Response to NIOSH's Review of SC&A's Nevada Test Site Resuspension Issues Status Report

Presentation to the
Nevada Test Site Work Group

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January 5, 2017

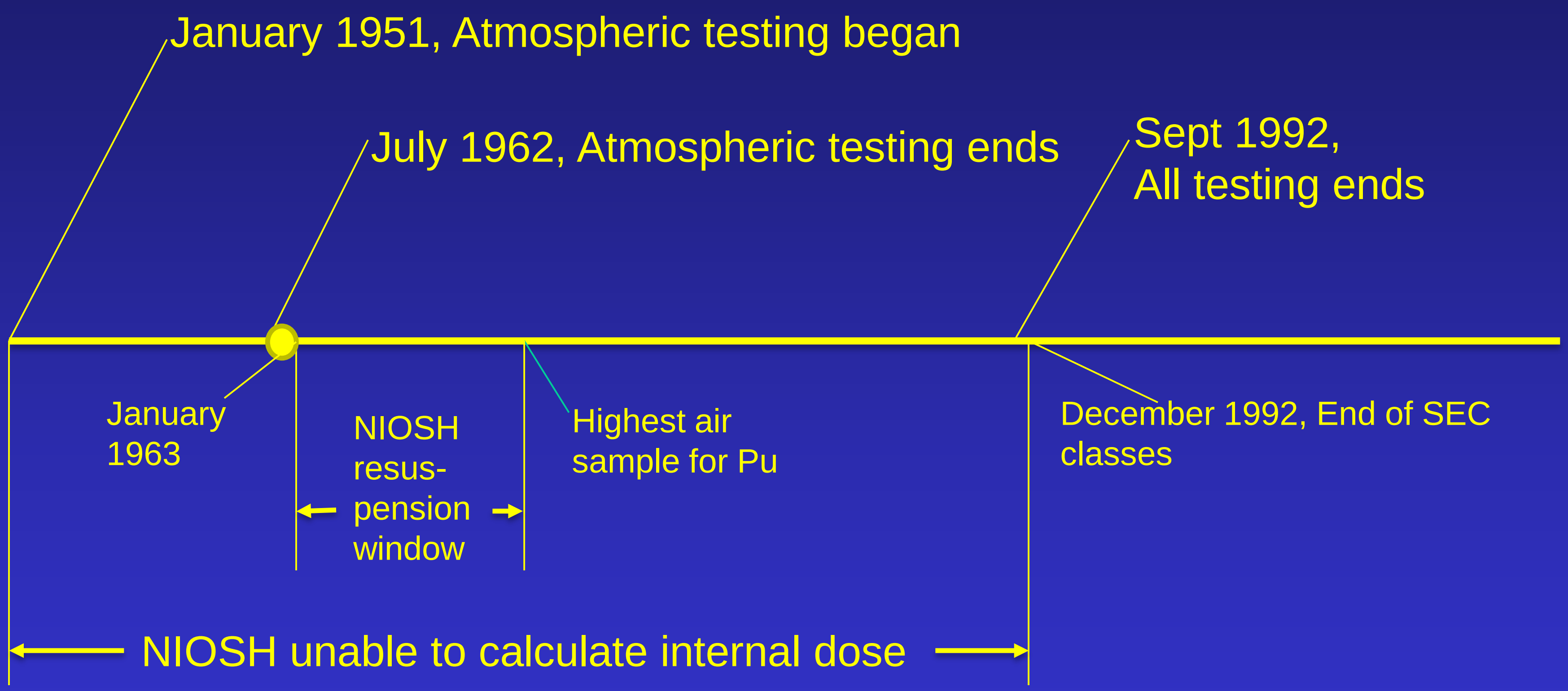
SC&A's Task

- Review the calculation of doses from the resuspension of radionuclides deposited on the ground.
- In essence, this amounts to the review of ORAUT (2012), Technical Basis Document, Revision 3, on Occupational Environmental Dose.
- There was also a review of how doses were actually being calculated by dose reconstructors.

Recent Documents

- ORAUT (2012) Technical Basis Document, Revision 3, on Occupational Environmental Dose
- SC&A (2015) Status Report on Resuspension Issues at the Nevada Test Site
- NIOSH (2016) NTS Resuspension Issues and Comments Matrix
- Strenge (2016) NIOSH Response to Short-lived Radionuclide Issues Raised in Comment 5 of SC&A's NTS Resuspension Issues Report
- Rollins (2016) NIOSH Response to Inconsistency Issues Raised in Comment 8 of SC&A's NTS Resuspension Issues Status Report
- SC&A (2016) Response to NIOSH's Review of SC&A's Nevada Test Site Resuspension Issues Status Report
- SC&A (2016) Memo: SC&A's Position on Comment 8 – Resuspension Issues at the Nevada Test Site

Major Events at the NTS



Claimants whose work time falls within the circle are not treated equally.

The last half of 1962 was a busy time at the NTS.

- Thirty underground tests were conducted during that six months.
- Preparations were underway for 46 additional tests in 1963.

SC&A's Recommendation 1 to Members of the NTS WG

Change the time period of reconstruction of occupational environmental dose to July 17, 1962, through December 31, 1992.

(The same method can be used as for the time period from January 1, 1963, through December 31, 1992.)

SC&A does not agree with the optimistic statement about the performance of bioassays.

- **NIOSH itself has identified that there were not enough bioassay data to allow for the reconstruction of internal dose.**
- **Investigations have shown that not all persons entering tunnels were identified and not all were sent for bioassays.**

SC&A's Recommendation 2 to the Members of the NTS WG

Provide a more valid statement about the likelihood of identification and bioassay results:

> **"These workers may have been identified on the rosters that were published before the event, and these workers may have had bioassay results in the DOE records."**

The aim of the NIOSH calculations is to reproduce concentrations of radionuclides in air.

- Relies upon measurements of plutonium in air starting in 1971.
- Corrects for other long-lived radionuclides based upon measured concentrations in soil in the 1980s.
- Corrects for short-lived radionuclides on the basis of the Hicks' tables.

Derivation of concentrations of radionuclides in air at times prior to 1971 depend upon use of the Anspaugh resuspension equation.

Resuspension at early times is much more important.

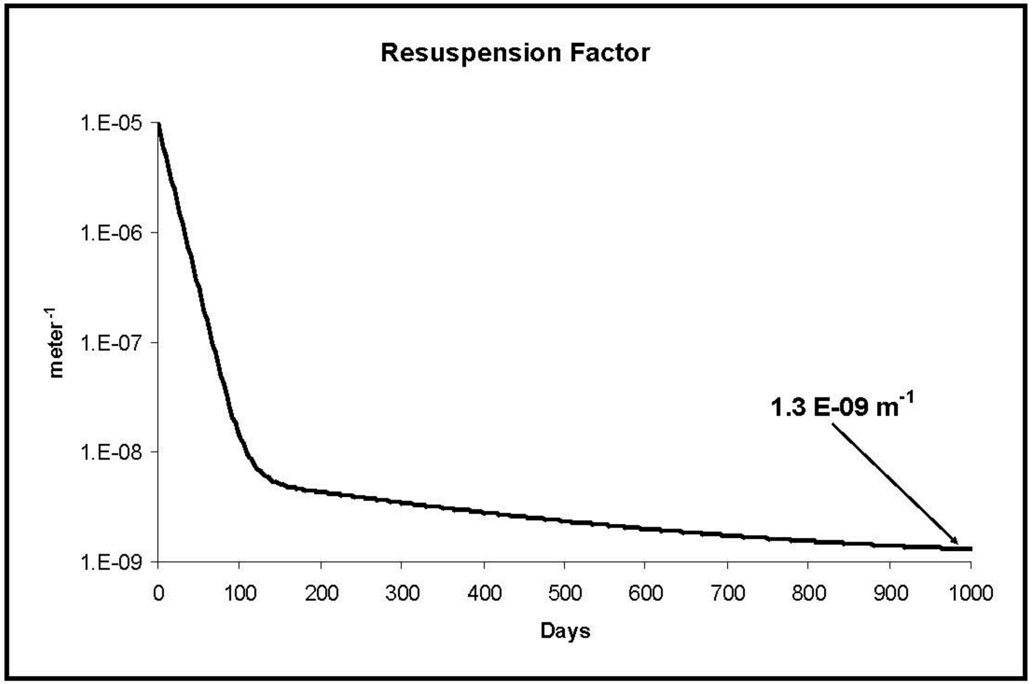


Figure A-1. Resuspension factor as a function of time after initial deposition.

From page 67 in ORAUT (2012)

An Example of the Hicks' Tables

SMALL BOY MICROCURIES/SQ METER PAGE 6
MR/HR AT H+12 HOURS = 1.000
FRACTION OF REFRACTORIES PRESENT = 0.400
RELAXATION LENGTH = 0.16 GM/SQCM
BOMB FRACTION PER SQ. METER = 4.092E-12

DEBRIS DECAY FROM 1 TO 21 HOURS

	ZERO TIME	1.00E+00	2.00E+00	3.00E+00	4.00E+00	6.00E+00	9.00E+00	1.20E+01	1.50E+01	1.80E+01	2.10E+01
I130	3.49E-02	3.30E-02	3.12E-02	2.95E-02	2.79E-02	2.50E-02	2.11E-02	1.78E-02	1.51E-02	1.28E-02	1.08E-02
SB131	2.72E+02	7.10E+01	1.16E+01	1.91E+00	3.13E-01	8.42E-03	3.71E-05	1.64E-07	7.21E-10	3.18E-12	1.59E-14
TE131M	1.31E-04	6.84E-01	7.81E-01	7.81E-01	7.67E-01	7.33E-01	6.84E-01	6.38E-01	5.95E-01	5.55E-01	5.18E-01
TE131	1.20E+02	1.31E+02	4.26E+01	1.11E+01	2.69E+00	2.53E-01	1.26E-01	1.16E-01	1.08E-01	1.01E-01	9.44E-02
I131	1.75E-02	6.06E-01	8.92E-01	9.79E-01	9.96E-01	1.00E+00	1.00E+00	9.96E-01	9.96E-01	9.88E-01	9.88E-01
TE132	1.19E+00	2.90E+00	2.87E+00	2.85E+00	2.82E+00	2.77E+00	2.69E+00	2.62E+00	2.56E+00	2.49E+00	2.42E+00
I132	2.93E+00	2.92E+00	2.91E+00	2.90E+00	2.88E+00	2.84E+00	2.77E+00	2.70E+00	2.63E+00	2.56E+00	2.50E+00
TE133M	1.40E-01	4.84E+01	2.11E+01	9.18E+00	3.99E+00	7.58E-01	6.24E-02	5.15E-03	4.24E-04	3.50E-05	2.89E-06
TE133	7.85E+02	4.45E+01	4.95E+00	1.64E+00	6.92E-01	1.31E-01	1.08E-02	8.92E-04	7.39E-05	6.07E-06	5.01E-07
I133	1.22E+00	1.31E+01	1.42E+01	1.42E+01	1.39E+01	1.32E+01	1.20E+01	1.08E+01	9.78E+00	8.92E+00	8.05E+00
XE133M	5.18E-08	2.95E-03	7.12E-03	1.14E-02	1.55E-02	2.33E-02	3.37E-02	4.28E-02	5.04E-02	5.70E-02	6.25E-02
XE133	9.05E-07	5.15E-02	1.25E-01	2.00E-01	2.74E-01	4.15E-01	6.09E-01	7.78E-01	9.31E-01	1.06E+00	1.18E+00
TE134	2.57E+02	1.19E+02	4.44E+01	1.65E+01	6.12E+00	8.48E-01	4.34E-02	2.22E-03	1.14E-04	5.84E-06	3.00E-07
I134	1.18E+02	1.58E+02	1.10E+02	6.47E+01	3.47E+01	8.82E+00	9.69E-01	9.90E-02	9.69E-03	9.29E-04	8.82E-05
I135	2.05E+01	3.62E+01	3.27E+01	2.94E+01	2.66E+01	2.16E+01	1.58E+01	1.16E+01	8.50E+00	6.26E+00	4.57E+00
XE135M	2.27E-03	1.05E+01	1.02E+01	9.21E+00	8.27E+00	6.73E+00	4.94E+00	3.62E+00	2.66E+00	1.95E+00	1.43E+00
XE135	2.37E+00	4.68E+00	6.85E+00	8.62E+00	1.00E+01	1.20E+01	1.33E+01	1.34E+01	1.28E+01	1.16E+01	1.04E+01
CS136	2.32E-02	2.31E-02	2.31E-02	2.30E-02	2.30E-02	2.29E-02	2.27E-02	2.26E-02	2.24E-02	2.23E-02	2.21E-02
CS137	1.07E-04	1.15E-03	1.15E-03	1.15E-03	1.15E-03	1.15E-03	1.15E-03	1.15E-03	1.15E-03	1.15E-03	1.15E-03
BA137M	2.25E-07	1.07E-03	1.07E-03	1.07E-03	1.07E-03	1.07E-03	1.07E-03	1.07E-03	1.07E-03	1.07E-03	1.07E-03
XE138	6.47E+02	5.57E+01	4.84E+00	4.19E-01	3.63E-02	2.72E-04	1.77E-07	1.15E-10	7.47E-14	4.86E-17	3.16E-20
CS138	9.63E+01	1.62E+02	5.62E+01	1.65E+01	4.63E+00	3.52E-01	7.32E-03	1.52E-04	3.16E-06	6.57E-08	1.36E-09
CS139	8.17E+02	2.61E+01	3.27E-01	4.11E-03	5.15E-05	8.09E-09	1.61E-14	3.18E-20	6.30E-26	1.25E-31	2.47E-37
BA139	1.51E+01	1.68E+02	1.04E+02	6.30E+01	3.81E+01	1.40E+01	3.10E+00	6.89E-01	1.53E-01	3.39E-02	7.54E-03
BA140	1.03E-01	6.43E-01	6.43E-01	6.39E-01	6.39E-01	6.34E-01	6.34E-01	6.29E-01	6.24E-01	6.19E-01	6.14E-01
LA140	2.45E-07	1.10E-02	2.18E-02	3.24E-02	4.27E-02	6.29E-02	9.18E-02	1.19E-01	1.44E-01	1.68E-01	1.91E-01
BA141	1.47E+02	4.43E+01	4.40E+00	4.36E-01	4.33E-02	4.30E-04	4.19E-07	4.09E-10	3.98E-13	3.91E-16	3.81E-19
LA141	1.35E+00	2.87E+01	2.68E+01	2.27E+01	1.90E+01	1.33E+01	7.82E+00	4.57E+00	2.69E+00	1.58E+00	9.25E-01
CE141	1.68E-07	1.86E-02	4.36E-02	6.56E-02	8.42E-02	1.13E-01	1.40E-01	1.56E-01	1.65E-01	1.70E-01	1.73E-01
BA142	2.69E+02	1.07E+01	2.44E-01	5.57E-03	1.27E-04	6.60E-08	7.83E-13	9.29E-18	1.10E-22	1.31E-27	1.55E-32
LA142	6.19E+00	4.29E+01	2.83E+01	1.80E+01	1.15E+01	4.63E+00	1.20E+00	3.08E-01	7.94E-02	2.04E-02	5.27E-03
LA143	8.99E+01	1.75E+01	8.99E-01	4.62E-02	2.37E-03	6.22E-06	8.38E-10	1.13E-13	1.52E-17	2.06E-21	2.77E-25
CE143	3.59E-02	2.29E+00	2.37E+00	2.31E+00	2.27E+00	2.19E+00	2.05E+00	1.92E+00	1.81E+00	1.69E+00	1.59E+00
PR143	1.05E-08	3.51E-03	8.47E-03	1.34E-02	1.82E-02	2.75E-02	4.06E-02	5.30E-02	6.43E-02	7.50E-02	8.49E-02
CE144	1.34E-03	9.59E-03	9.59E-03	9.59E-03	9.59E-03	9.59E-03	9.57E-03	9.57E-03	9.57E-03	9.57E-03	9.57E-03
PR144	3.67E-07	8.73E-03	9.51E-03	9.57E-03	9.59E-03	9.59E-03	9.59E-03	9.59E-03	9.57E-03	9.57E-03	9.57E-03
PR145	6.03E-02	8.87E+00	7.89E+00	7.02E+00	6.26E+00	4.96E+00	3.50E+00	2.47E+00	1.75E+00	1.23E+00	8.73E-01
CE146	1.98E+02	1.02E+01	5.21E-01	2.66E-02	1.37E-03	3.61E-06	4.86E-10	6.56E-14	8.83E-18	1.19E-21	1.61E-25
PR146	4.10E+00	3.57E+01	8.08E+00	1.52E+00	2.73E-01	8.59E-03	4.75E-05	2.62E-07	1.45E-09	8.01E-12	4.38E-14
PR147	2.26E+01	6.54E+00	2.04E-01	6.38E-03	2.00E-04	1.95E-07	5.95E-12	1.82E-16	5.54E-21	1.69E-25	5.16E-30

From Hicks (1981).

The Hicks' tables were normalized to an external gamma-exposure rate of 1 mR/hr at H+12 hours with use of the Beck tables.

An Example of the Beck Tables

TABLE 1

EXPOSURE RATES FOR FISSION PRODUCTS (μR-h^{-1})/(mCi-km^{-2})

Nuclide	Relaxation Length (g-cm^{-2})				
	Plane	0.16	1.6	4.8	16
GE-77	2.08E-2	1.81E-2	1.22E-2	8.41E-3	4.54E-3
AS-77	1.82E-4	1.58E-4	1.08E-4	7.40E-5	4.00E-5
GE-78	5.00E-3	4.32E-3	2.99E-3	1.98E-3	1.05E-3
AS-78	2.10E-2	1.82E-2	1.23E-2	8.66E-3	4.75E-3
SE-83	4.36E-2	3.78E-2	2.56E-2	1.79E-2	9.83E-3
BR-83	1.42E-4	1.26E-4	8.40E-5	5.80E-5	3.10E-5
SE-84	7.93E-3	6.85E-3	4.60E-3	3.10E-3	1.66E-3
BR-84	2.88E-2	2.44E-2	1.69E-2	1.21E-2	6.85E-3
RB-88	1.07E-2	9.04E-3	6.27E-3	4.48E-3	2.53E-3
RB-89	3.51E-2	3.03E-2	2.06E-2	1.47E-2	8.20E-3
SR-91	1.27E-2	1.10E-2	7.33E-3	5.18E-3	2.81E-3
Y-91M	1.00E-2	8.84E-3	5.91E-3	4.06E-3	2.18E-3
SR-92	2.28E-2	1.98E-2	1.34E-2	9.44E-3	5.29E-3
Y-92	4.50E-3	3.91E-3	2.61E-3	1.84E-3	1.01E-3
SR-93	4.04E-2	3.50E-2	2.36E-2	1.67E-2	9.17E-3
Y-93M	1.41E-2	1.24E-2	8.32E-3	5.73E-3	3.03E-3
Y-93	1.53E-3	1.31E-3	8.96E-4	6.28E-4	3.48E-4
Y-94	1.38E-2	1.20E-2	7.98E-3	5.66E-3	3.10E-3
Y-95	2.07E-2	1.76E-2	1.22E-2	8.72E-3	4.94E-3
ZR-95	1.39E-2	1.20E-2	7.94E-3	5.63E-3	3.02E-3
NB-95	1.44E-2	1.24E-2	8.20E-3	5.82E-3	3.13E-3
ZR-97	3.19E-3	2.77E-3	1.87E-3	1.30E-3	7.14E-4
NB-97M	1.37E-2	1.19E-2	7.83E-3	5.55E-3	2.98E-3
NB-97	1.24E-2	1.08E-2	7.15E-3	5.03E-3	2.69E-3
MO-99	2.98E-3	2.59E-3	1.72E-3	1.21E-3	6.44E-4
TC-99M	2.12E-3	1.92E-3	1.29E-3	8.78E-4	4.31E-4
MO-101	2.74E-2	2.37E-2	1.60E-2	1.13E-2	6.18E-3
TC-101	6.33E-3	5.49E-3	3.84E-3	2.52E-3	1.34E-3
MO-102	7.42E-3	6.59E-3	4.46E-3	3.01E-3	1.54E-3
TC-102	1.02E-2	8.93E-3	5.96E-3	4.12E-3	2.22E-3

From Beck (1980)

The Hicks' tables were provided for use in calculations of dose downwind from the NTS.

- It was necessary to correct for fractionation, which is the chemical and physical separation of nuclides according to volatility.
- The Small Boy calculations were done with the assumption that 0.4 of the refractories were present downwind.
- The refractories must be assumed to have remained on the NTS.

Four steps are needed to correct for fractionation on site.

1. **Starting with the calculations for 0.4 of refractories present in Hicks, add back in the 0.6 of refractory radionuclides missing to create an unfractionated source term.**

2. **Renormalize the unfractionated source term to 1 mR/hour at H+12.**

Four Steps (concluded)

3. Starting with the now unfractionated source term, add in the 0.6 of refractory nuclides that are presumed to have remained on the NTS.

4. Renormalize the refractory-enhanced source term to an external gamma-exposure rate of 1 mR/hour at H+12.

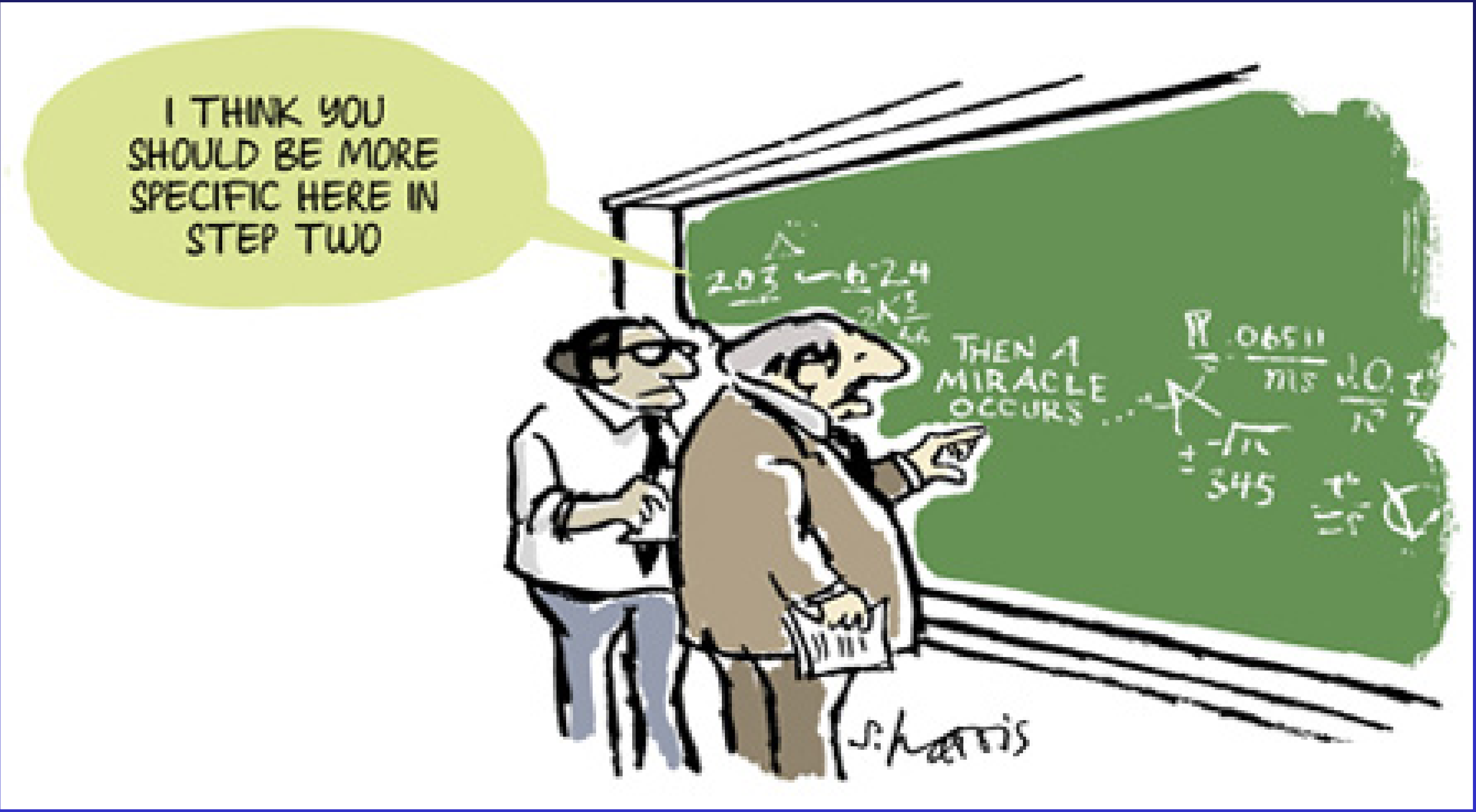
It does not appear that the renormalizations were done.

SC&A's Recommendation 3 to the Members of the NTS WG

NIOSH and contractors should redo the calculations for correction of fractionation to include all four steps. This requires the additional steps of renormalizing the source term after each addition of refractory elements.

A central problem is that the NIOSH and Strenge (2016) calculations are not transparent.

- The descriptions are not clear.
- Intermediate results are not shown.


I THINK YOU SHOULD BE MORE SPECIFIC HERE IN STEP TWO
THEN A MIRACLE OCCURS
S. Harris

What is the miracle?

IMBA was run to determine the relative importance of 177 radionuclides to 26 ICRP organs for 10 one-year periods:

$$177 \times 26 \times 10 = 46{,}020 \text{ IMBA runs}$$

And Strenge did it for 5 scenarios:

$$177 \times 26 \times 10 \times 5 = 230{,}100 \text{ IMBA runs}$$

It does not seem possible.

Integration of Equation A-2 from ORAUT (2012).

“Integrating Equation A-2…from 0 to 365 days and dividing the result by 365 (the value that represents the integrated total dose for one year), it was determined that for the first year after detonation the lung dose from ^{90}Sr represented 0.0000738…of the dose from all 177 radionuclides.”

The meaning of time 0 is unclear.

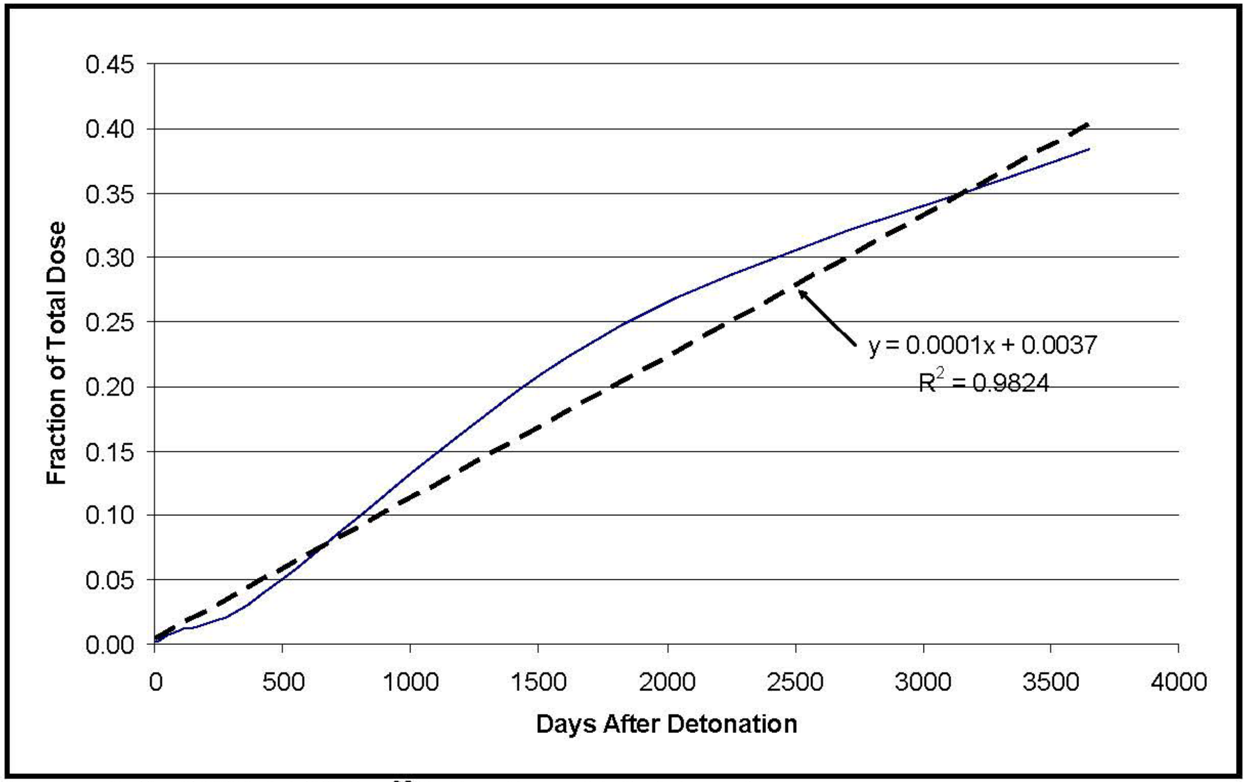


Figure A-2. SMALL BOY – ^{90}Sr fraction of total dose lungs.

From Page 70 of ORAUT (2012).

The previous statement is not correct.

Dividing by 365 does not give an integral.

The second problem is the integration. The following equation is a reproduction of what the authors *said* they did:

$$\frac{\int_0^{365}(0.0001x+0.0074)dx}{365} = \frac{\left.\frac{0.0001x^2}{2}+0.0074x\right|_0^{365}}{365} = 0.026$$

The calculated value of 0.026 is obviously very different from 0.0000738. The above equation is, in fact, the classic definition of an average of the function over the 365-day period, and according to the authors' Figure A-2, which is reproduced here as Figure 1, the average value has to be about midway between 0.00 and 0.05. The authors' contention that they have calculated an integrated total dose does not match the reproduction of what they said they did.

From SC&A (2016), page 24.

SC&A's Recommendation 4 to the Members of the NTS WG

NIOSH and contractors should be very specific about how their calculations were made and provide the results of all intermediate calculations so that SC&A and others can verify the calculations.

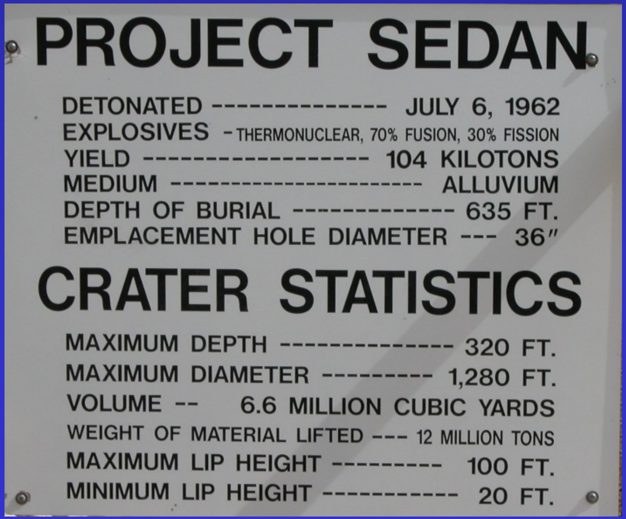
This may require that one or more DVDs be provided, as the intermediate data are likely voluminous.

SC&A's Recommendation 5 to the Members of the NTS WG

NIOSH and contractors should also consider the source term for the Sedan event, which was a large thermonuclear event on July 6, 1962.

The Sedan source term is different than one for a fission event.

Sedan was a major event.



Photos courtesy of National Nuclear Security Administration / Nevada Site Office

The NIOSH calculations do not consider contaminating events post July 1962.

- There were 225 underground shots that vented during 1963-1970.
- There were 5 Plowshare events during 1964–1968 that released 10^5 to 10^6 Ci at H+12.
- The Baneberry vent released nearly 10^7 Ci at H+12.
- There were 25 tests of nuclear rocket engines during 1963–1970.

Baneberry was a massive vent that occurred on December 18, 1970.

Photo courtesy of National Nuclear Security Administration / Nevada Site Office

SC&A's Recommendation 6 to the Members of the NTS WG.

The impacts of hundreds of releases of large quantities of short-lived radionuclides in the 1962–1970 period should be considered in a more serious manner so that exposures to claimants are considered fairly.