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RESEARCH MEMORANDUM

Distribution Tests

RAND SUNSHINE PROJECT

Conference December 16, 17, 18, 1953

Santa Monica, California

RM-1175-AEC

December 30, 1953

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Dr. Jane Hall
Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico

Dear Dr. Hall:

At the request of the Division of Military Application I am sending you herewith copy No. 27A of Rand report RM-1175-AEC for your retention. You are also being placed on the distribution list for future reports on this subject.

Because of the classification of this project, distribution of the reports is severely restricted to those who are actively contributing to the project. Will you therefore please handle this report accordingly.

Yours very truly,

Walter D. Claus
Chief, Biophysics Branch
Division of Biology and Medicine

Enclosure:
Report RM-1175-AEC, Cy. 27A

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The following individuals participated in the RAND SUNSHINE Conference, December 16 - 18, 1953, held at The RAND Corporation, Santa Monica, California:

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RAND SUNSHINE PROJECT

Conference December 16, 17, 18, 1953

Santa Monica, California

I. INTRODUCTION

The conference was convened to consider the experimental data obtained since the study conducted during summer 1953 (RAND Report R-251-AEC).

Following the report of last summer, the Division of Biology and Medicine let a contract with the University of Chicago for the measurement of a few dozen samples as quickly as possible in order that the program be properly oriented. This is referred to in the RAND SUNSHINE Report as the Pilot Assay Program. The Chicago group has completed analysis on about 100 samples. Their data and some data from other groups are presented in Appendix A.

In Appendix A the unit known as the SUNSHINE UNIT is 2.2 disintegrations per minute of Sr^{90} per gram of calcium. This is 1/1000th of the maximum permissible concentration. A "standard man" has 1000 grams of calcium in his body. Since the maximum permissible concentration is one microcurie per standard man it follows, since 1 microcurie of Sr^{90} is $2.2 10^6$ dpm, that one SUNSHINE UNIT is 1/1000th of maximum permissible concentration. The same unit is used for both animals and food. It is, of course, impossible to use this unit for rain and water and other types of samples which do not contain calcium. In these samples the actual Sr^{90} specific activities are given e.g., in disintegrations per minute per gallon in the case of rainwater.

The costs for the Chicago measurements are interesting in themselves since they indicate the budget likely to be required for PROJECT SUNSHINE

in the future. They are summarized in Appendix B. It is seen here that the cost averaged about $300 per sample. Of course, it should be borne in mind that a University Laboratory denotes many services which would not be procurable in other environments but it should also be borne in mind (now that the capital equipment is in hand) that the cost of establishment of the project is much higher per sample earlier in history of the project than later. It can be seen from experience on hand that a figure like $100 to $150 per sample will be most likely in the future, and that the possibility of reducing it much below this is rather remote except for certain particular types of samples. Furthermore, AEC administrative costs have not been considered. One could, for example, say that rain sample is much less expensive but the human sample assay has the large cost of ashing which cannot be avoided. So averaging over the broad spectrum of samples which are likely to be desired, the figure is something like $100 - $150 per sample.

II. DEDUCTIONS

Cursory perusal of the data contained in the Pilot Assay Program of the Chicago SUNSHINE indicates the following:

A. Newborn babies in the Chicago area have about 1/6th SUNSHINE UNIT of Sr^{90} or about 1/6000th of tolerance. In other words, there are about 0.37 disintegrations per minute of Sr^{90} per gram of calcium in these human materials. Wide fluctuations from this average occur. It was strongly suggested by the conference that medical records be examined to see whether any correlations exist; when the additional 30 babies now on hand in Chicago have been analyzed the total number of data may be such that a medical search will reveal correlations.

B. It appears from the agreement between the Utah, Wisconsin and Swiss assays for cheese and milk that Sr^{90} dissemination mechanism is such as to indicate considerable uniformity in this distribution. In other words, it appears from these that Sr^{90} may not be likely to vary as much as one might have anticipated. It is true that the data on which this conclusion is based are inadequate, but recalling the conclusions of the RAND SUNSHINE summer conference that stratospheric dissemination and storage were most likely, together with the failure of the long range fall-out group under Dr. Eisenbud to detect more than a few percent of the total debris from the MIKE shot at IVY, assays are correct in strongly indicating that the Sr^{90} content does not vary enormously from spot to spot at least in the northern hemisphere. This conclusion is possibly at variance with deduction A if 1/6 of a SUNSHINE UNIT is to be regarded as high on a world-wide basis. However, the expected Chicago baby average cannot be theoretically predicted on the basis of the present data.

C. The data available strongly indicate that river waters are pure or at least much less contaminated than rain. It would seem that the action of the soil is the explanation of their purity. The Sr^{90} is removed as the water runs to the rivers from the spot where it fell as rain. Further data are necessary to fully establish this point but it seems likely that they will.

D. It seems that sea food in general will be pure. The data are inadequate to establish this but the indications are that this is so. It seems eminently reasonable on the basis of the mixing which most certainly must take place in the action of the waves in the ocean, that any material which falls into the sea will rapidly mix and be diluted. Consequently, one may fully expect a very low assay as has indeed been found in the few cases given in Appendix A.

E. With these general conclusions in mind we may discuss the bearing on:

1. Future Tests

It would seem from the results now available that a limited number of future tests of about the Castle scale would be permissible, and that continuing efforts to determine the distribution of Sr^{90} are not likely to upset this conclusion. It seems necessary, however, to make one exception; namely, the tests of large weapons are likely to lead to local fall-out of appreciable fraction of the fission products produced and should be most carefully examined from the point of view of the SUNSHINE PROJECT. Additionally, there should be the most minute and detailed examination of any tests of the deep underwater or deep underground variety involving either thermonuclear or large scale fission weapons.

2. Warfare

The only comment on this point that the conference made was that civilian defense against Sr^{90} might be accomplished by such a simple device as the use of a calcium-rich diet. The conference therefore strongly suggests that the Division of Biology and Medicine institute studies of the palliative effects of the addition of soluble calcium to the diet. For example, the effect of a compound such as calcium glutonate on the Sr^{90} uptake. In other words, by the use of Sr^{89} to avoid hazards to the individual a study might be made on humans of the rate at which Sr^{89} in the diet is assimilated normally and then in the case of a

diet with calcium glutonate added. It seemed to the group that there might be other ways of preventing widespread Sr^{90} damage, but that this would be one of the simplest and it is obvious the data should be obtained immediately.

Another point indicated by the data and the underlying physical principles themselves is that changing to a seafood diet might reduce very greatly the hazard due to Sr^{90} exposure.

III. SUNSHINE FUTURE

The purpose of the Pilot Assay Program was not only enlightenment on the facts of Sr^{90} distribution but also to make it possible to better plan the Full Scale Assay. On the basis of the data given above from the samples obtained this fall, it seems possible to develop some tentative conclusion about the direction which the SUNSHINE PROJECT should take in the future.

A. Who Should Make the Measurements?

The procedure developed is one that is quite simple and requires relatively little chemical training and only the standard low level radioactivity techniques. The Analytical Method is discussed in Appendix C. However, the amount of radioactivity being measured is so small that the most rigid standards of cleanliness are essential. The habits of procedure necessary to this low-level assay are perhaps more difficult to acquire than the understanding of the principles of chemical separation and the physical measurements being made. It would seem that groups selected to continue the PROJECT should perhaps come to Chicago and learn procedures, but more particularly should complete one or two assays in order to become acquainted

with the procedures for maintenance and cleanliness.

Possible groups for continuance of the SUNSHINE measurements would be the National Laboratories such as the Argonne, Brookhaven, and in particular, the Los Alamos Health Division in which Dr. E. C. Anderson, a man very skilled in low-level techniques, is employed. Industrial companies seem to be less likely to serve the purposes of the Project, in that there seems to be little possibility that they are in a position to make measurements without extensive development and training. We hope that this situation will change, since not only Project SUNSHINE but all of the low-level applications to medicine and industry await the offerings of these measurement services by industry. If one were willing to train the personnel, the companies could, of course, perform the measurements; this providing they would allow continued surveillance by outside personnel to guarantee the reliability of the measurements and techniques until they had learned the procedure. Whether this type of contractual arrangement is practical or not is difficult to decide but it does seem that it is not likely to be very satisfactory. Among the companies which might be considered are those in the counter and radiochemical business and such groups as North American Aviation, Stanford Research, Armour Research Foundation and many others.

B. How Much Will the Full-scale SUNSHINE Assay Cost?

As shown in the Introduction, it seems likely that the assays will cost about $100 per sample in the end. So, the cost will be determined largely by the number of samples assayed. It is to be borne in mind that some samples are essentially much easier and cheaper than others. Bodies and soils are

intrinsically much more expensive than either rains or foods because the reduction of the sample to a measureable form is in itself more expensive. Bodies require cremation and soils require extensive chemical extraction under controlled conditions. In the months of September, October, November, and December of 1953, the Chicago SUNSHINE Pilot Assay group measured about 100 samples. This averages about 1 per day. Of course this includes the development of the technique and the acquisition of the major apparatus necessary, though it is to be remembered that in the early stages of the Chicago SUNSHINE work, all of the apparatus necessary was borrowed from laboratories already functioning at the University. However, the samples were acquired during the period of measurement, and now that the sample acquisition program is well in hand domestically, one can presumably expect many more measurements and a higher rate of measurement from the group. This being only a Pilot Assay program we can anticipate that a full-scale program pursuing the points will involve more samples. Assuming 10 samples per day as a figure, we have something between $300,000 and $1,000,000 per year as an estimate for the Full-scale SUNSHINE Assay.

C. How Long Will the SUNSHINE PROJECT Exist?

The conference debated this question at length and concluded that as far as we can determine at the present time, it must run for at least two or three years and that during this future period the continuance of the project be discussed again.

IV. THE FUTURE SAMPLING PROGRAM

The conference discussed the adequacy of the present sampling program and concluded that it was quite adequate for the United States but extremely inadequate abroad. It was the feeling by many of the members of the conference that this was due almost entirely to the difficulty of operating abroad under secrecy conditions. Some of the group felt that this would be prohibitively difficult and that foreign assay with anything like the completeness which is foreseeable in the United States will be impossibly difficult unless some relaxation of the secrecy regulations occurs. The argument is a very simple one; one cannot buy babies or human materials or the effort to bottle a sample of rain water and ship it. These things are not purchaseable because the people who must do them are people so learned, and so interested otherwise, that the money that could be involved would be of no consequence. The only way of obtaining the samples is to obtain the cooperation of the foreigners themselves and this can be done only by telling them what the point or the main part of the plan of the nation is. It is not clear that it is necessary to tell them about the assays obtained, how radioactive people actually are or how serious the danger is. It is probably clear that it is necessary to inform them about the overall likelehood of the danger and that the problem is one of considerable importance. So it seems to a group in the conference that the choice to be made at the moment is largely between ignorance of the foreign situation with some hope that the SUNSHINE hazard be kept secret and a frank admission of the purpose of the SUNSHINE PROJECT together with the proper emphasis of the humanitarian aspects and an ability or opportunity to assay the world as a whole.

A. The sampling program is therefore not likely to yield a full-scale assay of the world at the present time as far as human materials are concerned. It does seem clear that one can sample quite adequately for foods, particularly milk solids or milk products. The correlation that can be obtained in the United States, particularly in the Chicago area, may be sufficient when taken together with the few foreign human samples which are likely to be procured. Some general conclusion can thus be drawn.

B. It seems clear from the examination of the data presented above that the "Chicago Baby Program" should be continued, perhaps at a lower rate. It also seems desirable that another "Baby Series" be started, preferably in the Salt Lake area, to check with certainty the preliminary results based upon the milk samples, to determine whether the strontium hazard in Salt Lake is no worse than it is in Chicago.

C. It seems clear to the conference that more use should be made of animal bones, particularly calf bones. This kind of material being procurable all over the world, a program should be instituted to obtain the samples immediately and to set up ashing facilities so that the bones can be processed at the lowest cost.

D. The milk solids and cheese samples look so promising at the moment that this type of sample should be emphasized in the future.

E. The measurement of adults should be undertaken immediately. It is clear from the general principles that, as set forth in last summer's RAND SUNSHINE Report, adults should have essentially zero assay. However, this point has not been established experimentally and the result is of such importance that it must and should be established in the immediate future. The Chicago

group will undertake a measurement on one or two specimens providing it appears likely that an ordinary crematorium will operate under sufficiently clean conditions from the radiochemical point of view that it can be employed to do the cremation.

F. It seemed clear to the conference that the possibility of classified cooperation with the British would bear further examination. The conference was aware, however, that there were several considerations which might bar such cooperation.

V. THE CASTLE SAMPLING PROGRAM FROM THE POINT OF VIEW OF THE SUNSHINE PROJECT

A. Task Force

It appears that the MIKE shot at IVY had no fall-out stations in the region most likely for local fall-out. This occurred because the rafts which had been planned appeared to be security risks in the sense that they looked like submarines; so they were eliminated. The result is that we do not know with certainty whether 90 percent of the MIKE debris fell out within 200 or 300 miles of the test site, and thereby was missed. A detailed discussion of this point is given in Appendix D. The facts at the present time are that world-wide assay indicates that only a few percent of the MIKE debris could possibly appear any place else on the earth's surface, so we are left with the conclusion that the MIKE debris either is still in the stratosphere or is in the Pacific Ocean.

Furthermore, the elaborate preparations for determining the height of rise of the cloud and the wind velocities at various heights using the

RAYWIND methodology were eliminated also. This would have given the height of rise of the cloud and the direction of the winds at various heights - these matters being extremely important for the correlation of any local fall-out that did occur with meteorological conditions and allowing the prediction for future tests of local fall-out. The conference therefore concludes that it is of the utmost importance that local sampling all around, particularly in the down-wind direction, be done at the CASTLE tests. It is also important that the measurements on height of rise of the cloud and velocity of wind and function of height using the RAYWIND methodology be used. A communication urging this was sent by the conference to the Chairman of the Atomic Energy Commission (Appendix E to this Report).

B. World-wide Sampling in Connection with CASTLE.

It seems clear that the dissemination of radioactivity over the whole world can be measured in a number of ways, but since the time is short and the secrecy conditions or restrictions are such to prevent any use of any admission of the real purpose of the program, some conferees agreed that the Chicago SUNSHINE PROJECT should proceed to institute a world-wide rain-sampling program for next March, April, May, June and July using the project now in existence at the University, on the "Occurrence of Tritium in Nature" as a cover operation. At the present time water samples are being acquired from all over the world to allow for measurement of the tritium content in an effort to determine the distribution of cosmic-ray-produced tritium. These samples can be perfectly well used for strontium assay without in any way changing them for the tritium assay. The procedure is simply to add soluble starch and salt to the sample,

precipitate it out, oxilate or carbonate and to take the filtrate water and proceed with the tritium analysis. The strontium salt precipated is then subjected to the strontium 90 assay. In this manner the rains included in Appendix A have in general been measured for tritium as well, or are in the process of being measured. Practically all of the samples listed in Appendix A were obtained from the Tritium Project. It seems likely that the Chicago Tritium group can write to perhaps 100 places to people who have already been collaborating in the rain and water sampling program and ask them to take the samples. The cost to the project will be only the cost of communication and transport and the canning of the samples. It was decided by the conference that in the interests of practicality and ease of acquisition, the suggestion would be that the collection be made from down-spouts and that the collector be asked to give the roof area and the date, time and location. Samples should then be bottled and shipped directly to Chicago and payment made for any costs or expenses involved. This program will be instituted under the Chicago SUNSHINE PROJECT.

No other suggestion was thought to be practical in view of the very short time before the test series begin.

VI. CONCURRENT BIOLOGICAL RESEARCH PROGRAM

The conference urged most strongly a continuation of the biological research programs related to the SUNSHINE Program. Particularly important is the work on the Maximum Permissible Concentration of Sr^{90}.

APPENDIX A

PROJECT SUNSHINE PILOT ASSAY RESULTS

December 18, 1953

Sample	Assay (Unit: 1/1000 Allowable)
A. Chicago babies: samples furnished by Drs. E. L. Potter and L. O. Jacobson	
1. No. 1: Stillborn July 26, 1953; 37 weeks gestation; 90 gms ash	$\leq 0.3 \pm 0.04$
2. No. 2: Stillborn July 30, 1953; 29 weeks gestation; 57 gms ash	$\leq 0.36 \pm 0.08$
3. No. 3: Premature; Sept. 11, 1953; live weight 1830 gms; 38.3 gms ash	$\leq 0.4 \pm 0.1$
4. No. 4: Premature; Sept. 5, 1953; live weight 930 gms; 24.2 gms ash; 6 months gestation	$\leq 0.4 \pm 0.1$
5. No. 5: Stillborn Sept. 15, 1953; 39 weeks gestation; 58 gms ash	$\leq 0.23 \pm 0.05$
6. No. 6: Stillborn Sept. 13, 1953; 38 weeks gestation; 65 mgs ash	$\leq 0.17 \pm 0.04$
7. No. 7: Premature; Sept. 17, 1953; live weight 660 gms; 13 gms ash	$\leq 0.071 \pm 0.038$
8. No. 10: Stillborn Sept. 20, 1953; 32 weeks gestation; 25 gms ash	$\leq 0.068 \pm 0.015$
9. No. 11: Stillborn Sept. 27, 1953; 32 weeks gestation; 24 gms ash	0.070 ± 0.052
10. No. 12: Stillborn Sept. 26, 1953; 40 weeks gestation; 81 gms ash	$\leq 0.102 \pm 0.031$
11. No. 14: Stillborn Sept. 26, 1953; 37 weeks gestation; 35 gms ash	0.043 ± 0.014
12. No. 15: Stillborn Sept. 28, 1953; 20 weeks gestation; 18 gms ash	0.143 ± 0.024
13. No. 16: Stillborn Sept. 24, 1953; 34 weeks gestation; 52 gms ash	0.207 ± 0.019

Sample	Assay (Unit: 1/1000 allowable)
14. No. 17: Stillborn Sept. 27, 1953; 36 weeks gestation; 88 gms ash	0.15 ± 0.01
15. No. 18: Stillborn Sept. 28, 1953; 39 weeks gestation; 72 gms ash	0.13 ± 0.02
16. No. 19: Stillborn Oct. 7, 1953; 36 weeks gestation; 46 gms ash	0.218 ± 0.023
17. No. 24: Stillborn Oct. 10, 1953; 30 weeks gestation; 26.2 gms ash	0.11 ± 0.01
18. No. 27: Born Sept. 30, 1953; live weight 2400 gms; 39 weeks gestation; 61 gms ash	0.094 ± 0.008
19. No. 28: Stillborn Oct. 14, 1953; 36 weeks gestation; 15.2 gms ash	0.32 ± 0.05
20. No. 29: Premature; Oct. 12, 1953; 36 weeks gestation; live weight 1880 gms; 42.6 gms ash	0.24 ± 0.051
21. No. 31: Stillborn Oct. 27, 1953; 39 weeks gestation: 75.7 gms ash	0.147 ± 0.013
22. No. 32: Premature; Oct. 27, 1953; 31 weeks gestation; live weight 2020 gms; 39.7 gms ash	0.095 ± 0.020
23. No. 33: Premature; Oct. 29, 1953; 31 weeks gestation; live weight 1150 gms; 27.5 gms ash	0.21 ± 0.01
24. No. 34: Stillborn Nov. 2, 1953; 34 weeks gestation; 57.3 gms ash	0.067 ± 0.03
25. No. 37: Stillborn Nov. 8, 1953; 36 weeks gestation; 79.4 gms ash	0.12 ± 0.04
26. No. 38: Stillborn Nov. 8, 1953; 34 weeks gestation; 46.6 gms ash	0.066 ± 0.02
27. No. 39: Premature; Nov. 9, 1953; 32 weeks gestation; live weight 1800 gms; 42.5 gms ash	0.15 ± 0.04
28. No. 40: Born Nov. 7, 1953; 39 weeks gestation; live weight 2225 gms; 62.1 gms ash	0.131 ± 0.025
29. No. 41: Stillborn Nov. 9, 1953; 34 weeks gestation; 58.8 gms ash	0.06 ± 0.02

Sample	Assay (Unit: 1/1000 allowable)
30. No. 42: Premature; Nov. 10, 1953; 38 weeks gestation; live weight 2530 gms; 50.5 gms ash	0.15 ± 0.05
31. No. 43: Stillborn Nov. 10, 1953; 30 weeks gestation; 34.3 gms ash	0.18 ± 0.03
32. No. 44: Stillborn Nov. 11, 1953; 28 weeks gestation; 16.6 gms ash	0.19 ± 0.02
33. No. 45: Stillborn Nov. 11, 1953; 28 weeks gestation; 13.5 gms ash	0.21 ± 0.02
34. Later milkings from babies Nos. 2, 3, 4, and 5 were combined for average	0.162 ± 0.01
B. Samples furnished by Dr. A. K. Solomon, Harvard University	
1. Harvard adult rib (Age unknown to us; 16.1 gms ash)	0 ± 0.12
2. Harvard children's ribs (Ages: 7 yrs., 7 yrs., 3-1/2 yrs., 1 yr., 1 yr., 5 wks., 12 days, 8 days, 6 days; 8.9 gms ash)	0 ± 0.32
C. Data of J. L. Kulp of Columbia University	
1. Ancient clam shells (> 30,000 years)	< 0.018
2. Modern clam shells (2 years old)	< 0.018
3. Wisconsin cheese (1 month old Munster; 20 lbs; 70 gms calcium)	1.3 ± 0.09
4. Wisconsin calf (2 years old; from Madison area)	1.9 ± 0.09
5. Montana calf (6 months old; from Lewiston area)	3.9 ± 0.18
6. Lamont, N.Y., top soil (12 sq. ft. to 2 in. down. Extracted 66 lbs. with equal volume of concentrated HCl); 36 gms calcium	10.9 ± 0.11
D. Section of vertebral column and ribs furnished by Dr. Shields Warren	
1. No. 226: Age 3-3/12 years; Mass.; 24 gms ash	0.17 ± 0.01
2. No. 232: Age seven years; area, Ohio; 17 gms ash	0.12 ± 0.01

Sample	Assay (Unit: 1/1000 allowable)
D.(Cont.)	
3. No. 237: Age seven years, eleven months; area, Maine; 18.7 gms ash	0.13 ± 0.02
4. Group I: Pooled samples, 218, 221, 225 and 228; ages ranged from 1 to 30 days; Massachusetts; 17.21 gms ash	≤ 0.10 ± 0.03
5. Group II: Pooled samples, 219, 220, 236 and 243; ages ranged from 6 to 8 weeks; Maine and Massachusetts; 12.95 gms ash	≤ 0.13 ± 0.02
6. Group III: Pooled samples Nos. 230, 235, 240 and 250; ages ranged from 4 to 6 months; Massachusetts and New Hampshire; 11.58 gms ash	0.12 ± 0.03
7. Group IV: Pooled samples 241, 247 and 251; ages ranged from 3 to 6 years; Maine and Massachusetts; 12.56 gms ash	0.31 ± 0.07
E. Cheese Samples	
1. Wisconsin Swiss (17-5 lbs; from around Monroe in Green County; manufactured July 3, 1953); 110.9 gms ash	1.16 ± 0.043
2. Imported Swiss (19 lbs; Switzerland); 353 gms ash	1.25 ± 0.15
3. Japanese Meiji (10 lbs; processed; obtained by J. E. Mayer; area represented - Tokyo or Osaka, Honshu Island, Japan); 243.4 gms ash	1.4 ± 0.03
4. Japanese Hokkaido (10 lbs; natural; obtained by J. E. Mayer; area represented - Hokkaido Island, Japan); 192.8 gms ash	0.06 ± 0.01
5. Wisconsin Munster (18 lbs from Dodge County, Wisconsin); manufactured end of July, 1953; 372 gms ash	2.07 ± 0.07
F. Chicago milk shed samples: Dr. Lyle Alexander of the U.S. Dept. of Agriculture collected milk-alfalfa-soil samples from several farms in Illinois and Wisconsin. We have not received the soil samples yet, but following are the alfalfa and milk samples which have been processed.	
1. Alfalfa: These samples were dried and ground (but not washed) by Dr. N. Scully of Argonne National Lab.	

Sample	Assay (Unit: 1/1000 allowable)	
a) No. 1: From Grabow Farm, Rock County, Wisconsin; 140.5 gms ash	≤ 12.8	± 0.3
b) No. 3: From Swanson farm, Winnebago County, Illinois; Sept. 29, 1953; 123.0 gms ash	≤ 7.1	± 0.4
c) No. 5: From Lewke farm, Dane County, Wisconsin; Sept. 30, 1953; 137.0 gms ash	≤ 20.9	± 0.9
d) No. 7: From Kurpecki farm, McHenry County, Ill.; Sept. 30, 1953; 152.5 gms ash	≤ 7.44	± 0.46
e) No. 9: From McKee farm; McHenry County, Illinois; 143.5 gms ash	≤ 14.8	± 0.3

2. Milk: These samples were dried by Dr. Arthur Swanson at the University of Wisconsin.

a) No. 1: From Grabow farm, Rock County, Wisconsin; Sept. 28, 1953; 75.6 gms ash	1.7	± 0.08
b) No. 3: From Swanson farm, Winnebago County, Ill.; Sept. 29, 1953; 134.2 gms ash	1.21	± 0.02
c) No. 5: From Lewke farm, Dane County, Wisconsin; Sept. 30, 1953; 88.2 gms ash	2.25	± 0.104
d) No. 7: From Kirpeski farm, McHenry County, Ill.; Sept. 30, 1953; 199.9 gms ash	1.3	± 0.02
e) No. 9: From McKee farm, McHenry County, Ill.; Oct. 1, 1953; 149 gms ash	1.4	± 0.1

3. Soil: These samples were processed to the calcium oxalate form by Dr. Alexander's group at Beltsville, Maryland

a) No. 1: From Grabow farm, Rock County, Wisconsin; Sept. 28, 1953; Knox Loam, 0" - 1"	≤ 26.3	± 1.0
b) No. 1; 1" - 6"	≤ 6.7	± 0.4
c) No. 3: From Swanson farm, Winnebago County, Ill.; Sept. 29, 1953; Carrington Loam, 0 - 1"	≤ 12.0	± 3.0

Sample	Assay (Unit: 1/1000 allowable)	
d) No. 6: From Premo farm, Columbia County, Wisconsin; Sept. 30, 1953; Miami silt, 0 - 1"; leached with NH_4 Ac	13.1	± 0.3
e) No. 6: From Premo farm, Columbia County, Wisconsin; Sept. 30, 1953; Miami silt, 0 - 1"; leached with HQ after NH_4 Ac	15.8	± 0.8

G. Other samples from Dr. Alexander

1. Milk

a) Powdered whole milk; dated 1943; source unknown; 73.8 gms ash	0	± 0.008
b) Dried skim milk; Logan, Utah; Oct., 1953; 289.4 gms ash	1.35	± 0.05
c) Dried skim milk; Beaver, Utah; Oct., 1953; 266.1 gms ash	0.91	± 0.02

2. Soil: Processed by Dr. Alexander's group to calcium oxalate form

a) No. C-2916; Iowa, 1937; Carrington loam; 0" - 3"	0	± 0.5
b) No. C-2917; Iowa, 1937; Carrington loam; 3" - 13"	0	± 0.3
c) From Turkey, Oct., 1953	1.17	± 0.10

H. Egg shells

1. 250 gms obtained from Coffee Shop at the University of Chicago on Sept. 4, 1953	0.485	± 0.62
2. 411 gms obtained from Billings Hospital, University of Chicago, Sept. 8, 1953	0.284	± 0.033

I. Calf Bone Samples from J. H. Harley, NYO Office: ashed by Analytical Branch of the New York Operations Office of A.E.C.

1. Q-1 leg bone ash of calf born March 1953, raised at Easton, New York; pasture fed without supplementary feeding; slaughtered Nov. 1, 1953; 92.99 gms ash	6.1	± 0.2
2. Q-2 - same as above; apparently two portions of same sample but milked and counted separately; 106.96 gms ash	6.3	± 0.15

Sample	dpm/gal.

J. Rain samples obtained from the University of Chicago tritium group.

1.	No. 16: 3.4 gal.; collected in Chicago, Nov. 17, 1952, 0.11 in.	7.[illegible] ± 0.2
2.	No. 18: 3.8 gal.; collected in Chicago, Nov. 22, 24, 25 and 26, 1952; 1.24 in.	4.[illegible] ± 0.2
3.	No. 30: 3.9 gal.; collected in Chicago, Feb. 11, 1953; 0.03 in.	3.[illegible] ± 0.15
4.	No. 40: 1.7 gal.; collected in Chicago, Mar. 12, 1953; 0.30 in.	0 ± 0.3
5.	No. 50: 1.5 gal.; collected in Chicago, Mar. 31, 1953; 0.03 in.	7.2 ± 0.5
6.	No. 51: 2.0 gal.; collected in Chicago, Apr. 3, 1953; 0.04 in.	5.[illegible] ± 1.0
7.	No. 56: 5 gal.; collected in Chicago, Apr. 15, 1953; 0.06 in.	8.[illegible]2 ± 0.60
8.	No. 60: 1.6 gal.; collected in Chicago, Apr. 30, 1953; 1500-1520; 0.03 in.	67.[illegible] ± 3.2
9.	No. 61: 0.7 gal.; collected in Chicago, Apr. 30, 1953; 1830-1910; 0.01 in.	26.[illegible] ± 0.9
10.	No. 67: 2-1/2 gal.; collected in Chicago, May 22, 1953; 0.82 in.	4.[illegible]0 ± 0.48
11.	No. 74: 5 gal.; collected in Chicago, June 5, 1953; 0.05 in.	12.[illegible]5 ± 0.222
12.	No. 79: 2.4 gal.; collected in Chicago, July 5, 1953; 0.20 in.	5.[illegible] ± 0.4
13.	No. 90: 2-1/2 gal.; collected in Chicago, Aug. 1 to 3, 1953; 0.62 in.	2.[illegible]7 ± 0.35
14.	No. 92: 5 gal.; collected in Chicago, Aug. 4, 1953; 0.05 in.	3.[illegible]8 ± 0.46

Sample	dpm/gal.
15. No. 96: 5 gal.; collected in Chicago, Sept. 11, 1953; 0.50 in.	13.54 ± 0.59
16. No. 97: 5 gal.; collected in Chicago, Sept. 18, 1953; 0.63 in.	39 ± 1.16
17. No. 98: 5 gal.; collected in Philippine Islands, March, 1953	7.76 ± 1.79
18. No. 103: 5.0 gal.; collected in Chicago, Oct. 26, 1953; 0.13 in.	46.0 ± 1.5

K. Other water samples

1. Pacific Ocean (Santa Monica Beach); 80 liters, collected May 20, 1953	≤ 1 ± 0.4
2. Mississippi River water at St. Louis, 5.0 gal.; collected April 17, 1953	< 0.77 ± 0.18
3. Chicago tap water, 9.83 gal.; collected Oct. 27, 1953	0.39 ± 0.08
4. Snow sample No. 19: 4.5 gal.; collected in Chicago Dec. 2, 1952; 3.90 in.	≤ 3.3 ± 0.4

These data are complete to date.

W. F. Libby
University of Chicago

SUNSHINE PILOT ASSAY EXPENSES FOR FIRST FOUR MONTHS

Salaries	$12,000
Overhead (43%)	5,160
Travel	300
Supplies, etc.	5,600
Equipment	7,000
	$30,060
Number of samples run	96
Cost per sample	$300.00

APPENDIX C

THE ANALYTICAL METHOD

A. Preliminary treatment of samples

Before any chemical preparation was done, most of the solid samples were dried or burned in an oven or incinerator and then reduced to ash in a muffle furnance at 900°C. Samples treated in this way included the human, alfalfa, cheese and milk specimens. The Bureau of Plant Industry at Beltsville, Maryland, processed the soil samples and sent them to us in the form of calcium oxalate.

The water samples, including the rain, snow, lake, river and ocean samples, were filtered to remove solid material.

B. Chemical preparation of samples

The ashed samples were dissolved in concentrated HCl and concentrated HNO_3 was also added if the sample did not go into solution satisfactorily. The residue, if any, was then filtered off, and, with the exception of the human group, strontium carrier was added to the solution, which was then milked with yttrium.

The alfalfa samples were still highly contaminated after the first milking. Repeated ferric phosphate precipitations were made to remove the rare earth contaminants. The strontium carrier which had been added was isolated using Harley's method, and then purified.

The soil samples in the form of calcium oxalate were dried, ignited to oxides, dissolved in concentrated HCl, diluted with water, and milked. The milking technique adopted by the Chicago group for the determination of the Sr^{90} content of various types of sample essentially consists of obtaining an HCl solution of the sample, adding carrier for the yttrium, separating the Y^{90} daughter of any Sr^{90} present in the sample by a phosphate precipitation of the

carrier, and determining the amount of Y^{90} and therefore also of Sr^{90} present by absolute counting.

The technique outlined above was tested and shown to yield satisfactory results both using inactive yttrium and neodymium as carriers for the Y^{90} and both in the presence and absence of calcium in the solution. The following example of a test experiment performed with neodymium carrier and in the absence of calcium serves to illustrate the details of the chemical procedure, the counting technique, and the calculations involved in making a Sr^{90} assay by the milking technique.

2.005 g $Sr(NO_3)_2$ were dissolved in 50 ml H_2O, and to it was added approximately 22,000 dpm of an acid solution of Sr^{90} - Y^{90} tracer in equilibrium. A few ml of 85% H_3PO_4 were next added, followed by 0.304 g of Nd^{III} carrier in HCl solution. The solution was stirred and heated. To the hot solution 2 N NH_4OH was added gradually with vigorous stirring until the precipitation of $NdPO_4 \cdot 2H_2O$ was believed to be complete. ($NdPO_4 \cdot 2H_2O$ and $YPO_4 \cdot 2H_2O$ precipitate out completely well below pH 1, while the phosphates of calcium and strontium do not begin to precipitate until pH 3 or 4 is exceeded). The precipitate was digested with heating for 15 minutes, filtered onto a 7-cm filter paper, and washed with water. To the filtrate were added a few ml of 2 N NH_4OH. No precipitation occurred, showing that the precipitation of neodymium had been complete. Additional NH_4OH was now added to the same solution until $SrHPO_4$ was precipitated completely. The $SrHPO_4$ was also filtered onto 7-cm paper. The precipitates were dried and mounted onto lucite semicylinders of 1-7/8" I.D.

The counting procedure is described in Section C below. The mounted samples were counted on a gold foil covered Q-gas flow counter of 1-1/2" diameter and 10" active length. The geometry factor for the position that was maintained between the counter and the sample was previously determined with use of a similarly mounted sample of KCl and was found to be 2.50.

The activities in the two samples were followed for over 10 days. The activity on the neodymium sample decayed from an initial rate of 4500 cpm with a constant half life of 61 ± 1 hours into a very long lived tail of 102 cpm. An aluminum absorption curve for the same sample determined within a few hours after milking was found to be absolutely straight to 360 mg/cm^2 and gave a half thickness value of 133 mg/cm^2.

When the Y^{90} activity was subtracted out, the aluminum absorption curve for the strontium sample, which was also determined soon after milking, also was a straight line as far as 40 mg/cm^2. The half thickness value was 12.0 mg/cm^2.

The intensities and identity of the activities in the strontium and neodymium samples corrected to milking time were as follows:

	Y^{90} activity, cpm	Sr^{90} activity, cpm
Strontium Sample	263	1068
Neodymium Sample	4540	102

Applying the Libby equation,

$$D = \frac{IG\frac{\ell}{\lambda}}{1 - e^{-\frac{\ell}{\lambda}}} \; e^{\frac{L}{\ell}} \quad ,$$

where D = the disintegration rate of the sample in dpm

I = the counting rate of the bare sample

G = the geometry factor = 2.50

L = thickness of air between sample and counter + thickness of counter wall (sum = 2.70 mg/cm^2)

ℓ = thickness of the sample in mg/cm^2

$\bar{\ell} = \frac{\ell_{1/2}}{0.693}$, where $\ell_{1/2}$ is the half thickness value of the activity in mg/cm^2,

the following results were obtained:

	ℓ	$\bar{\ell}$	D(Y^{90})	D(Sr^{90})
Strontium Sample	60.9	17.3	658	11,320
Neodymium Sample	15.1	192	10,970	447
			11,628	11,767

A very satisfactory agreement between the disintegration rates of Y^{90} and Sr^{90} was obtained. The recovery of the Y^{90} activity from the solution is seen to be 94% and the percentage of Sr^{90} carried over in the neodymium precipitate as contamination is seen to be 3.8%.

C. Counting technique

The absolute radioactivity measurements in the Chicago laboratories have been made with cylindrical thin-wall flow counters. These are shielded with several inches of iron and with anti-coincidence counters.

The large sample counters have been built after a design by T. Sugihara, R. Wolfgang and W. F. Libby (Rev. Sci. Inst. 24, 511 (1953)). These counters have lucite end pieces connected by three thin brass rods at their periphery. Thin plastic film 2.69 mg/cm^2, with a conducting gold-coated surface, is used for the counter wall. Miniature flow counters have been constructed with field adjusting rings at the ends and with external end supports (to avoid internal rods and their field distortion). These counters have been covered with DuPont Mylar film coated on the inner side with aluminum 0.975 mg/cm^2. The Mylar, a poly ester, is very durable, being resistant to moderate physical stress and common organic solvents. The background for the large counters (1-1/2" x 6" to 10") runs about 6 to 10 counts per minute within the shielding mentioned above. The miniature counters (1.4 x 3.0 cm) have a background of 0.4 counts per minute. (The counters with aluminum-Mylar walls are quite photosensitive, but are ordinarily operated in the dark.)

Samples are mounted on plastic half cylinders, two of which completely surround the sample counter. The geometry is as good as is permitted by the necessity for placing absorbers between the sample surface and the counter wall. For the large counters the geometry is 38% and for the small ones 33%. The corresponding factors used in conversion of cpm to dpm are 2.7 and 3.0 respectively. These geometry determinations were made using potassium^{40} as a secondary standard and using the figure 28 dps/gm K. Most powdered samples are mounted with the aid of dilute agar in alcohol and water, which provides a nearly weightless binder after drying.

The samples have usually been counted to a standard error of 10 to 15% where activity is sufficient. If such precision would require an extraordinarily long

counting period greater error is allowed.

The calculation of disintegrations per minute from the measured counts per minute is made in the following way. The counts per minute (cpm) are multiplied by the appropriate geometry factor, by a factor to correct for absorption by the counter wall and absorbers (ex.(wall thickness mgs/cm^2)/(mean thickness of radiation being measured)), and by the sample weight in mgs. The resulting number is divided by the mean thickness of the radiation, by the sample area, and by a correction factor for samples less than "infinitely" thick (1-1/exp. (surface density of sample)/(mean thickness for the measured radiation)). For example, a sample of Y^{90} counted on a miniature counter gives 5.7 ± 0.1 net cpm. Its weight is 0.416 gms and its area is 5.75 cm^2. An absorber of 112 mgs/cm^2 was used.

$$\text{dpm} = \frac{5.7 \text{ cpm} \times 3.0 \times 416 \text{ mgs} \times e^{\frac{113}{188}}}{188 \text{ mgs/cm}^2 \times 5.75 \text{ cm}^2 \times \left(1-e^{-\frac{72.4}{188}}\right)} = 37.6 \text{ dpm } Y^{90}.$$

Backscattering corrections have not been made in these calculations. The plastic sample mounts "reflect" only about 8% of the radiation striking them and this backscattered radiation has only about half the energy of the original radiation. Since the samples are of finite thickness, ca. 60 to 80 mgs/cm^2, most of the backscattered radiation is absorbed. The backscattering contributes about 1% of the observed activity. This is at least partically corrected for by the geometry determinations where backscattering corrections were not made.

To calculate SUNSHINE UNITS from this dpm figure, it is multiplied by the decay correction factor (exp.(hours since milking from Sr^{90})/(mean life of Y^{90}))

and by any yield factor. This number is divided by the weight of calcium in the milked sample in grams, by 2.2 (see SUNSHINE UNIT definition), and by a growth correction factor in case the Y^{90} was not in complete equilibrium with the Sr^{90} at the time of milking (1-1/exp.(hours Sr^{90} has had to produce Y^{90})/(mean life of Y^{90})). As an example, the above Y^{90} sample came from a sample containing 22.1 grams of calcium. The yield factor due to handling losses was 1.56 (unusually high). The milking took place at a time when complete equilibrium was established and the counting time was 7.58 hours after milking.

$$\text{Sunshine Units} = \frac{37.6 \text{ dpm } Sr^{90} \times e^{\frac{7.58}{88}} \times 1.56}{22.1 \text{ gms} \times 2.2 \times 1.0} = 1.32.$$

A position of fall of 75M particles from various altitudes. Altitudes in 1000's of feet.

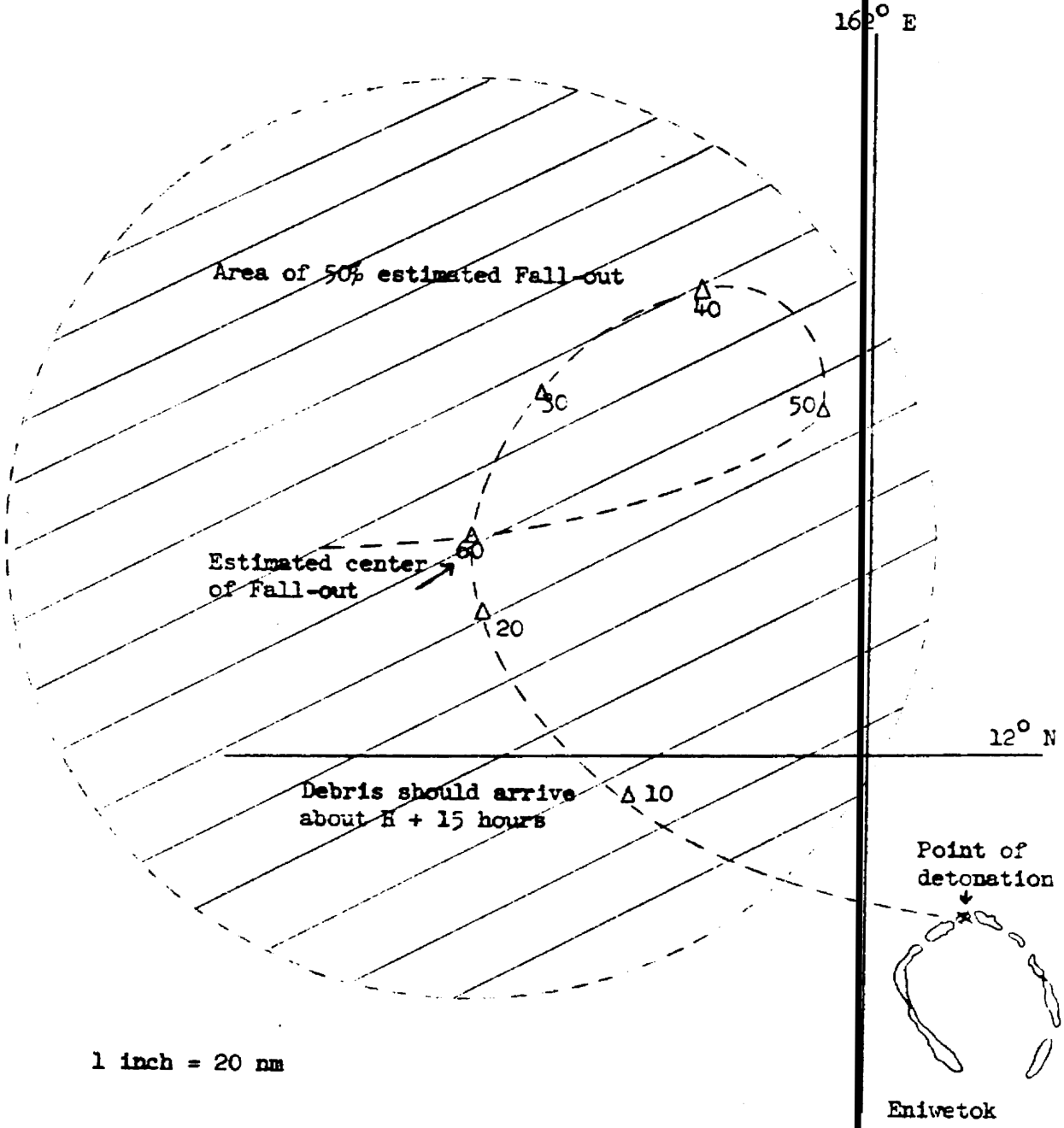

Fig. 1 Estimate of the Fall-out from Mike Shot

APPENDIX D

FALL-OUT FROM MIKE

The experience of detonating devices on low towers and the surface of the earth in Nevada indicates that there is a sizeable fraction of residual radiation deposited on the ground within a few hours after the shot. The current speculation as to the cause of this fall-out is that sand and soil are drawn into the hot fireball if it intersects the earth, and either provides large condensation nuclei which are heavy enough to fall, or picks up small radioactive particles as it falls back to the earth. It would be expected, as it is indeed observed, that these falling particles are transported by the wind. Thus, the downwind area to distances appropriate to the wind speed and time of fall of the particles are contaminated by residual radioactivity.

For the IVY Mike shot the major downwind areas were large expanses of ocean in which no sampling was made of residual radiation. The true amount of fall-out from Mike is therefore unknown. There was only one surface shot where downwind samples were made, and these were not complete. In order to estimate the fall-out from Mike, it will be necessary to make some arbitrary scaling from the meager JANGLE surface shot data. This technique is fraught with uncertainty because the JANGLE data are poor and there are no good theories which provide a scaling from 1 KT to 10 MT. Nevertheless, it is considered worthwhile to attempt the extrapolation in order to prevent a possible accidential contamination and to guide future test programs to adequate measurements.

Lulejian[1] has presented an analysis of the JANGLE surface shot which shows the pattern of downwind fall-out as deduced from an aerial survey after the detonation. The Summary Report: Weapons Effects Tests[2] gives very detailed results of the fall-out within a few miles of ground zero. The residual activity was integrated over the entire area by means of a planimeter and it indicated that about 10 percent of the bomb debris fell within 4 miles of GZ and that another 80 percent fell within the next 150 miles downwind. Within the downwind area there were two "hot spots," one centered 20 miles downwind of about 550 mi^2 with 50 percent of the debris, and one centered about 60 miles downwind of about 520 mi^2 with about 17 percent of the debris. From observations of the detonation it appeared that the debris was separated into 2 clumps, the mushroom proper centered at 13,000' and the top of the stem centered at 9000'. If it is assumed that the debris settles at the same rate as the Stoke's law, fall for a spherical particle of 70 μ diameter, the maximum at 60 miles would have come from the mushroom and the maximum at 20 miles would have come from the clump at the top of the stem. Thus there is some evidence that a large fraction of a surface burst comes rapidly to the ground and that the rate of fall of a 70μ particle provides an estimate of the rate of settling.

For the Mike shot the exact height of rise and the complete wind structure to the top of the cloud is not known. There is some rather strong evidence, however, that there was a clump of debris, at what might be termed the top of the stem, at about 60,000'. The report on fall-out distribution[3] shows a plot of the point of impact of 75μ particles falling from 60,000' and is shown in Fig. 1. The time it would take such a particle to reach the

ground would be about 15 hours. If it is assumed that the area covered by the fall-out from this stem top is proportional to the square of the distance downwind, the area covered would be about 10,000 mi^2. If it is further assumed that if this area contained 50 percent of Mike, there would be an average concentration 5.8 mc/mi^2 at 15 hours; the time the debris would have reached the ground. The circular area on Fig. 1 indicates the extent of the area affected.

It must be concluded that if such a high average concentration were produced, peak concentrations might be high enough to be exceedingly dangerous. It can also be seen, by superposing Fig. 1 on a chart of the area around Eniwetok, that, if this debris did in fact fall out, there was no fall-out measurement to detect it. The problem of the world-wide distribution of Mike debris will take on a vastly different aspect if 50 to 80 percent of the debris fell undetected on the ocean. The problem of radiological safety will also be made much more difficult if plans must be made to keep personnel from such large areas. With the present state of ignorance of the reality and magnitude of the fall-out from megaton range bombs, it is necessary to insure that there is proper documentation of the fall-out from future tests.

(1) Lulejian, N.M., Radioactive Fall-out from Atomic Bombs, Hq., ARDC, November, 1953.

(2) Operation JANGLE, Summary Report: Weapon Effects Test, WT-414, AFSWP, November, 1952.

(3) Operation IVY; Nature, Intensity, and Distribution of Fall-out from Mike Shot, NRDL, April, 1953.

APPENDIX E

17 December 1953

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TT-1741 We consider it absolutely essential to establish in the CASTLE Tests whether there is large close-in fall-out accompanying large-scale detonations. This knowledge is essential both to the military utilization and the SUNSHINE evaluation. The IVY Raft data program, the cloud height measurements, and RAYWIND program were cancelled. These necessary data consequently are now lacking for SUNSHINE and for the evaluation of close-in radioactive fall-out of large detonations. By close in we mean up to several hundred miles for the CASTLE series. We propose reactivation of these programs for CASTLE.

Willard F. Libby

cc: Dr. John C. Bugher, Director
Division of Biology and Medicine
U. S. Atomic Energy Commission
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