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INTER-OFFICE MEMORANDUM

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June 16, 1945

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VERIFIED UNCLASSIFIED

BP 9/25/97

FINAL DETERMINATION
UNCLASSIFIED
L. M. Redman
FEB 4, 1981

TO: K. T. Bainbridge

FROM: J. O. Hirschfelder and John Magee

SUBJECT: DANGER FROM ACTIVE MATERIAL FALLING FROM CLOUD - DESIREABILITY OF BONDING SOIL NEAR ZERO WITH CONCRETE AND OIL.

PUBLICLY RELEASABLE
LANL Classification Group
BP 9/25/97

There is a definite danger of dust containing active material and fission products falling on towns near Trini~~ty and~~ necessitating their evacuation. This is shown by the following calculations based on the assumptions that:

1. The active material condenses on the surface of the normal Trinity dust to give a distribution of activity with particle size similar to that observed by H. L. Anderson in the 100 ton shot.

2. The dust on which the active material is deposited is quickly (3 minutes) raised to a height of approximately 12,000 feet. This is approximately the height to which the smoke puff rose in the 100 ton shot and this same height may be expected in the next shot. Between 1000 and 12000 feet the change in temperature with altitude should very nearly follow a dry adiabat and therefore there should be no tendency for material which has risen above 1000 feet to stop before it gets to 12,000. After 12,000 feet Hubbard expects a temperature inversion so that it will be difficult for any material to rise much above the 12,000 foot level.

3. The dust settles in accordance with a modified Stokes law like normal industrial dust settling in still air.

4. The material as a whole is carried along at a wind velocity of 30 miles per hour. This dangerous situation could be eliminated by reducing the number of dust particles of around 100 microns which get into the cloud. This can be done by bonding the ground in the vicinity of zero - preferably using a light slurry of concrete in the vicinity of the future crater and a coating of oil thinly distributed to a distance of 2000 feet from zero.

I. Distribution of Active Material

Lacking any indications to the contrary, it is natural to assume that the distribution of active material with particle size will be the same as Anderson found in the last Trinity shot. This distribution indicated that the active material was uniformly distributed on the surface of the sand particles - the activity of the particles being roughly proportional to their surface area. The following table summarizes Anderson's observations together with some recent measurements of the particle size distribution of Trinity dirt made by Kamm and Magee (which will be discussed in detail in another memorandum).

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Particle Diameter (microns)	DIRT FROM CRATER			NORMAL TRINITY DIRT	
	Percentage Weight by Screening	Percentage Activity	Percentage Surface Area	Percentage Weight	
				Sample #1	Sample #2
> 840	32	3.8	4.2	52	30
840-250	21	12.6	4.8	35	45
250-149	15	14.5	9.2	7.6	10
149-74	16	18.1	8.5	2.1	9
< 74	16	51.0	73.3	2.4	6

It will be noticed from the last two columns that the weight distribution of various samples of Trinity dirt vary considerably. Similarly Anderson found considerable variations between different samples of dirt in the crater. Therefore we cannot argue about the amount of activity to be expected for a given range of particle size to within a factor of two.

II. The Rate of Settling of Dust

According to Stoke's Law, particles of specific gravity ρ and diameter D microns should fall at the rate:

$$0.00592\ D^2\rho \text{ feet/minute}$$

According to John L. Alden "Design of Industrial Exhaust Systems" (Industrial Press New York, 1939), dust particles found in industry follow this law quite well for particles between 5 and 300 microns. For larger particles the velocity of falling is somewhat slower:

D microns	Velocity ft/minute
5000	1750ρ
1000	790ρ
500	555ρ

Using the above data it is easy to calculate the length of time required for particles of various sizes to fall 12,000 feet. Here we assume that the specific gravity of the dust is 2.6. The results are summarised below:

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Diameter (microns)	Time to Fall 12,000 ft (hours)
840	0.110
500	0.139
250	0.208
200	0.325
149	0.585
110	1.08
74	2.37
60	3.61
33	12.0
22.6	25.5
16.0	50.8
11.3	102
8.0	204
5.65	408

From the above table and Anderson's data it follows that 3.8% of the activity drops in the first 6.6 minutes; 12.6% of the activity drops between 6.6 and 12.5 minutes; 14.5% of the activity drops between 12.5 minutes and 35 minutes; 18.1% of the activity drops between 35 minutes and 2 hours and 22 minutes; and the remaining 51% drops at a much later time.

The dust particles which have diameters ranging between 149 and 74 microns are therefore the most dangerous from the standpoint of nearby towns since they fall in the time interval between 35 minutes and 2 hours and 22 minutes. Since they contain 18.1% of the activity it follows that during this time interval the active material will be dropped at the average rate of 10% per hour. If this dust is swept along at an average velocity of 30 miles per hour, each mile along the path will contain 1/3% of the active material. It is reasonable to suppose that at this time the path of the active material on the ground will be 3 miles wide. (This figure is completely speculative but seems neither pessimistic nor optimistic). Then each square mile along the path at a distance between 17.5 and 71 miles contains 1/9% of the activity.

III. The Radiation Intensity Suffered by Person in Nearby Town

The following calculation was made with the help of A. Turkevitch and agrees with a similar calculation made by L. Hempelman. Assume that the gadget is 5% efficient so that 2 moles of fission products are formed. Then according to a formula of Fermi's .15 f/t gamma rays are emitted per second after t seconds after the explosion. Here f is the total number of fissions. If the total active material is spread uniformly over one square mile there will be emitted one hour after the explosion

$$10^9 \text{ gammas/sec/cm}^2 \text{ of surface area}$$

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Or spreading the 1/9 of 1% of the activity over one square mile, there will be emitted one hour after the explosion

$$10^6 \text{ gammas/sec/cm}^2$$

In unit solid angle this will amount to

$$I_o = 10^6/4\pi \text{ gammas/sec/cm}^2\text{/unit solid angle}$$

But since the mean free path of the gammas in air is of the order of $\lambda = 140$ meters, at a height h equal to one meter above the ground the flux of gammas is approximately

$$I = \pi I_o \log_e(\lambda^2/h^2 + 1) = 28 I_o = 2 \times 10^6 \text{gammas/sec/cm}^2$$

And since one R unit corresponds to 10^9 gammas/cm^2 we could therefore expect a person in the path of the cloud at a distance of between 17.5 and 71 miles to receive radiation at the rate of

$$7/T \quad \text{R/hour}$$

Here T is the time after the explosion in hours, In the first day he receives approximately 22 R. Here we have only considered the danger of gamma radiation. Weisskopf has made a similar consideration for 49 and finds that over a long period of time, it too might be dangerous.

IV. Suggested Remedy

Since the danger from the radiation is due to the presence in the cloud of a large percentage of dust ranging in size between 149 and 74 microns, the obvious solution is to take steps to prevent such dust from getting there. This should be feasible by filling the region which will become the crater with crushed rock (from a nearby quarry) and adding a small amount of concrete slurry. At larger distances (up to 2000 feet) it would suffice to cover the ground with a thin film of oil. Carlson estimates that this would require approximately 750,000 gallons - a large amount but not prohibitive.

cc:
Col. Warren
Capt. Jones
Capt. Nolan
Bethe
Carlson
Eberstat
Hempelman
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