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RESEARCH MEMORANDUM

SERIES A

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RAND SUNSHINE PROJECT

Conference January 9, 10, 1954

Washington, D. C.

RM-1280-AEC

C.48A

1 June 1954

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ACKNOWLEDGMENTS

Following the RAND SUNSHINE Report (R-251-AEC)[1] of the summer of 1953, the Division of Biology and Medicine of the AEC undertook to implement a number of the recommendations of that report. By the end of 1953 a number of experimental data, particularly those of the baby sampling program of the University of Chicago, had become available. For proper orientation of the future SUNSHINE program it appeared appropriate to call another conference of the principal parties.

A small meeting was called by W. F. Libby at RAND, Santa Monica, on December 16-18, 1953 preliminary to the major conference held in Washington, January 9-10, 1954. (The preliminary conference is recorded as RM-1175-AEC.)[2]

The following individuals attended the Washington conference. We are indebted to them for their individual contributions and particularly to Dr. J. C. Bugher for accepting the chairmanship of the conference.

Alexander, L. T.	Department of Agriculture
Brown, H. C.	Atomic Energy Commission
Bugher, J. C., M.D.	Atomic Energy Commission
Butts, J. S.	Atomic Energy Commission
Claus, W. D., M.D.	Atomic Energy Commission
Comar, C. L.	Atomic Energy Commission
Dean, L. A.	Department of Agriculture
Drysdale, Col. T.	Headquarters, U.S. Air Force
Dudley, R. A.	Atomic Energy Commission
Dunford, J. M.	Atomic Energy Commission
Dunham, C. L., M.D.	Atomic Energy Commission
Dunning, G. M.	Atomic Energy Commission
Eisenbud, M.	Atomic Energy Commission
English, S. G.	Atomic Energy Commission
Fine, P. C.	Atomic Energy Commission

Gibbs, Col. J. A.	U.S. Air Force
Gibson, Maj. T. A.	Armed Forces Special Weapons Project
Haight, Capt. H. H., USN	Atomic Energy Commission
Harley, J.	Atomic Energy Commission
Hill, J. E.	The RAND Corporation
Kramish, A.	The RAND Corporation
Kulp, J. L.	Columbia University
Libby, W. F.	University of Chicago
Lulejian, Lt. Col. N. M.	Air Research and Development Command
Machta, L.	U.S. Weather Bureau
Maynard, Capt. R., USN	Armed Forces Special Weapons Project
Mitchell, H. H., M.D.	The RAND Corporation
Northrup, D.	U.S. Air Force
Plesset, E. H.	The RAND Corporation
Warren, S., M.D.	New England Deaconess Hospital
Western, F.	Atomic Energy Commission
Wexler, H.	U.S. Weather Bureau

The New York Operations Office of the AEC had prepared for consideration at this meeting a comprehensive progress report mainly on the physical aspects of SUNSHINE. Available as NYO-4571,(3) it will be referred to in this conference report.

INTRODUCTION

The basic problem of SUNSHINE having been adequately stated previously, it seemed necessary for the conference to consider in detail the specific problems which had already been attacked and to recommend a future course of action. Accordingly the main subjects of discussion were

I. Scope of SUNSHINE

II. Biological Sampling

III. Determination of the Physical Phenomena

IV. Maximum Permissible Concentration

V. SUNSHINE Future

I. The Scope of SUNSHINE

Dr. Bugher presented a tabulation of the present AEC yearly effort on problems pertaining directly or indirectly to SUNSHINE:

TABLE I

	Scientific Man-Years	Dollars (in thousands)
A. Overall Studies		
1. Formation of Bomb Debris	-	-
2. Transport of Bomb Debris	4	37
3. Fall-out	18	440
4. Entry of Fission Products	6	54
5. Metabolism of Fission Products in Animals and Plants	35	544
6. Evaluation of the Hazard to Man	118	2,050
B. Special Studies		
1. SUNSHINE	8	110
2. Iodine-131 and others	3	64
TOTAL	200	3,349

Thus, the SUNSHINE project fits into a whole framework of research bearing on the creation of an environmental situation and man's involvement.

II. Biological Sampling

A unique set of data has become available, bearing on man, or at least prenatal man, and his involvement with a Sr^{90} contaminated environment. There are the Chicago baby measurements summarized in Appendix A.

The results indicate so far that newborn babies in the Chicago area have about 1/6th SUNSHINE Unit of Sr^{90} or about 1/6000th of tolerance. On the basis of the original SUNSHINE estimate of an even distribution of 2.5×10^4 MT of debris to bring the world population up to tolerance, 4 MT would give the Chicago babies the observed deposition. The integrated National Test Site detonation is of the order of 400 KT. Thus, one must assume a significant contribution from the Pacific tests or an extremely uneven distribution from the continental tests.

It is interesting to note, however, that regardless of the origin of the observed Sr^{90} in soil, there does appear to be a correlation between the measured soil values and the observed baby samples. This correlation is based on data received through January 4, 1954.

In Project SUNSHINE Bulletin No. 5[a] the Sr^{90} assays on 44 premature or stillborn Chicago babies are reported by Professor W. F. Libby. Nine of these measurements were made early in the project, while techniques were being developed and tested, and are reported as less than or equal to specified values. The birth dates for the first 43 samples span the period from July 26 to November 20, 1953. The birthdate of the 44th specimen was not stated but it was delivered to the project on December 4, 1953. The ash weights for individual samples vary from 13.5 to 90 grams. The Sr^{90} assays vary from 0.043 ± 0.014 to 0.4 ± 0.1 SUNSHINE units. The unweighted average for the 44 samples is 0.165 SUNSHINE units. If the nine, less certain assays, (1 through 8 and No. 10) are not considered the range of variation for the remaining 35 samples is from 0.043 ± 0.014 to 0.32 ± 0.05 SUNSHINE units with an average of [illegible]8.

The distribution of the number of samples falling in intervals of 0.05 SUNSHINE units, for the 44 babies, is given in Figure 1. The distribution for the reduced list of 35 samples is given in Figure 2.

Justification for considering a somewhat lower average value than that obtained by averaging the 44 samples is indicated by the fact that sample number 45, which was a combined average of later milkings of Yt^{90} from samples 2, 3, 4 and 5, gave [illegible] ± [illegible] SUNSHINE units, whereas the average of the earlier measurement on samples [illegible] was 0.347, with considerably greater uncertainties in the counting statistics. If the average of 0.182 is used with a weight of four, in obtaining the average assay from the 44 samples, a value of 0.15 instead of 0.165 is obtained. This is in close agreement with the average of [illegible] obtained from the reduced list of 35 samples. Consequently an average value of [illegible] SUNSHINE units, with a range of 0.04 to 0.32 will be considered as representative of the [illegible] burden, for the Chicago babies, measured to date. Since a SUNSHINE unit is [illegible] of the maximum permissible concentration of [illegible] $\frac{\text{microcuries of Sr}}{\text{gram of calcium}}$ fixed in bone*, the average of 0.15 SUNSHINE units for the Chicago babies corresponds to 0.15 x 10^{-3} or approximately 1/6700 of M.P.C.

It should be noted that the uncertainties, listed for individual samples in SUNSHINE Bulletin Number [illegible] (4), are based only on the counting statistics for the sample and do not include other uncertainties which are involved in other operations and measurements required to obtain the final result of a particular assay;

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* Reported by [illegible] Kulp at the Washington SUNSHINE Conference.

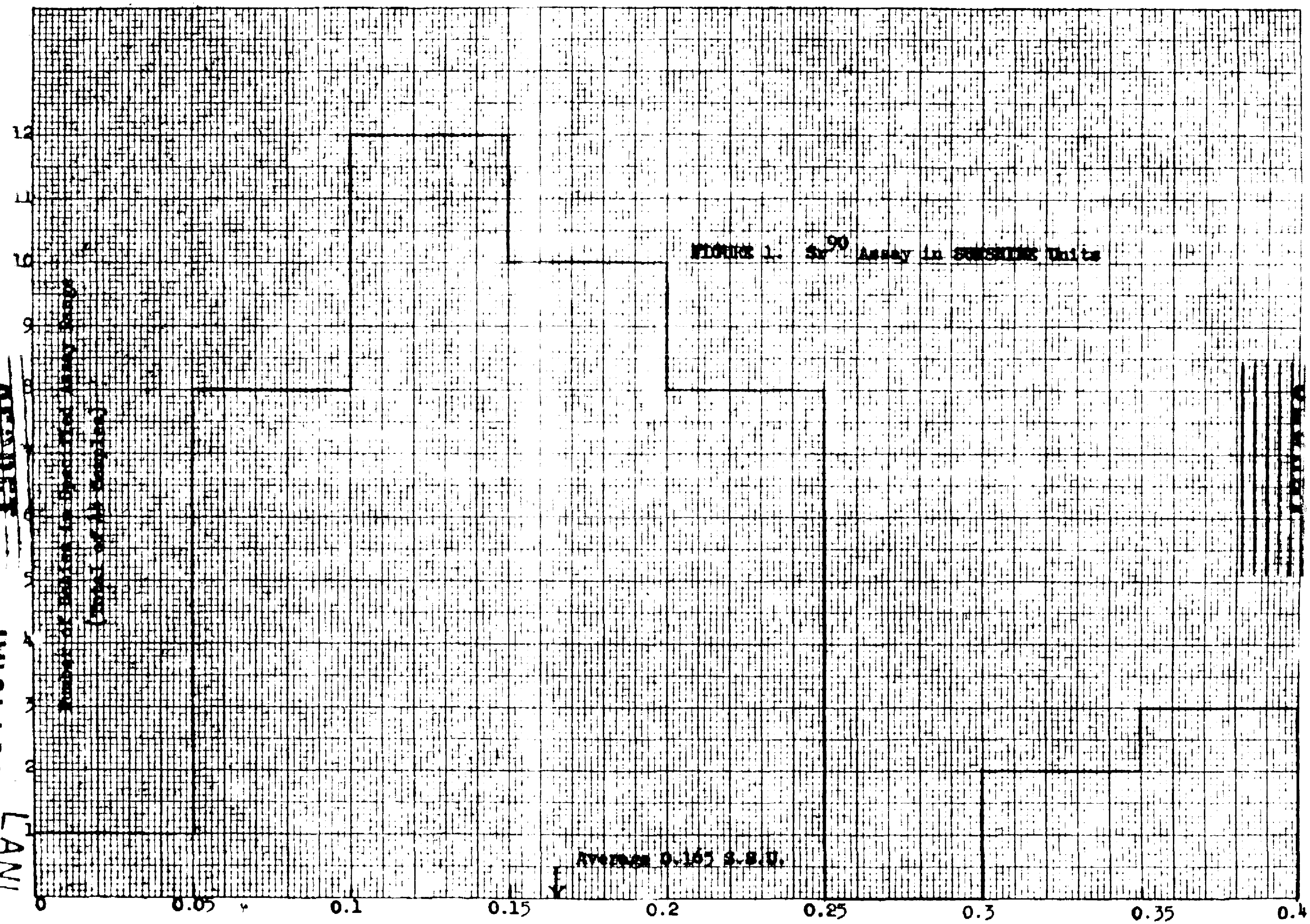

FIGURE 1. Sr^{90} Assay in SUNSHINE Units

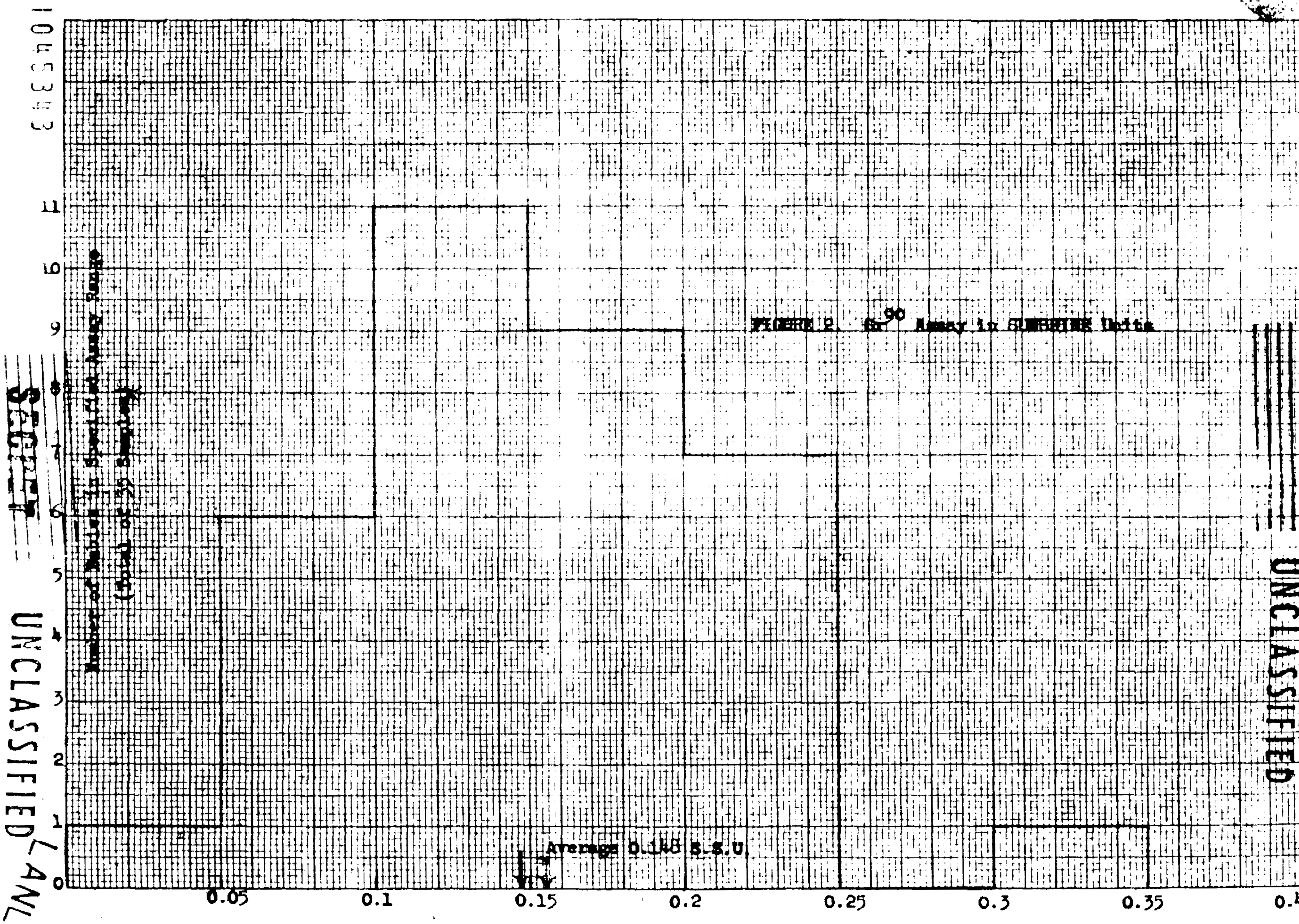

FIGURE 2. Sr^{90} Assay in SUNSHINE Units

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i.e., such uncertainties as are introduced in the chemical analyses, the self absorption corrections and the absolute calibration of the counters are not included.

With the possible exception of the absolute calibration of the counters, there is good evidence that the uncertainties introduced by such additional parts of the assay procedure are small compared to the uncertainties due to the counting statistics. For example three sets of fraternal twins were measured. These measurements are summarized in Table [illegible].

Table [illegible]

Sr^{90} Assay of Fraternal Twins

[illegible] of Twins	Sample Number	Sr^{90} Assay (S.S.U.)
[illegible]	[illegible]	0.19 ± 0.02
	[illegible]	0.21 ± 0.02
[illegible]	[illegible]	0.17 ± 0.04
	[illegible]	0.13 ± 0.04
[illegible]	[illegible]	0.18 ± 0.05
	[illegible]	0.22 ± 0.06

From Table [illegible] it is clear that the agreement between the measurements on the individuals within each set of twins is within the stated uncertainties due to the counting statistics. Since each twin of a given pair would have experienced the same dietary environment from the common mother, during the same gestation period, it is reasonable to expect that each would accumulate the same concentration of Sr^{90}.

In an assay for such low concentrations of radioactive elements, as are involved in the Sr^{90} determinations, accidental introduction of fission product contamination, from dust, water and in the chemicals used in the analyses, must be carefully avoided. Consequently, the fact that such "pre-atomic age" samples, as the Iowa soils samples C-2916 and [illegible] gathered in 1937 and the powdered milk, processed in [illegible], show no Sr^{90} activity adds greatly to the confidence which can be placed in the assays of other samples which show the presence of Sr^{90}.

Also listed in <u>SUNSHINE Bulletin No. [illegible]</u>(4) are the Sr^{90} assays for five soil samples from Illinois, five from Wisconsin, one from New York and one from near Ankara, Turkey. Most of these samples were collected between September 28 and October 6, 195[illegible]. The Sr^{90} assays varied from [illegible] ± [illegible] S.S.U. for the top one to two inches of heavy alluvial soil, from near Ankara, Turkey, to 26.3 ± 1.0 for the top one inch of Knox fine sandy loam from the Grabow farm in Rock County, Wisconsin.

Samples 1, [illegible] and [illegible] were soils collected from farms in Illinois and Wisconsin and were each assayed in two parts. The first part consisted of the top layer to a depth of 1 inch and the second part was a layer 5 inches thick extending from a depth of 1 inch to a depth of [illegible] inches. The average of the Sr^{90} assays for the top layers, 1 inch total, was [illegible]7.15 S.S.U. The underlying 5 inch layers averaged [illegible] S.S.U.

It is clear from these samples that the Sr^{90} is not uniformly distributed, even in the top [illegible] inches of soil, at any given location.

Samples 6 and [illegible] consisted of only the top 1 inch layers. However, each sample was leached first with ammonium acetate and this was followed with a second leaching using [illegible]. The materials dissolved in the successive leachings were each assayed separately for Sr^{90}. These data show that the leaching with ammonium acetate does not remove all the Sr^{90} or the calcium from the soil. Not enough information is given with samples [illegible] and [illegible] to compare them with samples 1, 3, 5 and 7.

Consequently, the average of samples [illegible], 5 and 7 will be taken as representative of the Sr^{90} concentration in Illinois and Wisconsin soils. For the top 1 inch this average is [illegible] S.S.U. and for the layer from 1 to 5 inches the average is [illegible] S.S.U.

The sample of soil from Lamont, New York, was assayed for Sr^{90} by J. L. Kulp of Columbia University. The result given in SUNSHINE Bulletin No. 5[4] was [illegible] ± 0.1 S.U. This value was changed to 9.[illegible] ± 0.1 by a more recent calibration of the counter used in the assay[illegible]. The sample consisted of the top 2 inches of soil collected from an area of 12 ft^2 and weighed 66 lbs. A total of [illegible] grams of calcium was extracted with concentrated HCl.

To date, no measurements on the stable strontium content or the stable strontium to calcium ratios have been reported for any of the samples.

Possible Correlation of the Chicago Baby Sr^{90} Assays With the Soil Sr^{90} Assays

In spite of the fact that no data are available on the stable strontium content of any of the samples, it is of interest to use the assumptions of the SUNSHINE Formula[1] combined with the Sr^{90} soil assays and the previously measured average stable strontium concentrations for soils and human skeletons, to calculate the Sr^{90} concentrations which would be predicted for human samples if they had been in equilibrium with such soils through their food intake, during their entire period of growth.

The basic assumption of the SUNSHINE Formula is that the ratio of Sr^{90} to stable strontium in the human skeleton will be the same as in the soil, which has been the source of its food supply, under equilibrium conditions. This is equivalent to the following expression

$$\frac{w_m}{W_m} = \frac{w_s}{W_s} \qquad (1)$$

where w_m = weight of Sr^{90} per unit weight of calcium in man,

w_s = weight of Sr^{90} per unit weight of calcium in soil,

w_m = weight [illegible] stable strontium [illegible] unit weight of calcium in man

w_s = weight [illegible] stable strontium [illegible] unit weight of calcium in soil.

Since [illegible] SUNSHINE unit [illegible] of Sr^{90} per gram of calcium, Equation (1) also [illegible] if both w_m and w_s are expressed in SUNSHINE units.

If we use the SUNSHINE figure [illegible] stable strontium per 1000 grams of calcium [illegible] average [illegible] man, w_m = [illegible] x 10^{-4}.

The average [illegible] available data [illegible] stable strontium content of soils is 1.7 x [illegible] grams [illegible] strontium [illegible] six inches of soil. Combining this with the [illegible] 36 grams [illegible] measured for the 12 ft^2 by 2 inch sample of Lamont, New York [illegible]

$$w_s = \frac{[illegible] \times 10^{[illegible]} \times [illegible]}{([illegible]\,280)^{[illegible]}} [illegible] = [illegible]\,.77 \times 10^{-2} \text{ grams}$$

of stable strontium per gram of calcium [illegible]

$$[illegible] = \frac{[illegible] \times 10^{-[illegible]}}{6.77 \times 10^{[illegible]}} [illegible]\,.48 \text{ S.U.},$$

as the expected [illegible] assay for human [illegible] if the entire period of growth [illegible] also assumed that the concentration [illegible] in the top [illegible] soil is the biologically significant one. Actually [illegible] for various depths of soil show that the [illegible] for the top 6 inches of soil, there is an ambiguity as to [illegible] concentration for the soil is biologically significant. If there were [illegible] additional fallout, however, it is probable that the process of tilling [illegible] would eventually make the Sr^{90} concentration more nearly uniform [illegible] the top 6 inches of soil.

If we assume that the Wisconsin and Illinois soils have the same ratio of natural strontium to calcium as the Lamont sample, the predicted assay of human material, referred [illegible] the average [illegible] inch of soil samples 1, 3, 5, and

7, would be [illegible] for the [illegible] inches deep the corresponding value would be [illegible].

The maximum soil assay was for the [illegible] inch of sample No. 1 (26.3 S.S.U.). The corresponding assay for humans would be [illegible] S.S.U. The minimum was for the 1 to 5 inch layer of Sample No. [illegible] ([illegible] S.S.U.) with the corresponding human value of [illegible].

It is interesting to note that the average value of the Sr^{90} assays for Chicago babies ([illegible] S.S.U.) is between the average values predicted from the averages of the assays of the top [illegible] and of the 1 to 5 inch samples of Chicago area soils. Also the spread in the predicted human assay values, referred to the maximum and minimum soil assays corresponds roughly to the spread in the assay values measured for the Chicago babies.

One may well question whether the assumption of equilibrium used in deriving the SUNSHINE formula applies to the Chicago babies. Also, the small number of soil samples and the lack of normal strontium measurements for them, certainly make doubtful the assumption that they represent a true picture of Chicago soils. Consequently the agreement between predicted human assay values and the values measured for the Chicago babies may be fortuitous. However, they certainly suggest that more soil samples should be assayed for Sr^{90} and their normal strontium concentrations determined so that a more reliable check on the SUNSHINE formula can be made.

Also similar data on human and soil samples from other areas would be valuable.

The other data in Appendix A are of interest only insofar as they might ultimately relate to man's involvement with environment. Three additional conclusions are

a. 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 th[illegible] [illegible] The Sr^{90} is removed as the water runs to the river [illegible] as rain. Further data are necessary to fully establish this point [illegible] seems likely that they will.

b. [illegible]t seems [illegible] pure. The data are inadequate to establish [illegible] that this is so. It seems eminently reasonable [illegible] which most certainly must take place in the a[illegible] that any material which falls into the sea will [illegible] mix and be [illegible] Consequently, one may fully expect a very [illegible] in the few cases given in Appendix A.

c. The [illegible] amount of fallout measured in the plant is [illegible] plant.

This bypassing [illegible] process will be important in assessing the [illegible]

An important [illegible] sampling program concerns itself with the contr[illegible] and then measuring deposition or output of [illegible] ultimate purpose is to determine the strontium-calcium uptake and equilibrium characteristics in the animal. Two-week milk [illegible] controlled amounts of calcium-45 and Sr^{90} indicate [illegible] calcium tracer in the milk by a factor of about [illegible]* This would [illegible] higher selective retention of Sr^{90} in the animal. Further measurements may enable one to picture animal bone as an ion-exchange mechanism of [illegible] characteristics. This perhaps will enable one to calculate the [illegible] equilibrium data.

These equilibrium data are required [illegible] only for the strontium-strontium and strontium-calcium SUNSHINE models [illegible] offer the hope of calculations

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* C. L. Comar, Washington conference

based on a strontium-calcium model. The ratio of radium in man to radium in his environment is well known. When the [illegible] radium-strontium uptakes in man [illegible] known, this should provide an answer to the man-environment strontium equilibrium question.

III. The Physical Phenomena

A great deal of the Washington conference was devoted to questions of fallout pattern, atmospheric storage, etc. These questions, important in themselves and in their relation to SUNSHINE, are discussed in detail in NYO-4571[3] and in the RAND AUREOLE report[5] which is being issued concurrently with this report.

Two other questions which concerned the conference were (a) the possibility of high-altitude particle detection by polarization measurements, and (b) electrostatic scavenging of charged particles. Appendix A describes the present state of problem (a), while (b) is [illegible] RAND Report RM-1153-AEC.[6]

IV. Maximum Permissible Concentration

The SUNSHINE standard (i.e., the "[illegible]" unit of Appendix A) is based upon the Maximum Permissible Concentration of [illegible] microcurie of Sr^{90} per "standard man." But the entire concept of what happens to a man or group of men at a given Sr^{90} level is still quite vague. We are also interested in relationships between injury to individuals and injury to population, mutation rates, etc.

Experience with radium and [illegible] dates through a period of some sixty years — with [illegible] neutron-produced [illegible], some twenty years. The data accumulated from these three sources indicate with a considerable degree of firmness that the human organism, as well as the animal organism, is able to compensate for slight injuries inflicted by very small amounts of radiation, that there will [illegible] certain ill effects [illegible] levels related to a maximum permissible dosage [illegible] per week. Most of the maximum permissible dosages of the isotopes have been calculated with this as a standard.

In the case of radio-iodine or radio-phosphorus, where the body concentration mechanism is fairly well determined, the maximum permissible concentration in [illegible] fairly firm [illegible] with regard to radio-strontium, bone is the animal organ [illegible]

On the basis of radium experience [illegible] would be concerned with the development of tumors and injury to the bone marrow cells. In both types of injury the threshold dose for injury is unknown. The problem of the child dosage is further complicated by the greater uptake in proportion to mass and greater cellular activity. Dr. Warren suggests that a safety factor of at least five may be required for the child in relation to the permissible adult dose.

With regard to [illegible] relation of the strontium diet to the [illegible] is another unsolved question.

V. SUNSHINE Future

The purpose of [illegible] 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 [illegible] given above from the samples obtained thus far, it seems possible to [illegible] some tentative conclusion about the direction which the SUNSHINE Project [illegible] take in the future.

A. Interlaboratory Coordination

The procedure developed is [illegible] quite simple and requires relatively little chemical training and only the standard low-level radioactivity techniques. The analytical methods are discussed in RM-[illegible]75-AEC (2) and NYO-4571 (3). 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

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principles of chemical separation and the physical measurements being made.

The problem of standardization, however, is one that should be given more emphasis. An aliquot of ash was provided each of three laboratories engaged in SUNSHINE radiochemical analysis. The results were:

	SUNSHINE units
Lamont	4.1 ± 0.5
Chicago	6.2 ± 0.2
NYOO	2.7 ± 0.15

The factor of [illegible] in spread emphasizes the need for a continual interlaboratory check.

B. Collection of Samples

It appears that the present collection scheme augmented by the plans of the Department of Agriculture for the gathering of foreign samples is adequate. Specific sampling recommendations were:

a. The sampling program is at present 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 we can sample quite adequately for foods, particularly milk and other 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 conclusions can then be drawn.

b. It seems clear from the examination of the data presented above that the "Chicago Bone Program" should be continued, perhaps at a lower rate. It also seems desirable that another "Bone 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.

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c. [illegible] clear to the conference that more use should be made of animal bones, particularly [illegible] kind of material being procurable all over the [illegible] program should [illegible] obtain the samples immediately and [illegible] that the bones can be processed at the lowest [illegible]

d. [illegible] so promising at the moment that this type of [illegible] in the future.

e. [illegible] measurement of [illegible] be undertaken immediately. It is clear from the [illegible] in last summer's RAND SUNSHINE report [illegible] assay. However, this point has not [illegible] result is of such importance that it [illegible] immediate future. The Chicago group will undertake [illegible] specimens providing it appears likely that [illegible] sufficiently clean conditions from the [illegible] employed to [illegible] the cremation

f. [illegible] through the New York Operations Office [illegible] AEC and [illegible] cooperating agencies. The CASTLE sampling program [illegible] (2) [illegible] augmented in part and results are discussed [illegible] report.

C. Relat[illegible] Research

With a latent [illegible] years for the production of tumors at [illegible] necessary to conduct animal experiments [illegible]

a. [illegible] throughout the animal's life; and

b. [illegible] a relatively static skeleton structure [illegible]

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Another biological problem which has received little consideration so far in SUNSHINE is that of development of carcinoma in the bronchial tree. This may become particularly important if a population is to be subject to a continual atmospheric "drip" over a period of many years.

Should the SUNSHINE hazard ever become serious, one should be prepared to reduce this hazard through physical or biological means.

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APPENDIX A

PROJECT SUNSHINE BULLETIN

April 1, 1954

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	≤ 0.3 ± 0.04
2. No. 2: Stillborn July 30, 1953; 29 weeks gestation; 57 gms ash	≤ 0.36 ± 0.08
3. No. 3: Premature; Sept. 11, 1953; live weight 1830 gms; 38.3 gms ash	≤ 0.4 ± 0.1
4. No. 4: Premature; Sept. 5, 1953; live weight 930 gms; 24.2 gms ash; 6 months gestation	≤ 0.4 ± 0.1
5. No. 5: Stillborn Sept. 13, 1953; 39 weeks gestation; 58 gms ash	≤ 0.23 ± 0.05
6. No. 6: Stillborn Sept. 13, 1953; 38 weeks gestation; 65 gms ash	≤ 0.17 ± 0.04
7. No. 7: Premature; Sept. 17, 1953; live weight 660 gms; 13 gms ash	≤ 0.071 ± 0.038
8. No. 10: Stillborn Sept. 20, 1953; 32 weeks gestation; 25 gms ash	≤ 0.058 ± 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	≤ 0.102 ± 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
14. No. 17: Stillborn Sept. 27, 1953; 36 weeks gestation; 88 gms ash	0.153 ± 0.014

* ''Allowable'' = 1 microcurie of Sr^{90} contained in 1000 grams of calcium.

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Sample	Assay (Unit: 1/1000 allowable)
15. No. 18: Stillborn Sept. 28, 1953, 30 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. 26: Stillborn Oct. 12, 1953, 30 weeks gestation, 18 gms ash	0.19 ± 0.02
19. No. 27: Born Sept. 30, 1953; live weight 2400 gms; 39 weeks gestation, 61 gms ash	0.094 ± 0.008
20. No. 28: Stillborn Oct. 14, 1953, 36 weeks gestation; 15.2 gms ash	0.32 ± 0.05
21. No. 29: Premature; Oct. 12, 1953; 36 weeks gestation; live weight 1880 gms; 42.6 gms ash	0.24 ± 0.051
22. No. 31: Stillborn Oct. 27, 1953, 39 weeks gestation; 75.[illegible] gms ash	0.15 ± 0.02
23. No. 32: Premature; Oct. 27, 1953; 31 weeks gestation; live weight 2020 gms; 39.7 gms ash	0.095 ± 0.020
24. No. 33: Premature, Oct. 29, 1953, 31 weeks gestation; live weight 1150 gms; 27.5 gms ash	0.21 ± 0.01
25. No. 34: Stillborn Nov. 2, 1953, 34 weeks gestation, 57.3 gms ash	0.067 ± 0.03
26. No. 36: Stillborn Nov. 6, 1953; 26 weeks gestation; 15 gms ash	0.15 ± 0.05
27. No. 37: Stillborn Nov. 8, 1953, 36 weeks gestation; 79.4 gms ash	0.12 ± 0.04
28. No. 38: Stillborn Nov. 8, 1953; 34 weeks gestation; 46.6 gms ash	0.066 ± 0.02
29. No. 39: Premature; Nov. 9, 1953; 32 weeks gestation; live weight 1800 gms; 42.5 gms ash	0.15 ± 0.04
30. No. 40: Born Nov. 7, 1953; 39 weeks gestation; live weight 2225 gms; 62.1 gms ash	0.13 ± 0.03
31. No. 41: Stillborn Nov. 9, 1953; 34 weeks gestation; 58.8 gms ash	0.06 ± 0.02
32. No. 42: Premature; Nov. 10, 1953; 38 weeks gestation; live weight 2530 gms; 50.5 gms ash	0.15 ± 0.05

Sample	Assay (Unit: 1/1000 allowable)
33. No. 43: Stillborn Nov. 10, 1953; 30 weeks gestation; 34.3 gms ash	0.18 ± 0.03
34. No. 44: Stillborn Nov. 11, 1953; 28 weeks gestation; 16.6 gms ash	0.19 ± 0.02
35. No. 45: Stillborn Nov. 11, 1953; 28 weeks gestation; 13.5 gms ash	0.21 ± 0.02
36. No. 46: Stillborn Nov. 13, 1953; 36 weeks gestation; 49.98 gms ash	0.21 ± 0.02
37. No. 47: Stillborn Nov. 18, 1953; 30 weeks gestation; 47.22 gms ash	0.12 ± 0.01
38. No. 48: Stillborn Nov. 18, 1953; 31 weeks gestation; 21.68 gms ash	0.170 ± 0.04
39. No. 49: Premature; Nov. 18, 1953; 31 weeks gestation; live weight 1350 gms; 29.1 gms ash	0.13 ± 0.04
40. No. 50: Born Nov. 21, 1953; 39 weeks gestation live weight 3140 gms; 88.3 gms ash	0.12 ± 0.01
41. No. 51: Stillborn Nov. 21, 1953; 39 weeks gestation; 47.2 gms ash	0.11 ± 0.01
42. No. 52: Stillborn Nov. 22, 1953; 36 weeks gestation; 60.7 gms ash	0.13 ± 0.01
43. No. 53: Stillborn Nov. 20, 1953; 26 weeks gestation; 19.42 gms ash	0.18 ± 0.02
44. No. 56: Premature; Nov. 20, 1953; 26 weeks gestation; live weight 915 gms; 17.38 gms ash	0.18 ± 0.05
45. No. 57: Stillborn Nov. 20, 1953; 26 weeks gestation; 18.79 gms ash	0.22 ± 0.06
46. No. 61 Stillborn; weighed 3679 gms; 70.24 gms ash	0.11 ± 0.01
47. No. 68: Premature; Dec. 17, 1953; autopsy weight 2150 gms; 34 weeks gestation; 54 gms ash	0.12 ± 0.01
48. No. 69: Stillborn Dec. 19, 1953; 38 weeks gestation; 61 gms ash	0.10 ± 0.01
49. No. 70: Stillborn Dec. 19, 1953; 38 weeks gestation; 63 gms ash	0.16 ± 0.02
50. No. 71: Stillborn Dec. 22, 1953; 36 weeks gestation; 55 gms ash	0.14 ± 0.01

Sample	Assay (Unit: 1/1000 allowable)
51. No. 72: Stillborn Dec. 20, 1953; 3[illegible] weeks gestation; 54 gms ash	0.16 ± 0.01
52. No. 74: Premature; Dec. 11, 1953, autopsy weight 1450 gms; 31 wks. gestation; 40 gms ash	0.14 ± 0.01
53. No. 75: Stillborn Dec. 24, 1953; 40 weeks gestation; 44 gms ash	0.10 ± 0.01
54. No. 76: Stillborn Dec. 26, 1953; 4[illegible] weeks gestation; 44 gms ash	0.06 ± 0.01
55. No. 77: Stillborn Dec. 27, 1953, 39 weeks gestation; 41 gms ash	0.10 ± 0.02
56. No. 78: Stillborn Dec. 23, 1953; 35 weeks gestation; 23 gms ash	0.06 ± 0.01
57. No. 79: Stillborn Dec. 25, 1953, 34 weeks gestation; 39 gms ash	0.12 ± 0.02
58. No. 81: Stillborn Dec. 29, 1953; 41 weeks gestation; 68 gms ash	0.08 ± 0.01
59. No. 82: Born Jan. 4, 1954; 38 weeks gestation; 74 gms ash	0.14 ± 0.01
60. No. 83: Stillborn Dec. 26, 1953; 36 weeks gestation; 18 gms ash	0.18 ± 0.02
61. No. 84: Stillborn, Dec. 31, 1953; 38 weeks gestation; 69 gms ash	0.06 ± 0.01
62. No. 85: Stillborn Jan. 1, 1954; 37 weeks gestation; 48 gms ash	0.07 ± 0.02
63. No. 86: Premature, Jan. 2, 1954; live weight 1915 gms; 33 weeks gestation; 25 gms ash	0.14 ± 0.01
64. No. 87: Premature; Jan. 2, 1954, live weight 2100 gms; 33 weeks gestation; 28 gms ash	0.16 ± 0.02
65. Later milkings from babies Nos. 2, 3, 4, and [illegible] were combined for average	0.182 ± 0.010
66. The milks from 30 Chicago baby samples were combined and counted with absorbers	> 0.05 ± 0.001

NOTE: The four sets of fraternal twins received to date were No's. 44 and 45; No's. 48 and 49; No's. 56 and 57, and No's. 86 and 87.

Sample	Assay (Unit: 1/1000 allowable)
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, 1 yr, [illegible] wks, 12 days, 8 days, 6 days; 8.9 gms ash)	0 ± 0.32
3. Five samples pooled (ages unknown to us) total ash, 13.99 gms	0.25 ± 0.03
4. Six samples pooled (ages unknown to us) total ash, 6.19 gms	0.26 ± 0.07
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 (5 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	9.5 ± 0.11
D. Samples furnished by Dr. Shields Warren	
1. Sections of vertebral column and ribs of children	
a. No. 226: Age, 3-3/12 yrs; area, Massachusetts; 23.05 gms ash	0.17 ± 0.01
b. No. 232: Age, 7 yrs; area, Ohio; 17 gms ash	0.12 ± 0.01
c. No. 237: Age 7 11/12 yrs, area, Maine, 18.7 gms ash	0.13 ± 0.02
d. Four samples pooled; age range 1 to 30 days; area, Massachusetts; 17.21 gms ash	0.31 ± 0.02
e. Four samples pooled; age range 6 to 8 weeks; area, Maine and Massachusetts; 12.95 gms ash	0.13 ± 0.06
f. Four samples pooled; age range 4 to 6 months; area, Mass. and New Hampshire 11.58 gms ash	0.43 ± 0.03
g. Three samples pooled; age range 3 to 6 years; area, Maine and Massachusetts; 12.56 gms ash	0.31 ± 0.07

Sample	Assay (Unit: 1/1000 allowable)	
2. Adult legs		
a. No. 149913: Amputated Nov. 16, 1953; man aged 55 yrs had lived in Massachusetts since pre-war days and had earlier migrated from Russia; 214 gms ash	0.01	± 0.006
b. No. 149953: Amputated Nov. 18, 1953; man aged 68 yrs was born in Massachusetts and lived there all his life; 204 gms ash	0.02	± 0.003
c. No. 150295: other leg of No. 149953; amputated Dec. 3, 1953; 184 gms ash	0.011	± 0.0012
3. Root Dentine: T-1, Sample obtained from adults (ages 18 to 35 years) in London, England in April and May of 1950.	0.014	± 0.01
E. Three of six stillborn skeletons from Dr. E. W. Gault of the Christian Medical College and Hospital, Vellore, South India		
1. No. 1363: Born Dec. 24, 1953; autopsy weight 1850 gms, specimen weight 437 gms said to be full term; 35.2 gms ash	0.05	± 0.01
2. No. 1368: Born Jan. 3, 1954; autopsy weight 2050 gms; specimen weight 502 gms full term; 43 gms ash	0.04	± 0.01
3. No. 1369: Born Jan. 3, 1954; autopsy weight 2550 gms; specimen weight 563 gms full term; 50 gms ash	0.04	± 0.01
F. Stillborn received from Dr. J. Z. Bowers of University of Utah Medical School		
Specimen weight 981 gms; ash wt 18 gms	0.194	± 0.04
G. Calf leg bone ash sample sent by Dr. J. H. Harley of New York Operations Office. The calf was born in March 1953; raised at Easton, New York; Pasture fed without supplementary feed; slaughtered Nov. 1, 1953; Dr. Harley said that two other ash samples of this calf were being sent to two other laboratories which are working on Project Sunshine. Our ash sample was received in two containers and the samples from these were run separately.		
1. 92.99 gms ash	6.1	± 0.2
2. 106.96 gms ash	6.3	± 0.15

Samples | Assay (Unit; 1/1000 allowable)

H. Cheese Samples

	Samples	Assay
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 I (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	0.11 ± 0.005
4.	Japanese Hokkaido (10 lbs; natural; obtained by J. E. Mayer; area represented - Hokkaido Island, Japan); 192.8 gms ash	0.136 ± 0.004
5.	Wisconsin Münster (18 lbs from Dodge County, Wisconsin); manufactured end of July, 1953; 372 gms ash	2.07 + 0.07
6.	Imported Swiss II (11-1/2 lbs; Switzerland) 124 gms ash	2.7 ± 0.05
7.	Danish Blue (12 lbs; Denmark); 190 gms ash	0.99 ± 0.02
8.	Dutch Edam (10 lbs; Rotterdam, Holland); 207 gms ash	1.1 ± 0.02

I. 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.

1. Alfalfa: These samples were dried and ground (but not washed) by Dr. N. Scully of Argonne National Lab.

	Samples	Assay
a.	No. 1: From Grabow farm, Rock County, Wisconsin Sept. 28, 1953; 140.5 gms ash	12.8 ± 0.3
b.	No. 2: From Oliver Swain Farm, Rock County, Wisconsin, Sept. 29, 1953; 213.5 gms ash	5.5 ± 0.19
c.	No. 3: From Swanson farm, Winnebago County, Illinois; Sept. 29, 1953; 123.0 gms ash	7.1 ± 0.4
d.	No. 4: From Holcomb farm, Rock County, Wisconsin, Sept. 29, 1953; 145 gms ash	8.3 ± 0.27
e.	No. 5: From Lewke farm, Dane County, Wisconsin; Sept. 30, 1953; 137.0 gms ash	20.9 ± 0.9
f.	No. 6: From Premo farm, Columbia County Wisconsin, Sept. 30, 1953; 154.5 gms ash	4.26 ± 0.15
g.	No. 7: From Kurpeski farm, McHenry County, Illinois, Sept. 30, 1953, 152.5 gms ash	7.44 ± 0.46

Sample	Assay (Unit: 1/1000 allowable)
h. No. 8: From F. L. Austin Farm, McHenry County Illinois, Oct. 1, 1953; 171 gms ash	4.95 ± 0.27
i. No. 9: From McKee farm, McHenry County, Illinois, Oct. 1, 1953; 143.5 gms ash	14.8 ± 0.3
j. No. 10 From Blomberg farm, McHenry County, Illinois, Oct 1 1953; 204.3 gms ash	9.5 ± 0.34
k. No. 11 From Van Winkle farm near Wilmington Illinois, Oct. 2, 1953; 124 gms ash	4.98 ± 0.22

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. 2: From Oliver Swain Farm, Rock County, Wisconsin, Sept. 29, 1953; 64 gms ash	1.3 ± 0.08
c. No. 3: From Swanson farm, Winnebago County, Illinois, Sept. 29, 1953; 134.2 gms ash	1.21 ± 0.02
d. No. 4: From Holcomb farm, Rock County, Wisconsin, Sept. 29, 1953; 131 gms ash	1.6 ± 0.10
e. No. 5: From Levke farm, Dane County, Wisconsin; Sept. 30, 1953; 88.2 gms ash	2.25 ± 0.104
f. No. 6: From Premo farm, Columbia County, Wisconsin, Sept. 30, 1953; 139.7 gms ash	0.97 ± 0.04
g. No. 7: From Kurpeski farm, McHenry County, Illinois Sept. 30, 1953; 199.9 gms ash	1.3 ± 0.02
h. No. 8: From F. L. Austin farm, McHenry County, Illinois, Oct. 1, 1953; 85 gms ash	1.8 ± 0.07
i. No. 9: From McKee farm, McHenry County Illinois; Oct. 1, 1953; 149 gms ash	1.4 ± 0.1
j. No. 10: From Blomberg farm, McHenry County, Illinois, Oct. 1, 1953; 121.3 gms ash	1.19 ± 0.07

3. Soil: The calcium oxalate form of these samples was prepared by the Plant Industry Station personnel at Beltsville, Maryland.

a. No. 1: From Grabow farm, Rock County, Wisconsin; Sept. 26, 1953

1. Knox fine sandy loam 0-1'', NH, AC	26.3 ± 1.0

Sample	Assay (Unit: 1/1000 allowable)
2. Knox fine sandy loam 1"-6"; NH_4 [illegible]	6.7 ± 0.4
3. Knox fine sandy loam 0-1" leached with HCl after NH_4A[illegible]	24.6 ± 0.81
b. No. 2: From Oliver Swain farm, Ro[illegible] County, Wisconsin; Sept. [illegible], 1953	
1. Knox fine sandy loam 0-1"; NH_4[illegible]	7.36 ± 0.33
2. Knox fine sandy loam 1"-6"; NH_4[illegible]	2.2 ± 0.23
c. No. 3: From Swanson farm, Winnebago County, Illinois, Sept. [illegible], 19[illegible]	
1. Carrington-like silt loam [illegible]; NH_4A[illegible]	15.8 ± 0.37
2. Carrington-like silt loam [illegible]; NH_4A[illegible]	2.54 ± 0.17
d. No. [illegible]: From Lewke farm, Dane County, Wisconsin; Sept. 30, 19[illegible]	
1. Miami silt loam, [illegible]; NH_4[illegible]	10.2 ± 0.34
2. Miami silt loam, [illegible]-6"; NH_4[illegible]	2.93 ± 0.15
e. No. [illegible]: From Freme farm, Columbia County, Wisconsin; Sept. 30, 19[illegible]	
1. Miami silt loam 0-[illegible]; NH_4A[illegible]	13.1 ± 0.3
2. Miami silt loam [illegible] after NH_4A[illegible]	1[illegible].8 ± [illegible].8
f. No. [illegible]: From Karpeski farm, McHenry County, Illinois; Sept. 30, 19[illegible]	
1. Miami silt loam, 0-[illegible]; NH_4[illegible]	16.3 ± 0.53
2. Miami silt loam, [illegible]-6"; NH_4A[illegible]	5.59 ± 0.29
g. No. 9: From McKee farm, McHenry County, Illinois; [illegible]	
1. Drummer silty clay loam, 0-[illegible]; NH_4[illegible]	8.1 ± 0.19
2. Drummer silty clay loam, [illegible]	0.91 ± 0.07
h. No. 10: From Blomberg farm, McHenry County Illinois; Oct. [illegible], 19[illegible]	
1. Drummer silty clay loam, 0-[illegible]; NH_4A[illegible]	1.85 ± 0.04
2. Drummer silty clay loam, 0-1[illegible] leached with HCl after NH_4A[illegible]	5.82 ± 0.35

Sample	Assay (Unit: 1/1000 allowable)
I. No. 11 From Van Winkle farm near Wilmington, Illinois; Oct. 2 1953	
1. Plainfield sand, 0-1''; NH_4AC	13.8 ± 0.71
2. Plainfield sand, 1''-6''; NH_4AC	7.9 ± 0.09
J. Other samples furnished by Dr. L. Alexander	
1. 1937 Iowa soil samples which were sent in the form of calcium oxalate	
a. No. C-2916: Carrington loam, 0-3'' leached with HCl after NH_4AC	0 ± 0.05
b. No. C-2917: Carrington loam, 3''-13''; NH_4AC	0 ± 0.05
2. Ankara, Turkey; Alfalfa and soil collected by a member of the Ankara Provincial Extension Service Alfalfa Demonstration Area on Oct. 2 and 5, 1954, twenty kilometers west of Ankara	
a. Alfalfa 130.2 gms ash	2.16 ± 0.18
b. Soil; heavy alluvial, 1''-2''; NH_4AC	1.17 ± 0.10
3. Soil from India: Beltsville Lab. No. 551 803; NH_4AC	1.7 ± 0.01
4. Utah dried skim milk samples	
a. From Weber Central Dairy, Logan, Utah, Oct. 1953; 289.4 gms ash	1.35 ± 0.05
b. From Brooklawn Creamery Co., Beaver, Utah, Oct. 1953; 266.1 gms ash	0.91 ± 0.02
5. 1943 powdered whole milk: area represented not known; 73.8 gms ash	0 ± 0.008
K. Egg shells	
1. 250 gms obtained from Coffee Shop at the University of Chicago on Sept. 4, 1953	0.485 ± 0.062
2. 411 gms obtained from Billings Hospital, University of Chicago on Sept. 8, 1953	0.284 ± 0.033

Sample	(dpm/gal)
L. 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.	7.5 ± 0.2
2. No. 18: 3.8 gal.; collected in Chicago, Nov. 22, 24, 25, and 26, 1952; 1.24 in.	4.5 ± 0.2
3. No. 30: 3.9 gal.; collected in Chicago, Feb. 11, 1953; 0.03 in.	3.4 ± 0.15
4. No. 40: 1.7 gal.; collected in Chicago, Mar. 12, 1953; 0.30 in.	0 ± 0.3
5. No. 48: 1.4 gal.; collected in Chicago, Mar. 20 to 22, 1953; 0.05 in	2.6 ± 0.3
6. No. 50: 1.5 gal.; collected in Chicago, Mar. 31, 1953; 0.03 in.	7.2 ± 0.5
7. No. 51: 2.0 gal; collected in Chicago, Apr. 3, 1953; 0.04 in.	5.5 ± 1.0
8. No. 56: 5 gal. collected in Chicago, Apr. 15, 1953; 0.06 in.	8.42 ± 0.60
9. No. 59: 1.5 gal.; collected in Chicago, Apr. 24, 1953; 0.03 in.	4.0 ± 0.4
10. No. 60: 1.6 gal.; collected in Chicago, Apr. 30, 1953; 1500-1520; 0.03 in	67.3 ± 3.2
11. No. 61: 0.7 gal.; collected in Chicago, Apr. 30, 1953; 1830-1910; 0.01 in	26.5 ± 0.9
12. No. 67: 2½ gal; collected in Chicago, May 22, 1953; 0.82 in.	4.70 ± 0.48
13. No. 74: 5 gal. collected in Chicago, June 5, 1953; 0.05 in.	12.75 ± 0.222
14. No. 76: 2.1 gal.; collected in Chicago, June 25, 1953; trace	108 ± 2.5
15. No. 77: 2.2 gal.; collected in Chicago, July 1 and 2, 1953; 0.04 in	7.4 ± 0.25
16. No. 79: 2.4 gal.; collected in Chicago, July 5, 1953; 0.20 in.	5.0 ± 0.4
17. No. 86: 1.8 gal.; collected in Chicago, July 17 to 20, 1953; 0.12 in	10.4 ± 0.8

Sample (dpm/gal)

18. No. 90: $2\frac{1}{2}$ gal.; collected in Chicago, Aug. 1 to 3, 1953; 0.62 in. — 2.47 ± 0.35

19. No. 92: 5 gal.; collected in Chicago, Aug. 4, 1953; 0.05 in. — 3.48 ± 0.46

20. No. 96: 5 gal.; collected in Chicago, Sept. 11, 1953; 0.50 in. — 13.54 ± 0.59

21. No. 97: 5 gal.; collected in Chicago, Sept. 18, 1953; 0.63 in. — 39 ± 1.16

22. No. 98: 5 gal.; collected in Philippine Islands, March, 1953. — 7.76 ± 1.79

23. No. 103: 5.0 gal.; collected in Chicago, Oct. 26, 1953; 0.13 in. — 46.0 ± 1.5

M. Other Water Samples

1. Pacific Ocean (Santa Monica Beach); 80 liters, collected May 20, 1953. — <1 ± 0.4

2. Chicago tap water, 9.83 gal.; collected Oct. 27, 1953 — 0.39 ± 0.08

3. Snow

   a. No. 19: 4.5 gal.; collected in Chicago Dec. 2, 1952; 3.90 in — <3.3 ± 0.4

   b. No. 33: 3.3 gal.; collected in Chicago Feb. 16, 1953; 2.1 in. — 0.81 ± 0.15

4. River Water

   a. Mississippi River water at St. Louis, 5.0 gal.; collected April 17, 1953 — <0.77 ± 0.18

   b. Mosel River water at Metz, France 5.0 gal.; collected Sept. 7, 1953 — 0 ± 0.05

   c. Seine River water at Nogent, France, 5.0 gal.; collected Sept. 8, 1953 — 0 ± 0.09

   d. Donau River water at Ulm, Germany 5.0 gal.; collected Sept. 12, 1953 — 0 ± 0.07

   e. No. 28; Mississippi River water at Memphis, 3.6 gal.; collected Feb. 4, 1953 — 1.13 ± 0.16

5. Rain collected in Wellington, New Zealand, Oct. 1, 1953

Sample	(dpm/gal)
a. 5 gal.	0.30 ± 0.03
b. 5 gal.	0.23 ± 0.03

N. Filter paper from the Naval Research Laboratory's routine air filtration program. Army Chemical Corps Type 5 paper, 99% efficient down to particles of a few tenths microns diameter, 75% efficient for particles .01 to .001 microns in diameter. (dpm/10^6 cu. ft. of air)

1. No. 1: from Washington, D.C.; Oct. 12 to 15, 1953; 70 hours collection; total air flow estimated as 3.4 x 10^6 cu. ft.	70.4 ± 12
2. No. 2: from Kodiak, Alaska; Nov. 14 to 23, 1953; 120 hours collection; total air flow estimated as 17 x 10^6 cu. ft.	8.53 ± 1.6

These data are complete to date.

W. F. Libby
University of Chicago

APPENDIX B

POLARIZATION OF ATMOSPHERE BY ATOMIC DEBRIS

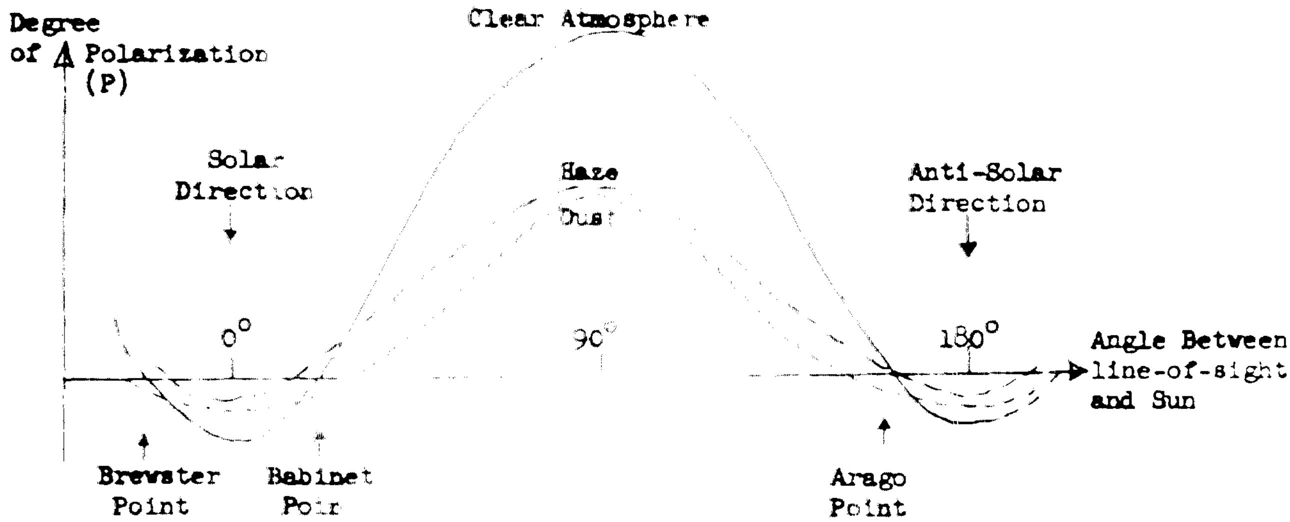
Memorandum of Discussion with Dr. Zdenek Sekera, U. C. L. A.

W. W. Kellogg

I have talked with Dr. Sekera, and have come to the following general conclusions:

- The atomic cloud from a large explosion would have a measurable effect on the light-scattering ability of the atmosphere, at least for the first few days of its existence
- There are certain natural fluctuations of the scattering of sunlight due to air mass changes, changes in turbulence, etc., and these natural fluctuations could mask the passage of the atomic cloud over a station.
- Surface observations have been made at Los Angeles and at Table Mountain (alt. 7000 or 8000 ft) of the light scattering of the atmosphere and the sky polarization. (Described further below.) The observations are possible only when there are no clouds in the sky, since even distant clouds will effect the illumination of the atmosphere overhead due to their reflected sunlight. Thus, the method cannot be used with any reliability from the ground except under clear weather conditions. From a high-flying aircraft one might be able to get observations with more frequency, since one could be above low clouds and could allow for the reflected sunlight from low clouds by maneuvering the path of the airplane so as to balance out the illumination from different areas of cloudiness.

Perhaps a brief description of the kind of measurement made by Sekera is in order here. The purpose of the atmospheric scattering measurements has been to determine the position of the points at which there is a cross-over from one plane of polarization to another, the "neutral points." The method consists essentially in a sweep of the sky in a vertical plane through the sun, continuously recording the direction of polarization of the scattered sunlight.



More precisely, it is the "degree of polarization" which is plotted in the sketch above, and this is defined as:

$$P = \frac{I_1 - I_{11}}{I_1 + I_{11}}$$

I_1 and I_{11} being respectively the components of the sky light which are polarized normally and parallel to the vertical plane through the sun.

The character of the degree of polarization curve changes markedly from day to day and from hour to hour, particularly in the red end of the spectrum. It depends on the solar elevation angle, of course, but of more interest to us at the moment is the change with atmospheric turbidity. Under clear air conditions one would measure only molecular or Rayleigh scattering, and this ideal curve has been computed. The excursions from this curve due to impurities in the air are quite pronounced. The change due to particles with an index of refraction near unity, i.e., transparent particles like those usually found in haze, is different from the change due to relatively opaque particles, as shown in the sketch. Moreover, the change which takes place in the red end of the spectrum is greater than that in the blue, and the data which Sekera showed me suggested that the red end is affected by small-scale inhomogeneities which cause appreciable changes in a matter of half an hour or less.

The curves marked "haze" and "dust" imply that the whole atmosphere from horizon to horizon is more or less uniformly contaminated. This was the case, for example, after the eruption of Katmai in [illegible], when the "Babinet point" moved out some 12° or [illegible]° for a solar elevation angle of + 2.5°, and the degree of polarization at the maximum [illegible]° point decreased by 20 to 30 percent. However, if an atomic cloud a day or two old passed overhead it is not at all certain that the cloud would fill the sky -- it might very well be a long thin filament due to the action of wind shear. Sekera felt that, in such a case, it would still be noticeable as a dip on the normal curve in the direction of the cloud.

In discussing the characteristics of the atomic cloud with Sekera, I suggested that there might be some 10^{10} lbs of dirt and sand, as an upper limit, with an unknown particle size distribution. For the sake of argument, if the particles had a diameter of 1μ, there would be [illegible] x 10^{24} particles in the cloud, and this would, if spread uniformly [illegible] layer of particle surface density of 10^8 particles per cm^2, allow the cloud to cover 3.6×10^6 km^2 (1.3×10^6 mi^2). These figures are [illegible] get a little feel for the amount of turbidity that an atomic cloud would produce, the surface density of 10^8 particles per cm^2 being a figure which [illegible] Perndorf gives as being the minimum which will give the effect of [illegible] sun." Actually, Sekera's method would detect fewer than this number, especially if they were in the smaller size range [illegible] diameter. ([illegible] get a figure from him for an estimate of the [illegible] limit.)

A year ago last November Sekera was asked [illegible] GRI to run his equipment more or less continuously on Table Mountain [illegible] week period, presumably to see if he could [illegible] passing overhead from the tests in the Pacific. The results were somewhat inconclusive, [illegible] a frontal passage prevented observations from about November [illegible] (dates may not be exactly correct), and this would have been about the time when the cloud would have gone by. Interestingly enough, there [illegible] sign of increased turbidity when they resumed the observations, which [illegible] been due to the debris. In checking what little information we have at RAND, it appears that only the 500 mb (about 18,[illegible]) trajectory would [illegible] close to Southern California, and this level is probably [illegible] relatively little material exists. We do not have trajectories [illegible] above [illegible] mb (about 40,000 ft), so we cannot check the motion of the main [illegible] of the mushroom cloud to see if it could have passed over Sekera.

The Department of Meteorology at U.C.L.A. [illegible] making these studies on an

Air Force contrac [illegible] sponsored by the [illegible] Research Directorate. They have just complet [illegible] new equipment [illegible] give more complete and conveniently useable [illegible] estimate [illegible] of the new equipment is in the order of $[illegible] but that [illegible] be made for quite a bit less. There woul [illegible] new [illegible] for equipment to make observations from a [illegible]

LIST OF REFERENCES

1. ''World-wide Effects of Atomic Weapons - Project SUNSHINE'', The RAND Corporation Report R-2[illegible]1-AEC, dated August 6, 1953 (SECRET-RESTRICTED DATA).

2. ''RAND-SUNSHINE Project Conference December 16-17-18, 1953, Santa Monica, California'', The RAND Corporation Research Memorandum RM-[illegible]75-AEC dated December 30, 1953 (SECRET-RESTRICTED DATA).

3. U. S. Atomic Energy Commission, New York Operations Office, ''Project SUNSHINE Progress from September 1953 to January 4, 1954'', New York Operations Office NYO-[illegible] dated January 8, 1954 (SECRET-RESTRICTED DATA).

4. University of Chicago, Project SUNSHINE Bulletin No. 5, dated January 4, 1954 (Official Use Only).

5. Greenfield, S. M., W. W. Kellogg, F. J. Krieger, R. R. Rapp, ''Transport and Early Deposition of Radioactive Debris from Atomic Explosions - Project AUREOLE'', The RAND Corporation Report R-[illegible]-AEC (SECRET-RESTRICTED DATA).

6. Greenfield, S. M., ''Ionization of Radioactive Particles in the Free Air'', The RAND Corporation Research Memorandum RM-1153-AEC (CONFIDENTIAL-RESTRICTED DATA).