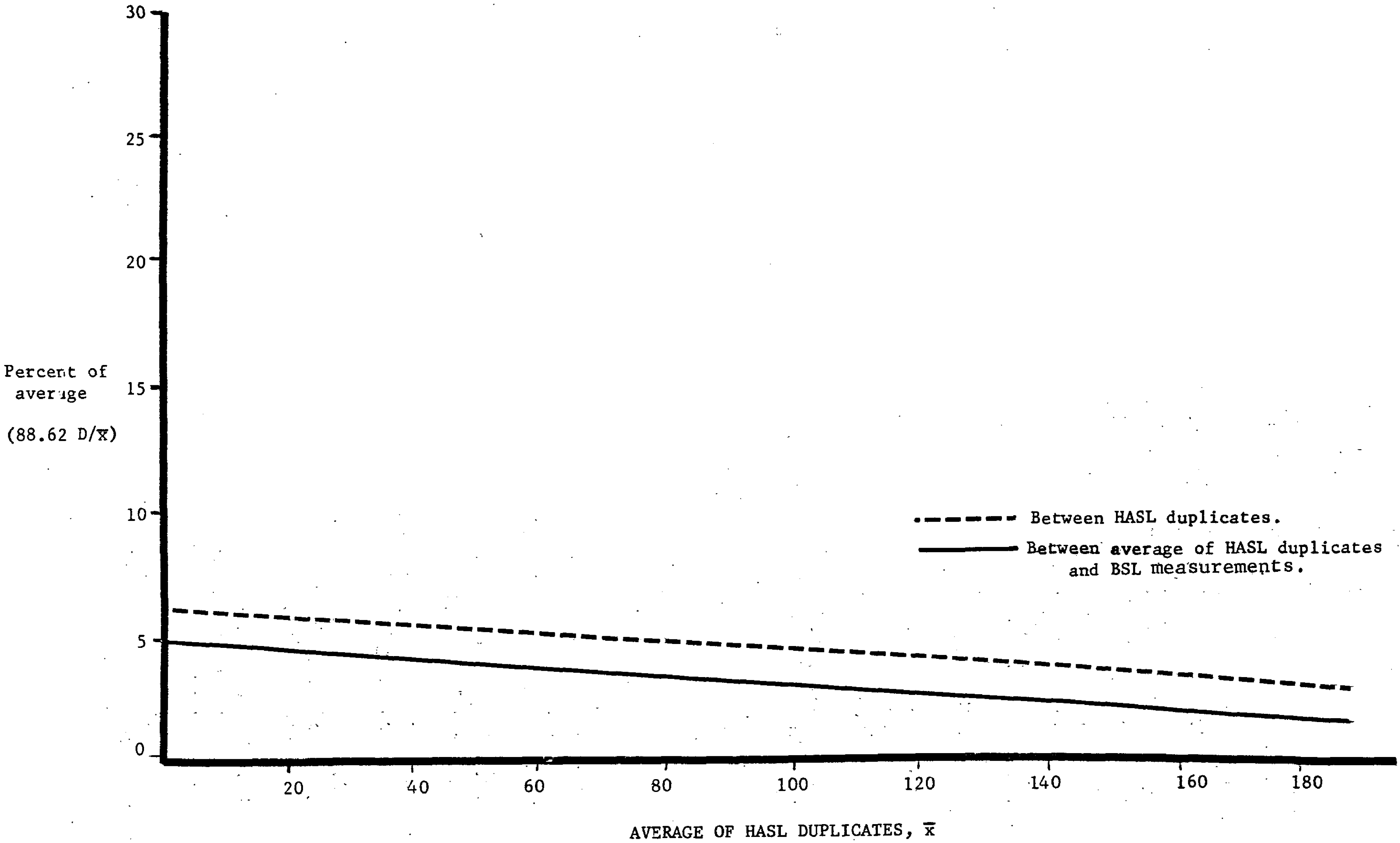


FIGURE 5. RELATIVE STANDARD DEVIATION BETWEEN HASL AND BSL Sr-90 SOIL MEASUREMENTS



Part IV - Recent Publications Related to Fallout

1. Bryant, F.J., et al., "Sr-90 in the Australian Environment During 1962", Aust. J. of Science, July 1964.

2. Cherry, R.D., "Alpha-Radioactivity of Plankton", Nature 203, No. 4941, p. 139, July 11, 1964.

3. Ellett, W.H. and Brownell, G.L., "Caesium-137 Fallout Body Burdens, Time Variation and Frequency Distribution", Nature 203, No. 4940, p. 53, July 4, 1964.

4. Gregory, L.P., "Ion-Exchange Methods for the Estimation of Sr-90 in Rain, Milk and Bone", Health Physics 10, No. 7, p. 483, July 1964.

5. Hansen, W.G., et al., Farming Practices and Concentrations of Fission Products in Milk, Environmental Health Series, Radiological Health; U.S. Dept. of Health, Education & Welfare, PHS, Washington, D.C.

6. Hanson, W.C., et al., "Radioactivity in Northern Alaskan Eskimos and Their Foods, Summer 1962", Health Physics 10, p. 421, 1964.

7. Hasanen, E. and Miettinen, J.K., The Body Burden of ^{137}Cs in People of Southern Finland 1961-1963, IAEA Symposium at Heidelburg, May 11-16, 1964.

8. ______________, "Caesium-137 Content of Fresh Water Fish in Finland", Nature 200, No. 4910, p. 1018, December 7, 1963.

9. Hawley, C.A. Jr., et al., Controlled Environmental Radioiodine Tests National Reactor Testing Station, Health & Safety Division, Idaho Operations Office, USAEC, IDO-12035, June 1964.

10. Hiyama, Y., et al.,"Japanese Dietary Habits and the Fallout Problem II," J. of Rad. Res. 5, No. 2, 1964.

11. Hvinden, T., et al., "Passage of Radioactive Cloud Over Norway, November 1962", Nature 202, No. 4936, p. 950, June 6, 1964.

12. Kigoshi, K., "Recent Variation of Atmospheric Contents of C-14 in Tokyo and Transfer Problem of Atmospheric Carbon Dioxide", J. of Rad. Res. 5, No. 2, 1964.

13. Klement, A.W., Jr. and Schultz, V., Terrestrial and Freshwater Radioecology A selected Bibliography, Supplement 2, TID-3910 (Supplement 2), USAEC Division of Technical Info., March 1964.

14. Kodaira, K., "Radioactive Contamination of Rice in Japan - With Reference to Sr-90 and Cs-137 Content in Rice Unitl 1962", J. of Rad. Res. 5, No. 2, 1964.

15. Krey, P.W., et al., Long Range Fallout From Sedan and Small Boy, Isotopes, Inc., Contract AT(30-1)-3055, June 15, 1964.

16. Mahmoud, K.A., et al., Fallout and Radioactive Content of Food Chain in UAR During the Year 1963, U.A.R.S.C.E.A.R., Vol. 6-1, June 1964.

17. Miettinen, J.K., et al., "Cesium-137 and Potassium in Finnish Lapps and Their Diets", Radiological Health Data 5, p. 83-97, 1964.

18. ______________, Measurements of Caesium-137 in Finnish Lapps in 1962-63 by a Mobile Whole Body Counter, Department of Radiochemistry, Univ. of Helsinki, Finland.

19. ______________, Radioactive Food Chains in Artic Regions, Presented at the Third International Conference on the Uses of Atomic Energy, Geneva, August 31, 1964 to September 19, 1964.

20. ______________, Radiochemistry and its Development at the University of Helsinki, Atomic Energy & Finland 1945-1962 in Finnish, p. 88-93, August 1962.

21. ______________, et al., Relationships of Radiocesium and Potassium in the Diet and Body of Finnish Lapps, presented at Northwestern University, Chicago, September 5-7, 1962.

22. ______________, Studies of Sr-90 and Cs-137 in Plants, Animals and Man in Lapland, Plenary lecture held at the 11th Meeting of Scandinavian Chemists in Turku, Finland, August 20-25, 1962.

23. Murayama, N., "A Comparison of Radioactivity Observations in the Upper Atmosphere", J. of Meteorological Reseach 19, No. 4, p. 276, 1963.

24. ____________, "Meteorological Feature of Cosmic Ray Produced Beryllium-7", J. of Meteorological Soc. of Japan, Series II 42, No. 1, p. 43, February 1964.

25. ____________, "Seasonal Variation of the Stratospheric Radioactive Fallout", J. of Meteorological Research 15, No. 9, p. 600, 1963.

26. Nelson, D.J., "Bilogical Vectors and Reservoirs of Strontium-90", Nature 203, No. 4943, p. 420, July 25, 1964.

27. Paakkola, O. and Miettinen, J.K., "Strontium-90 and Caesium-137 in Plants and Animals in Finnish Lapland During 1960", Ann. Acad. Sci. Finn. Series A, II. Chemica 125, p. 1-15, 1963.

28. Picciotto, E., et al., "Rate of Accumulation of Snow at the South Pole as Determined by Radioactive Measurements", Nature 203, No. 4943, p. 393, July 25, 1964.

29. Data from Radiation Protection Programs, Radiation Protection Division, Department of National Health & Welfare, Ottawa, Canada, Vol. 2, No. 4, April 1964.

30. Service Central De Protection Contre Les Rayonnements Ionisants, Rapport D'Activiti, SXPRI CRM, June 1964.

31. Resumen De Labores Año 1961, Publicaciones Del Laboratorio De Fisica Cosmica, Universidad Mayor De San Andres, La Paz, Bolivia, July 1962.

32. Rivera, J., "Sr-90 in Diet and Bone of San Juan, Puerto Rico and New York City Residents", Industrial Medicine & Surgery 33, No. 7, p. 494, July 1964.

33. Saiki, M., et al., "Assay of Strontium-90 in Human Bone in Japan, 1961-1963", J. of Rad. Res. 5, No. 2, 1964.

34. Salo, A., et al., "Cesium-137 in the Blood of the Finnish Lapps", Nature 200, No. 4911, p. 1119, December 14, 1963.

35. Santholzer, V., Dynamics of Transport of Fission Products by Atmospheric Precipitation, Jaderna Energie; Rocnik X, 1964.

36. Schroeder, G.L., "Radon-222 in Mine Atmosphere", Letters to the Editor, Science 145, No. 3633, p. 727, August 14, 1964.

37. Sievert, R.M., "Note on the Increase of Gamma Radiation from the Ground during September 1 - March 30, 1961", Tellus XV,3, p. 309, 1963.

38. Spencer-Laszlo, H., et al., "Sr-90 Balances during Starvation in Man", Rad. Res. 22, No. 4, p. 677, August 1964.

39. ________________, "Sr-90 Metabolism during Low Sr-90 Intake in Man", Rad. Res. 22, No. 4, p. 668, August 1964.

40. Stackee, L. and Mattern, F.C.M., Sr-90 and Cs-137 in the Human Diet in the Netherlands during 1962, Rijks Instituut Voor De Volksgezondheid Ntrecht, RA-21, 1964.

41. Suguri, S., et al., "Correlation between Ingestion, Body Burden and Excretion of Cesium-137 in Man", Health Physics 10, No. 7, p. 469, July 1964.

42. Sutton, D.C. and Dwyer, K.R., "Cerium-144 and Cesium-137 Measurements in the 1963 United States Wheat Crop and Milling Products", Science 145, No. 3631, p. 486, July 31, 1964.

43. Swedjemark, G.A., Gamma Radiation from the Ground in Sweden during 1960-1963, Inst. of Radiophysics, Stockholm.

<u>Recent Publications Related to Fallout</u> - cont'd.

44. Thompson, T. and Wieberg, P.A., "Some Observations of Variations of the Natural Background Radiation", Tellus XV 3, p. 313, 1963.

45. Tsugo, T., et al., "Radioactive Contamination of Milk in Japan (1961-1963)", J. of Rad. Res. 5, No. 2, 1964.

46. Van Middlesworth, L., "Long-life Radioactivity in Occasional Thyroids", Nature 203, No. 4941, p. 199, July 11, 1964.

47. Vuorinen, A.P.U. and Miettinen, J.K., Caesium-137 in Finnish Grass and Cow's Milk", Annales Academiae Scientiarum Fennicae, Series A. II. Chemica, No. 102, 1960.

48. Watt, D.E. and Romsden, A., Weak Sources of Ionizing Radiation, Pergamon Press (from Nature - July 4, 1964 - a Book review), 1964.

49. Yamasaki, F., et al., "External Doses of Radiation from Fallout in Tokyo and Its Vicinity", J. of Rad. Res. 5, No. 2, 1964.

50. Zander-Prencipati, G.E. and Kazma, J.F., "Zirconium citrate Reduces Sr-90 Body Burden", Health Physics 10, No. 7, p. 473, July 1964.

51. Davies, C.N., "Inhaled Radioactive Particles and Gases", Nature 203, No. 4943, p. 352, July 25, 1964.

TABLE OF CONVERSION FACTORS

The following abbreviation listing and conversion table involve units of measurement used in the HASL fallout and air sampling programs.

ABBREVIATIONS:

in. - inches	mm - millimeters	pc - picocuries (micro-microcuries - μμc)
ft. - feet	cm - centimeters	nc - nanocuries (milli-microcuries - mμc)
mi. - miles	m - meters	μc - microcurie
lb. - pounds	km - kilometers	mc - millicurie
liq.qt.-liquid quarts	kg - kilograms	d/m - disintegrations per minute
	l - liters	

SCF - standard cubic feet at 1 atmosphere (1013 mb) and 15°C (59°F)
SCM - standard cubic meters at 1 atmosphere (1013 mb) and 15°C (59°F)
kg air - kilograms air at 1 atmosphere (1013 mb) and 15°C (59°F)

CONVERSION TABLE

Multiply	by	to obtain	Multiply	by	to obtain
in.	25.4	mm	mm	0.0394	in.
in.	2.54	cm	cm	0.394	in.
ft.	0.305	m	m	3.28	ft.
mi.	1.61	km	km	0.621	mi.
lb.	0.4536	kg	kg	2.205	lb.
liq.qt.-U.S.	0.946	l	l	1.057	liq.qt.-U.S.
mi.^{2}	2.59	km^2	km^2	0.386	mi.^{2}
mc/mi.^{2}	0.386	mc/km^2 (nc/m^2)	mc/km^2	2.59	mc/mi.^{2}
mc/mi.^{2}/in.	15.2	pc/l	pc/l	0.0657	mc/mi.^{2}/in.
pc/l	0.01	mc/km^2/cm	mc/km^2/cm	100	pc/l
d/m	0.450	pc	pc	2.22	d/m
nc	1×10^3	pc	pc	1×10^{-3}	nc
d/m/l	0.45×10^{-9}	μc/cc	μc/cc	2.22×10^9	d/m/l
d/m/ft.^{2}	0.01256	mc/mi.^{2}	mc/mi.^{2}	79.6	d/m/ft.^{2}
10^3 SCF	28.3	SCM	SCM	0.0353	10^3 SCF
10^3 SCF	34.7	kg air	kg air	0.0288	10^3 SCF
SCM	1.226	kg air	kg air	0.816	SCM

AREA OF THE EARTH

	Area mi^2	Area km^2
land	57.470×10^6	148.847×10^6
ocean	139.480×10^6	361.254×10^6
total	196.950×10^6	510.101×10^6

latitude band	Area mi^2	Area km^2
0-10	17.142×10^6	44.398×10^6
10-20	16.621×10^6	43.048×10^6
20-30	15.595×10^6	40.392×10^6
30-40	14.096×10^6	36.508×10^6
40-50	12.167×10^6	31.512×10^6
50-60	9.870×10^6	25.565×10^6
60-70	7.271×10^6	18.833×10^6
70-80	4.454×10^6	11.536×10^6
80-90	1.258×10^6	3.257×10^6

TABLE OF RADIONUCLIDES

The following table is a listing of radionuclides of interest in the HASL fallout program. The half-life values are those currently in use at HASL and are subject to change as new data become available. The energy values for each nuclide are listed in order of decreasing abundance and include the most prominent radiations observed. Radiations which occur in less than 10 per cent of the disintegrations are given in parentheses. X-rays are listed only if electron capture or internal conversion are an important feature of the decay scheme. Data which differ significantly from that listed in previous reports of this series are marked with an asterisk.

Abbreviations:

CE: conversion electron
EC: electron capture

Nuclide	Radioactive Daughter	HALF-LIFE days	HALF-LIFE other units	Emitted Radiations (Mev.) electrons	Emitted Radiations (Mev.) photons	Emitted Radiations (Mev.) X-rays
Fission Products						
38 Sr-89		50.5		1.46		
38 Sr-90		10120.	27.7y	0.54		
	39 Y-90	2.675	64.2h	2.27		
39 Y-91		57.5		1.54	(1.2)	
40 Zr-95		65		0.40,0.36	0.72, 0.76	
	41 Nb-95	35		0.16	0.77	
44 Ru-103		39.8		0.21,0.12,(0.70)	0.50,(0.61)	
	45 Rh-103m		57m	0.037 CE		0.003
44 Ru-106		365	1.00y	0.039		
	45 Rh-106		0.50m	3.55,2.4,3.1,(2.0)	0.51,0.62,(1.04,1.55,0.87,1.13 sum)	
48 Cd-115m		43		1.63	(0.94,1.3,0.49)	
51 Sb-125 (21%)		985*	2.7y *	0.30,0.12,0.61,0.44	0.43,0.60,0.46,0.64,0.18	
	52 Te-125m	58		0.078 CE, 0.105 CE		0.027,0.004
53 I-131		8.08		0.61,0.34,(0.25)	0.364,(0.64,0.28,0.72)	
55 Cs-136		12.9		0.34,(0.66)	0.83,1.07,0.34,1.25,0.17,0.15,0.27, other sum	0.032
55 Cs-137 (92%)		11150	30.5y	0.51,(1.18)		
	56 Ba-137m		2.6m	0.62 CE	0.662	0.032
56 Ba-140		12.8		1.02,0.48,0.6,(0.9)	0.54,(0.16,0.43,0.30)	
	57 La-140	1.675	40.2h	1.38,1.10,0.83,1.71,(2.20)	1.60,0.49,0.82,0.33,0.92,(0.44,2.5)	
58 Ce-141		33.1		0.44,0.58,(0.10 CE)	0.145	0.036
59 Pr-143		13.8		0.93		
58 Ce-144		285		0.32,0.19,(0.24,0.09 CE,0.04 CE)	(0.134,0.081)	0.036
	59 Pr-144		17.3m	2.98,(2.29,0.80)	(0.69,2.18,1.48)	
60 Nd-147		11.1		0.81,0.38,(0.23,0.046 CE)	0.091,0.53,(0.28-0.44)	0.039
	61 Pm-147	964	2.64y	0.22		
Other Radionuclides						
1 H-3		4480	12.3y	0.018		
4 Be-7		53.6		EC	0.48	
6 C-14		2.0 X 10^6	5500y	0.155		
25 Mn-54		310		EC		0.005
26 Fe-55		986	2.70y	EC		0.006
30 Zn-65		245		(0.32),EC	1.11,0.51 Annihilation Rad.	0.008
39 Y-88		104		EC	1.85,0.91,(2.76 sum)	0.014
45 Rh-102		210		1.15,1.28,(0.81),EC	0.48,1.08,0.63,0.72,0.77,(0.42)	0.021
45 Rh-102m		~900	~2½y	EC		
48 Cd-109		470	1.65y	EC		0.022,0.003
	49 Ag-109m		0.65m	0.062 CE,0.084 CE	(0.088)	
48 Cd-113m		~5000	~14y	0.57		
51 Sb-124		60		0.61,2.3,0.25,(1.6,0.9)	0.60,1.69,0.72,(2.09,1.0,1.3-1.5)	
74 W-181		145		EC		
74 W-185		74		0.43		0.058
81 Tl-204		1416	3.88y	0.76,(EC)		0.071