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The Science of Radiological Security and the Importance of Non-Radiological Characteristics of Radionuclides

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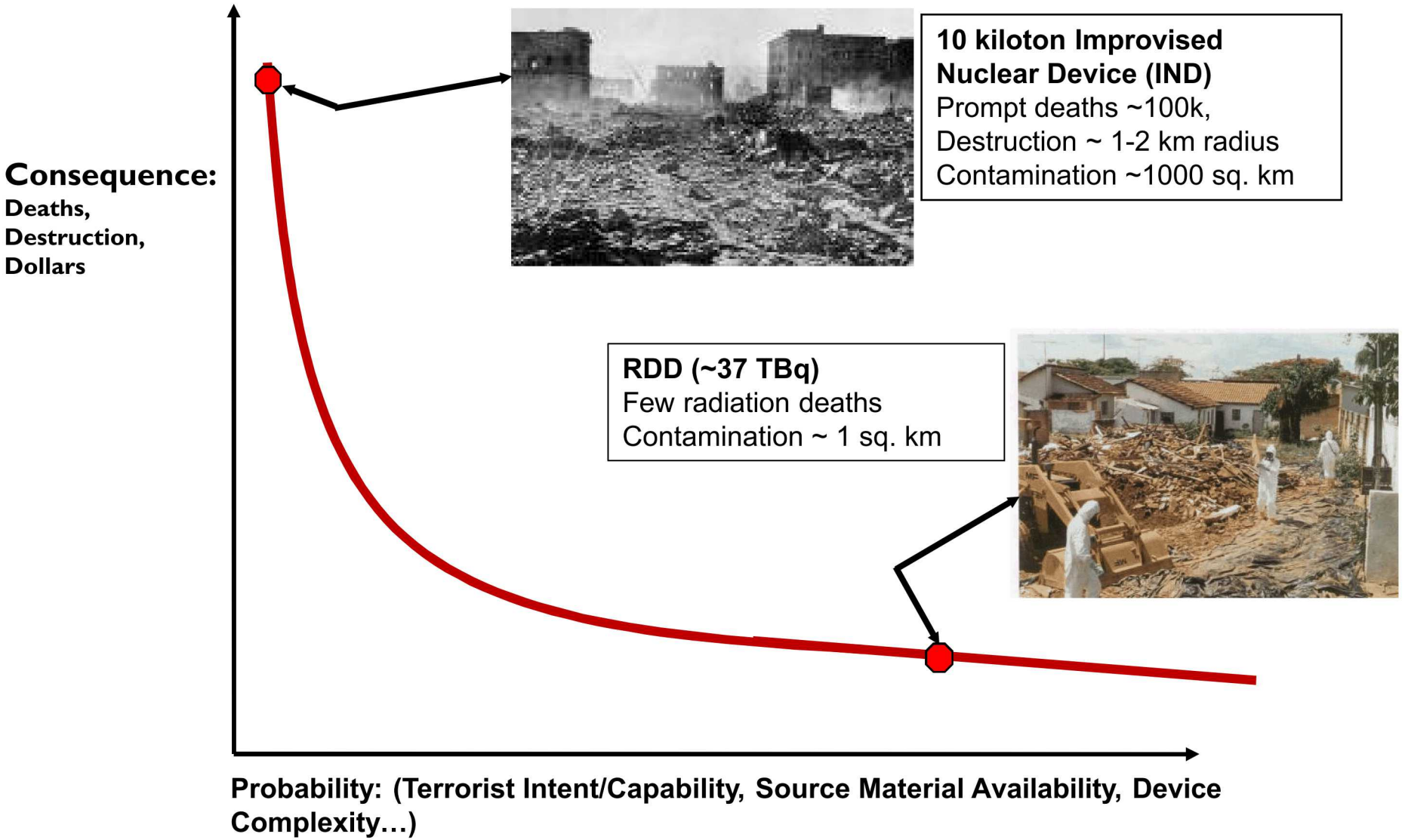
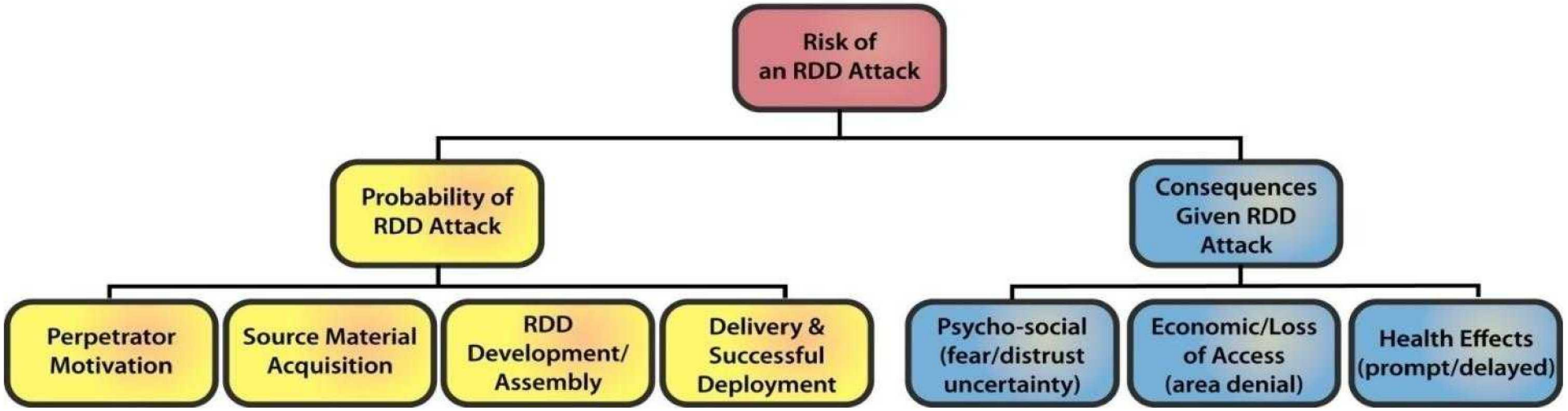
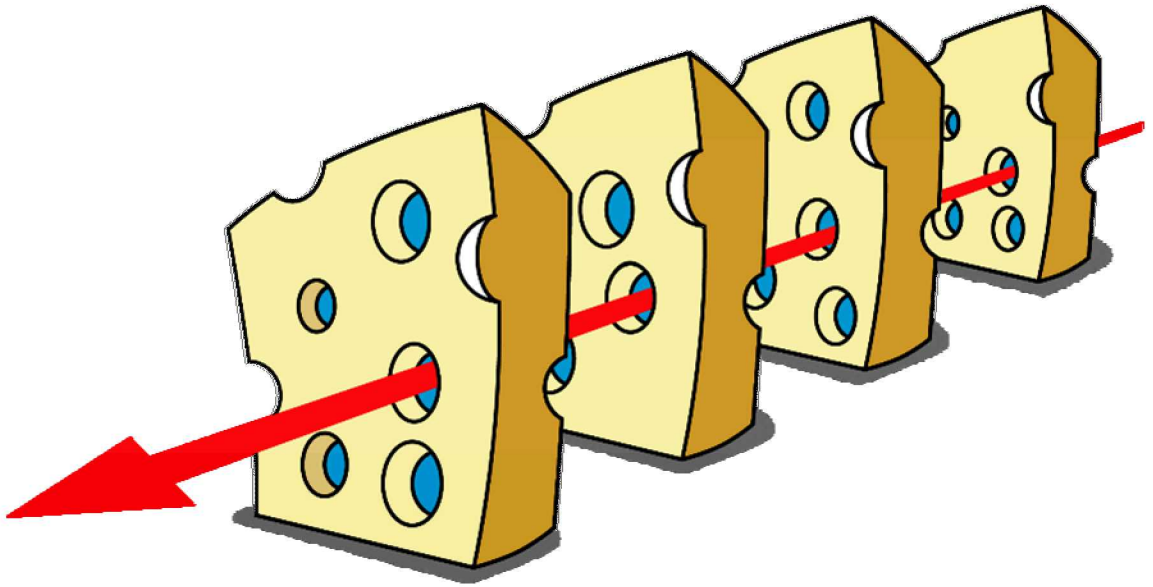
Radiological consequences are by nature much reduced from nuclear, but likelihood is greater.



The RDD threat framework allows view of the breadth of the problem.





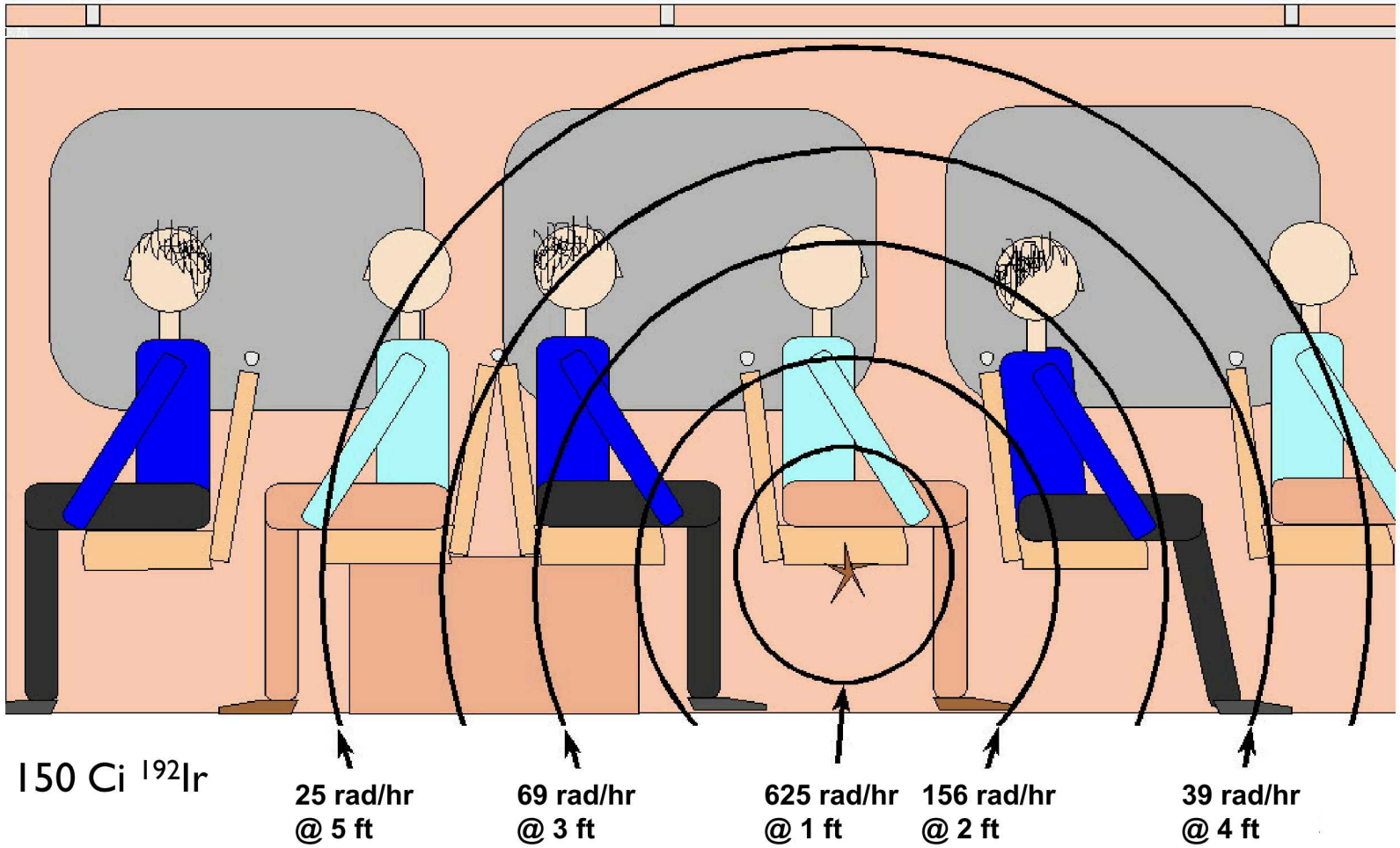
Jihadists and anarchists have included the radiological threat in their rhetoric.

Abu Ayyub al-Masri, 2006

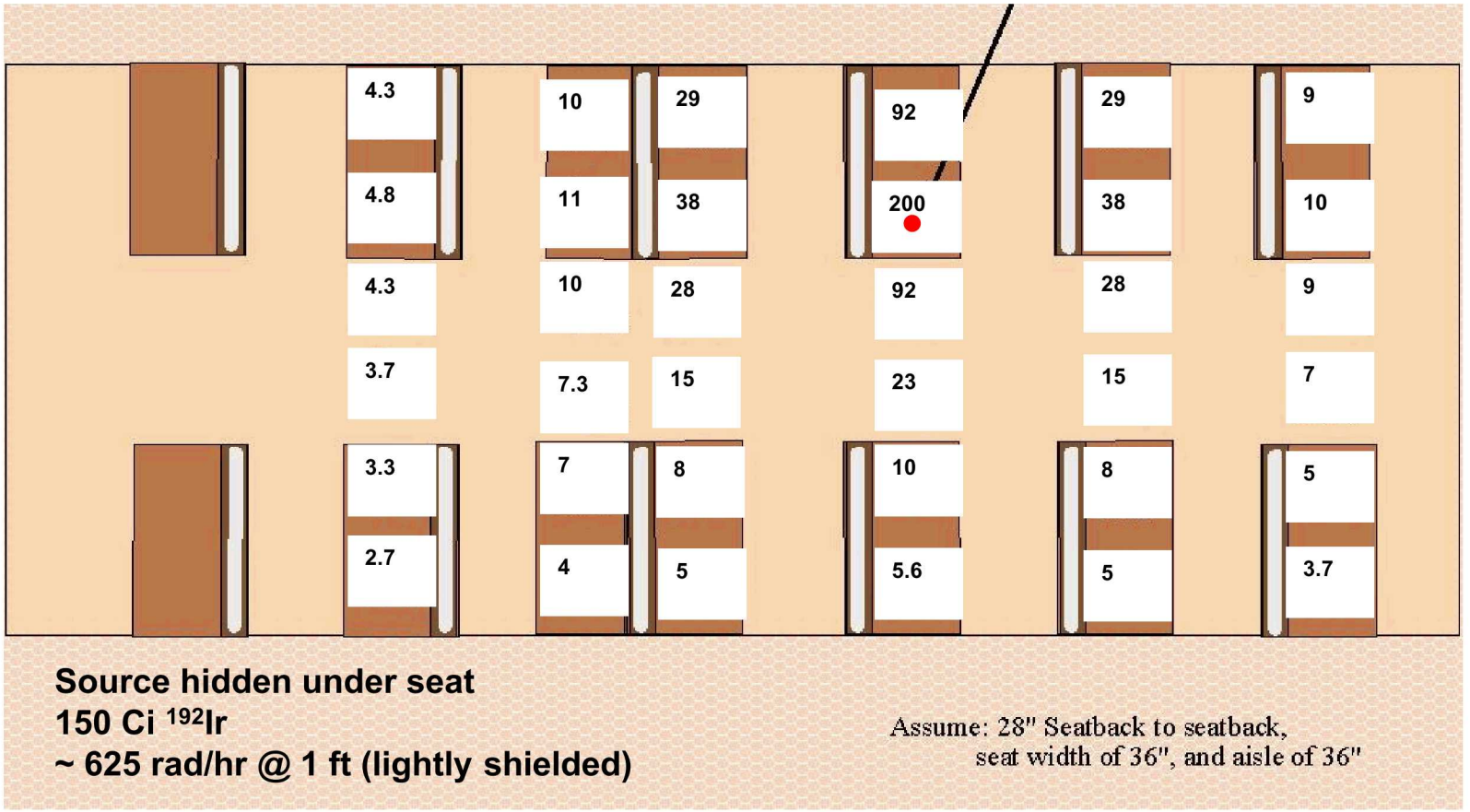
Anders Breivik, 2011

Al-Taqwq Media Foundation, 2018
(notionalized)

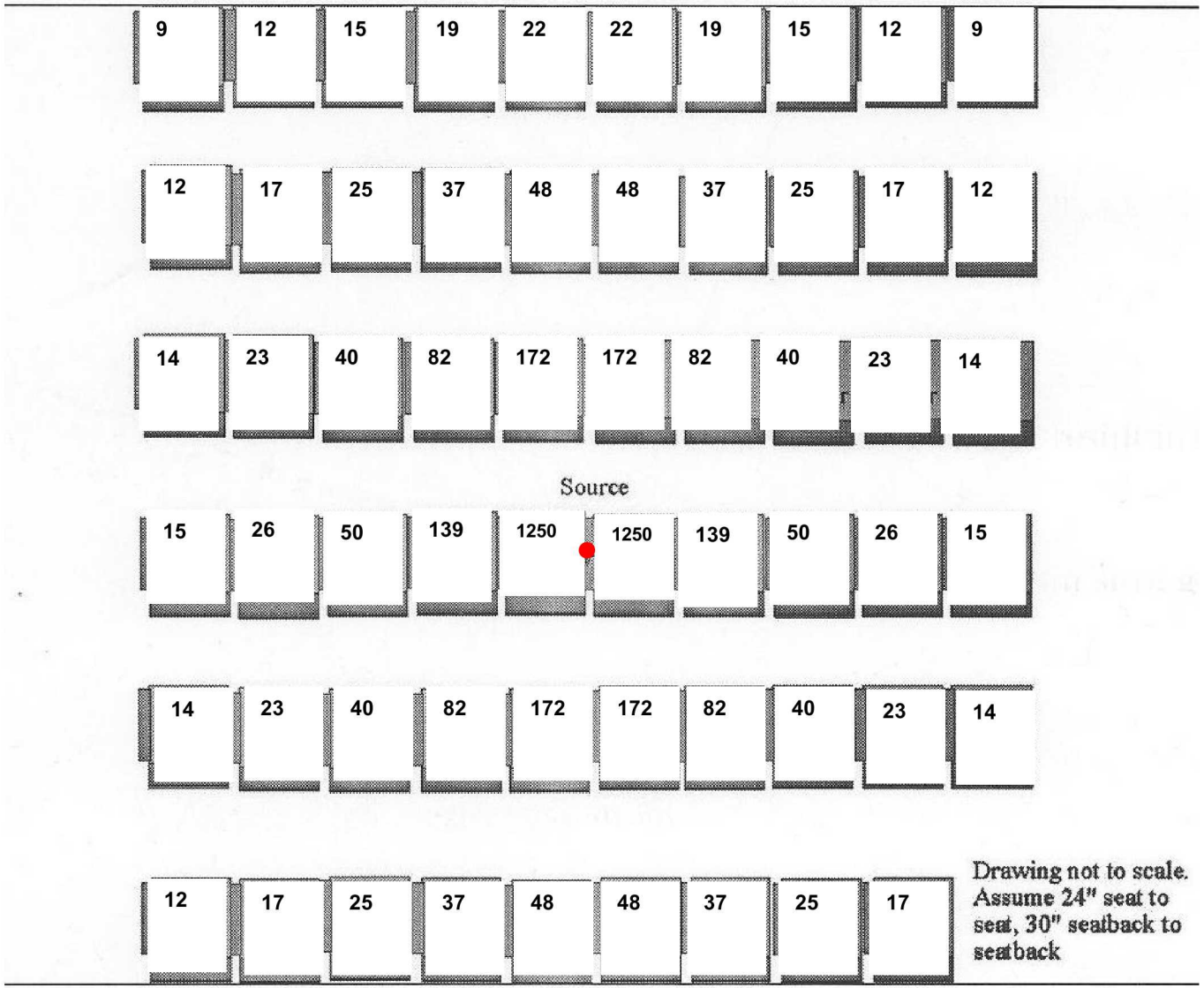
Any RED scenario requires time for victims to accumulate exposure.



With a 20-minute subway ride, only a few individuals will experience deterministic effects.

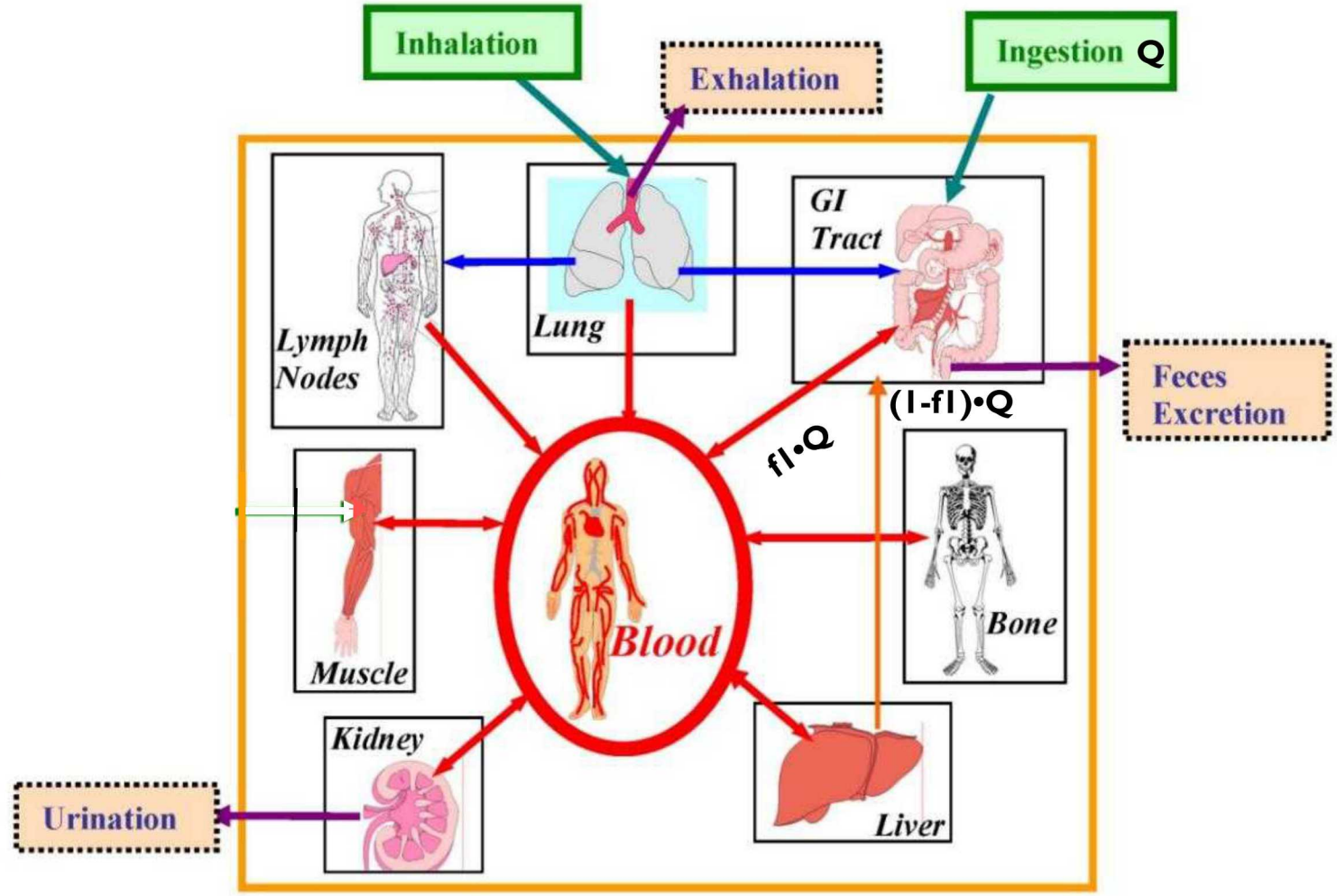


A movie theater or sporting event could allow the time necessary for one or two individuals to accumulate a life-threatening dose.

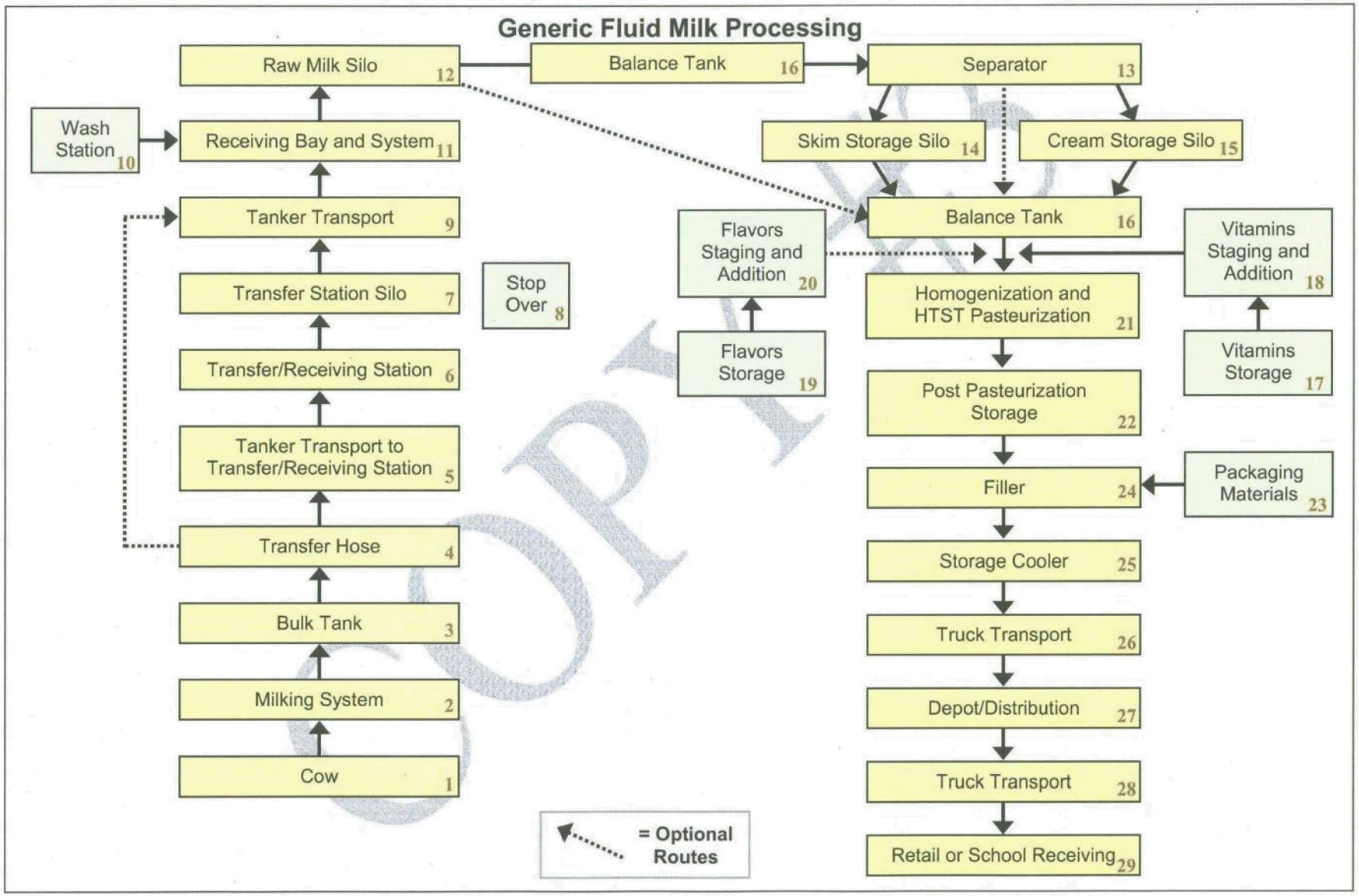


REDs have been used worldwide for personal attacks.

The efficacy of poisoning with radioactive material is dependent on the chemical and physical properties of the *element*.

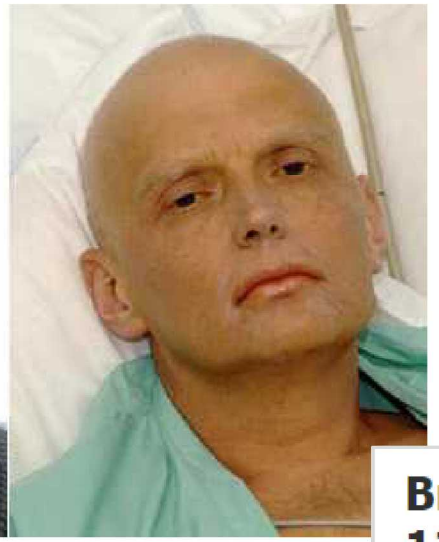


Food can be vulnerable, but dilution makes it difficult to cause actual deterministic effects.



As with REDs, poisonings with radioactive material have been personal.





Brown Student Poisons Ex-Girlfriend with Iodine-125

from UNIVERSITY WIRE

Providence police arrested a Brown University graduate student on Friday and charged him with poisoning two fellow students - one of whom is his ex-girlfriend - with a radioactive chemical he allegedly stole from a Brown laboratory.

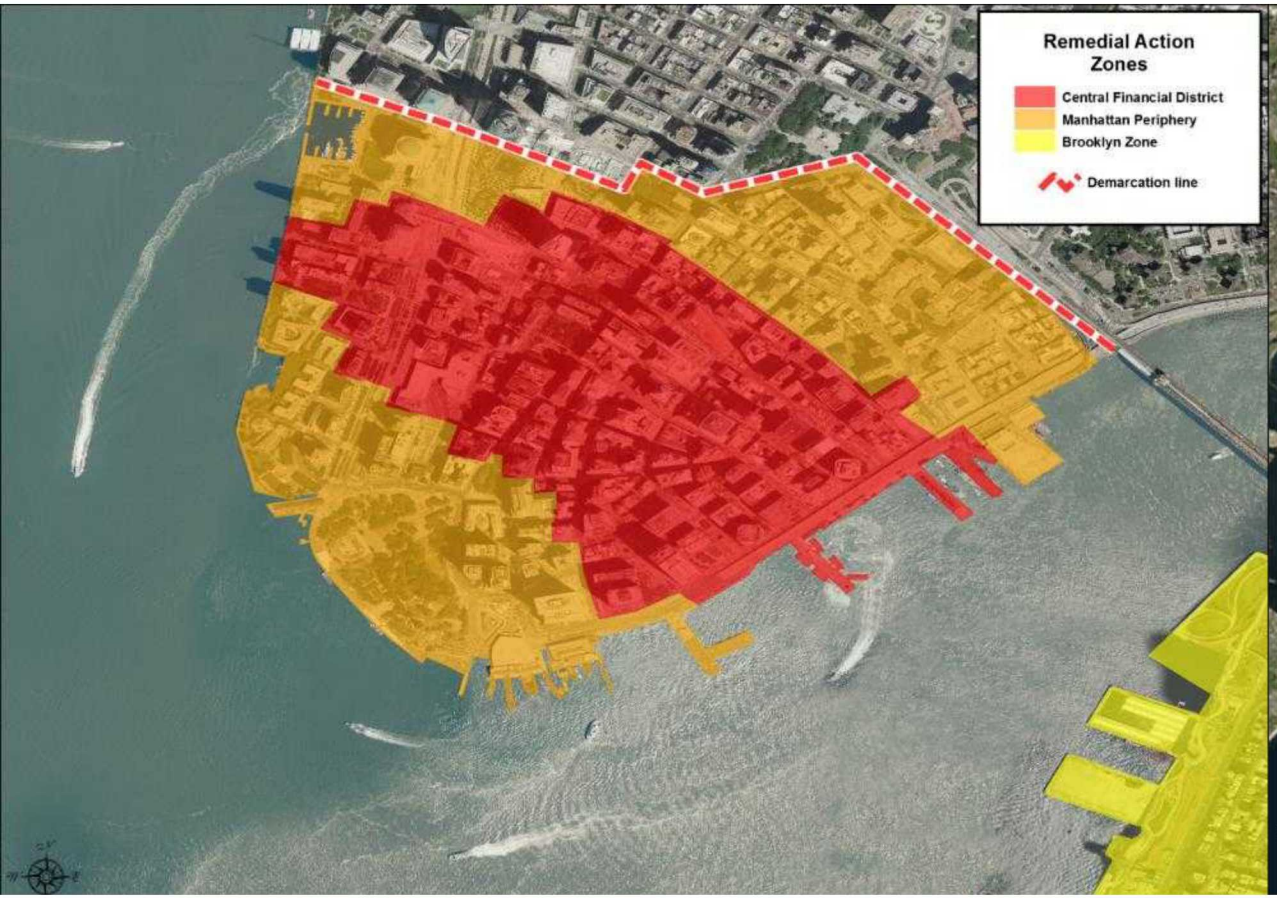
According to Brown News Bureau Director Mark Nickel, Cheng Gu, a student in molecular pharmacology, prepared a chicken and vegetable dish laced with iodine-125, which he then served Yuanyuan Xiao and her roommate James O'Brien at their home.

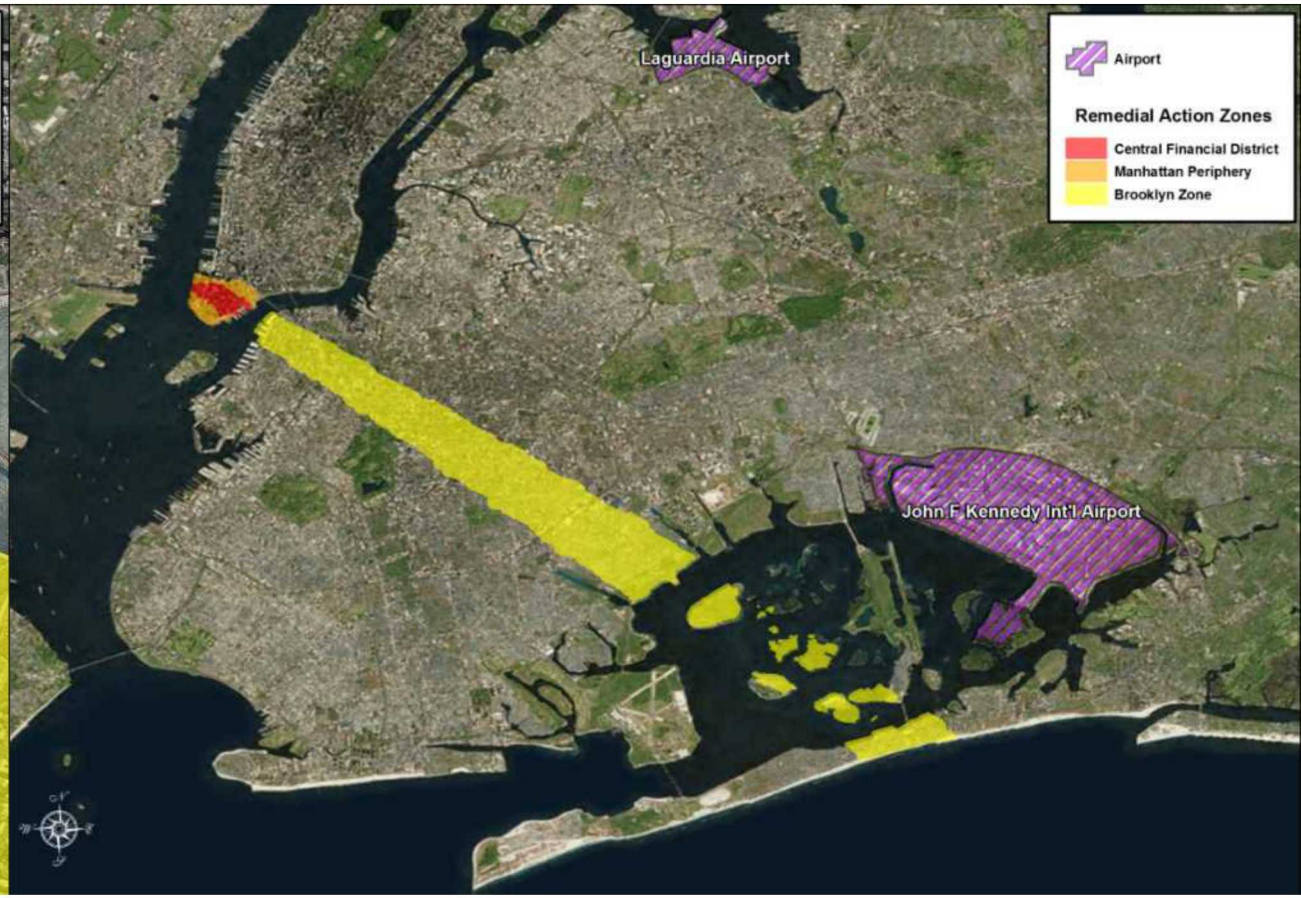
Xiao is also a graduate student in molecular pharmacology. O'Brien is a Resumed Undergraduate Education student.

Gu faces five felony charges: assault against O'Brien, domestic assault against Xiao, larceny for theft of the radioactive material from Brown, poisoning O'Brien, and poisoning Xiao.

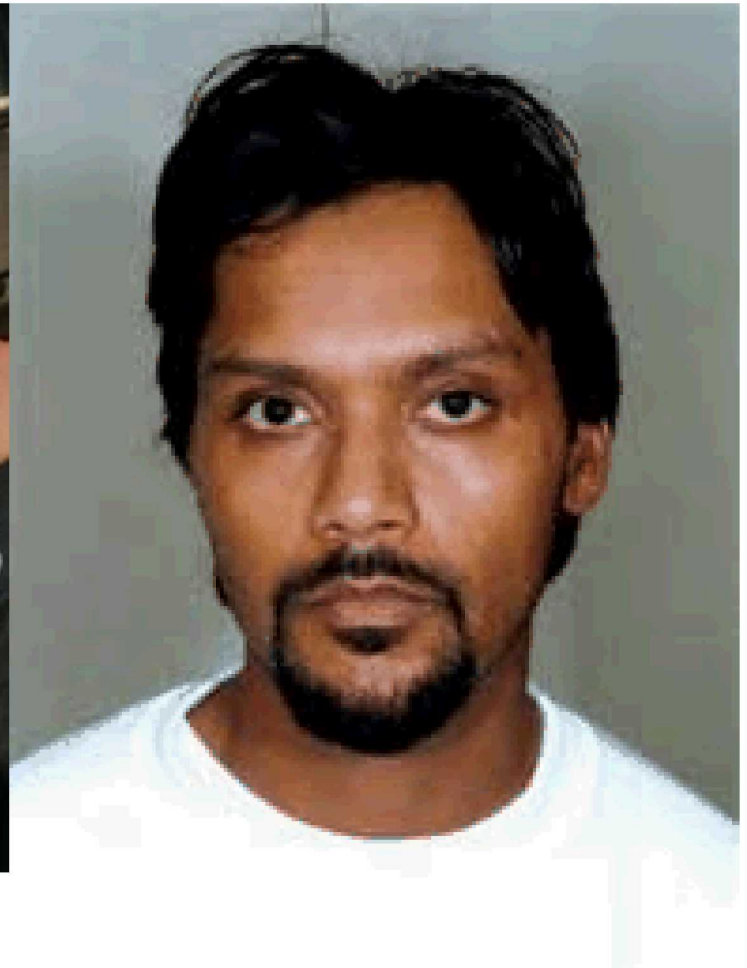
Captain John Ryan of the Providence Police told the Associated Press that he believed the attack to be motivated by "some kind of love interest."

Severity of an RDD is dependent on wind direction, speed, material properties, device efficiency, and *choice of target*.





There have been some unsuccessful attempts at obtaining material and constructing an RDD



There is some experience with widespread dispersion of radioactive material.

^{137}Cs, Goiânia, Brazil, September 1987

^{60}Co, Cuidad Juárez, Mexico, December 1983

The area-denial standard is based on the EPA's intermediate relocation protective action guide.

PAG = 2 rem projected dose over the first year post release

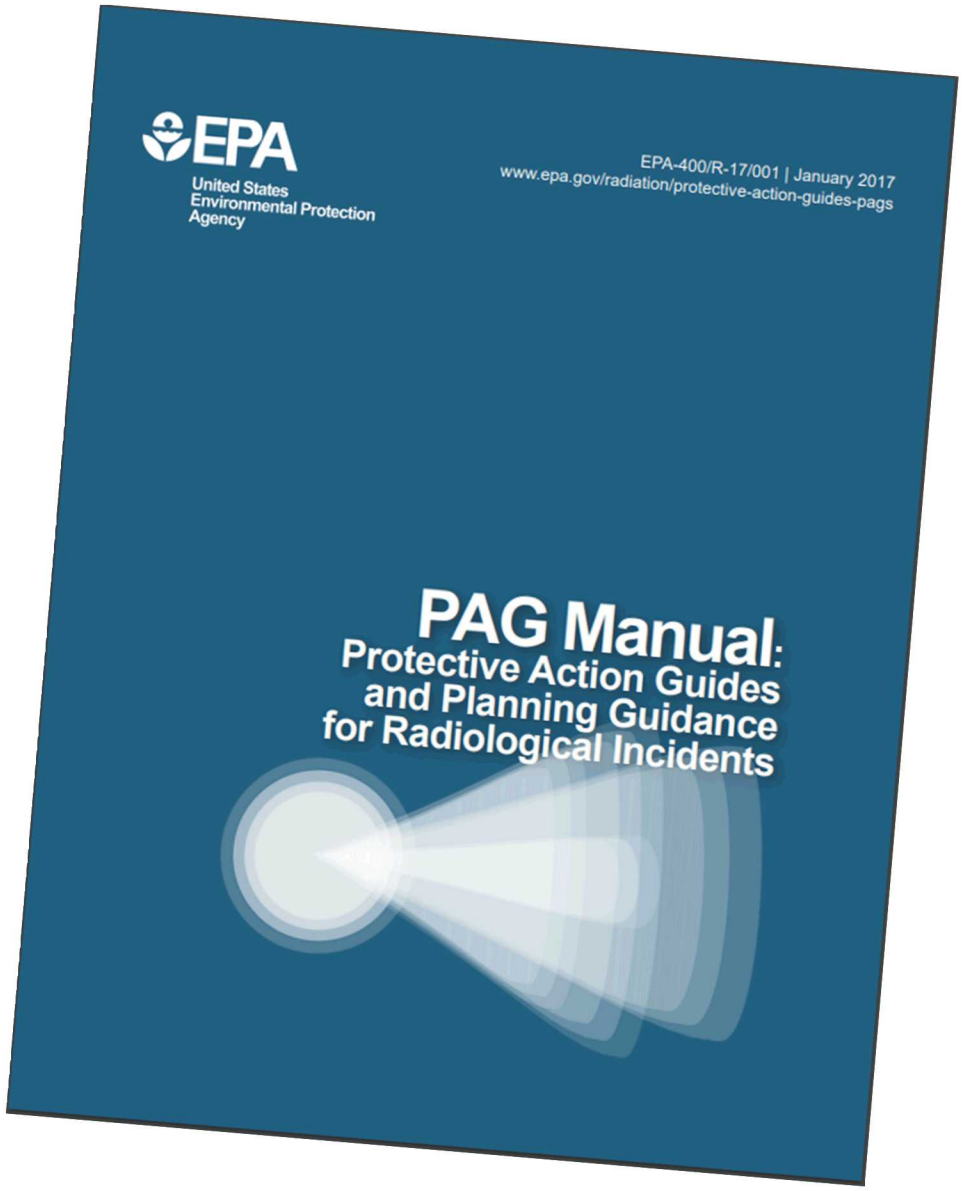
- 1/50 of public dose limit
- 0.08% (8 per 10,000) projected increase in cancer incidence

Based on reactor or fuel cycle release accident release of nuclear material and/or fission products (1992 version)

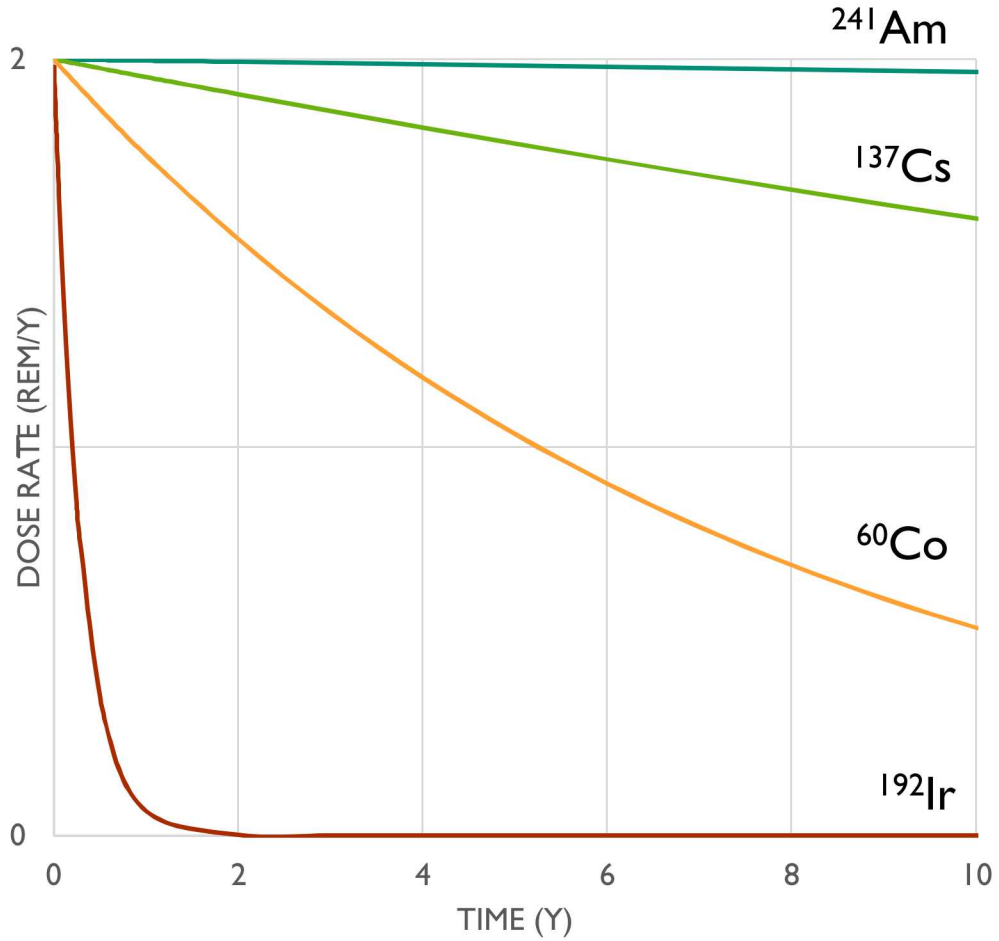
Time period begins "after the source and releases have been brought under control" (96 hours).

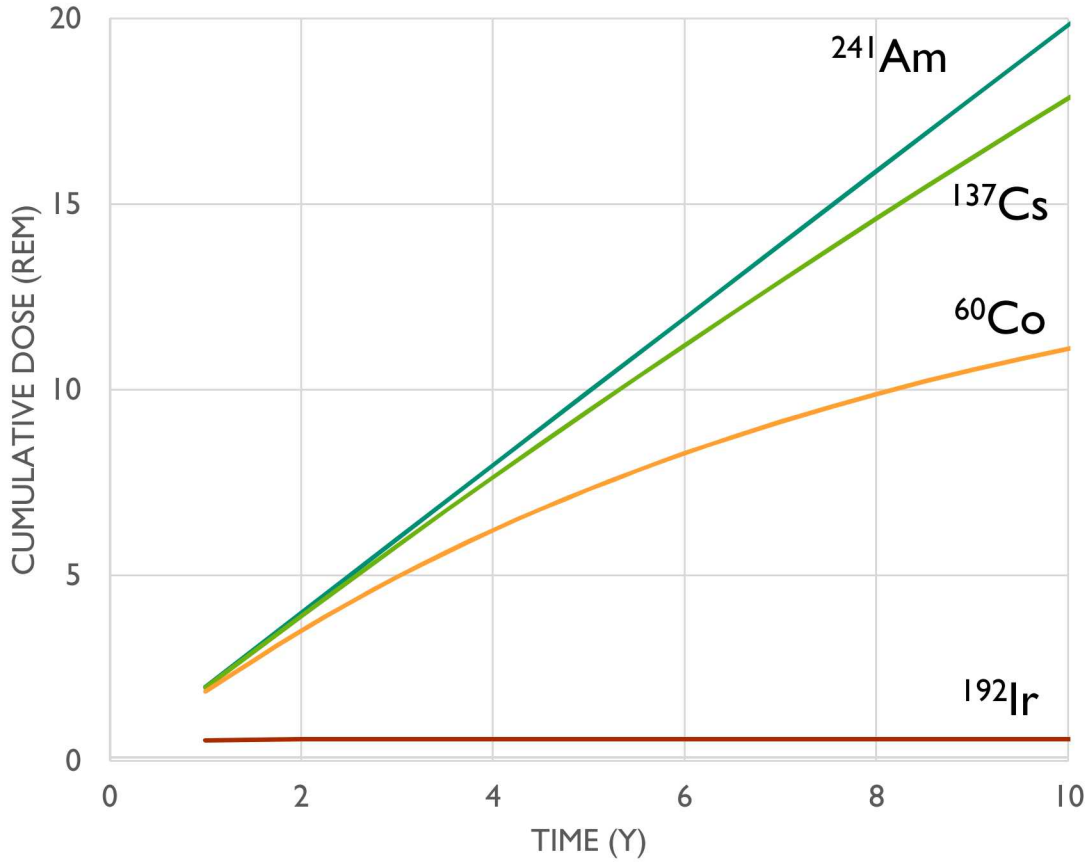
Calculation considerations (Turbo FRMAC):

- Cloudshine and direct plume inhalation not considered
- Beta/gamma emitters tend to have groundshine as limiting
- Alpha emitters tend to have particulate resuspension as limiting

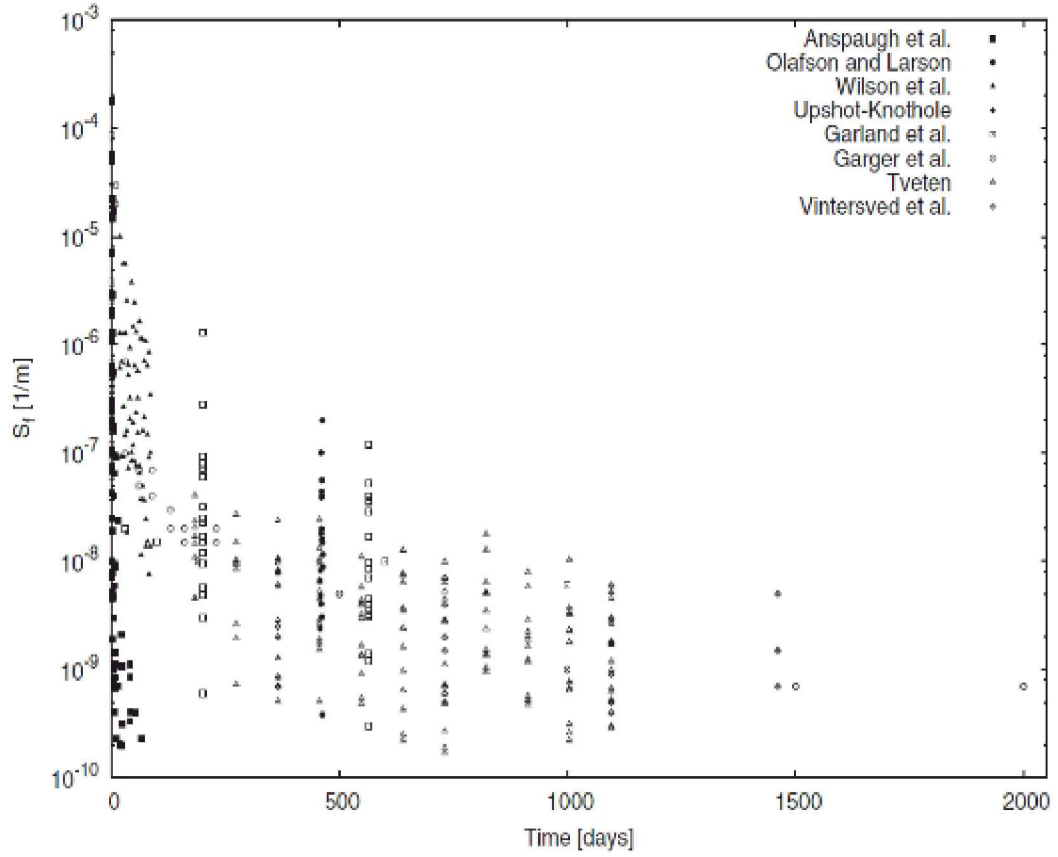


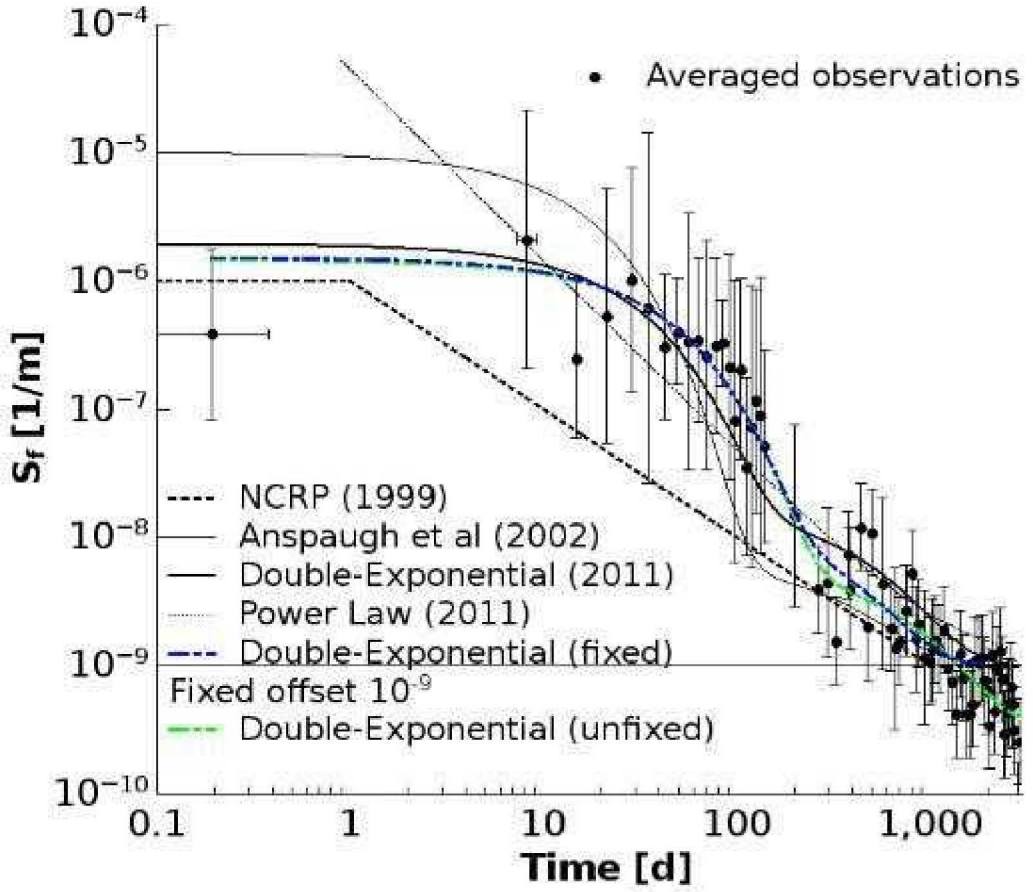
Consideration of half-lives itself shows difficulty in comparison of radionuclide consequences.





Prospective dose calculations from alpha emitters are difficult due to the lack of proper science behind resuspension models.





BEIR VII and ICRP-103 risk parameters should be understood and explainable by health physicists.

0.08/Sv

	All Solid Cancer		Leukemia	
Excess cases (including non-fatal cases) from exposure to 100 mSv	Males	Females	Males	Females
	800 (400–1600)	1300 (690–2500)	100 (30–300)	70 (20–250)
Number of cases in the absence of exposure	45,500	36,900	830	590
Excess deaths from exposure to 100 mSv	410 (200–830)	610 (300–1200)	70 (20–220)	50 (10–190)
Number of deaths in the absence of exposure	22,100	17,500	710	530

Table 1. The table shows the estimated number of cancer cases and deaths expected to result in 100,000 persons (with an age distribution similar to that of the entire U.S. population) exposed to 100 mSv. The estimates are accompanied by 95% subjective confidence intervals shown in parentheses that reflect the most important uncertainty sources including statistical variation, uncertainty in adjusting risk for exposure at low doses and dose rates, and uncertainty in the method of transporting data from a Japanese to a U.S. population. For comparison, the number of expected cases and deaths in the absence of exposure is listed.

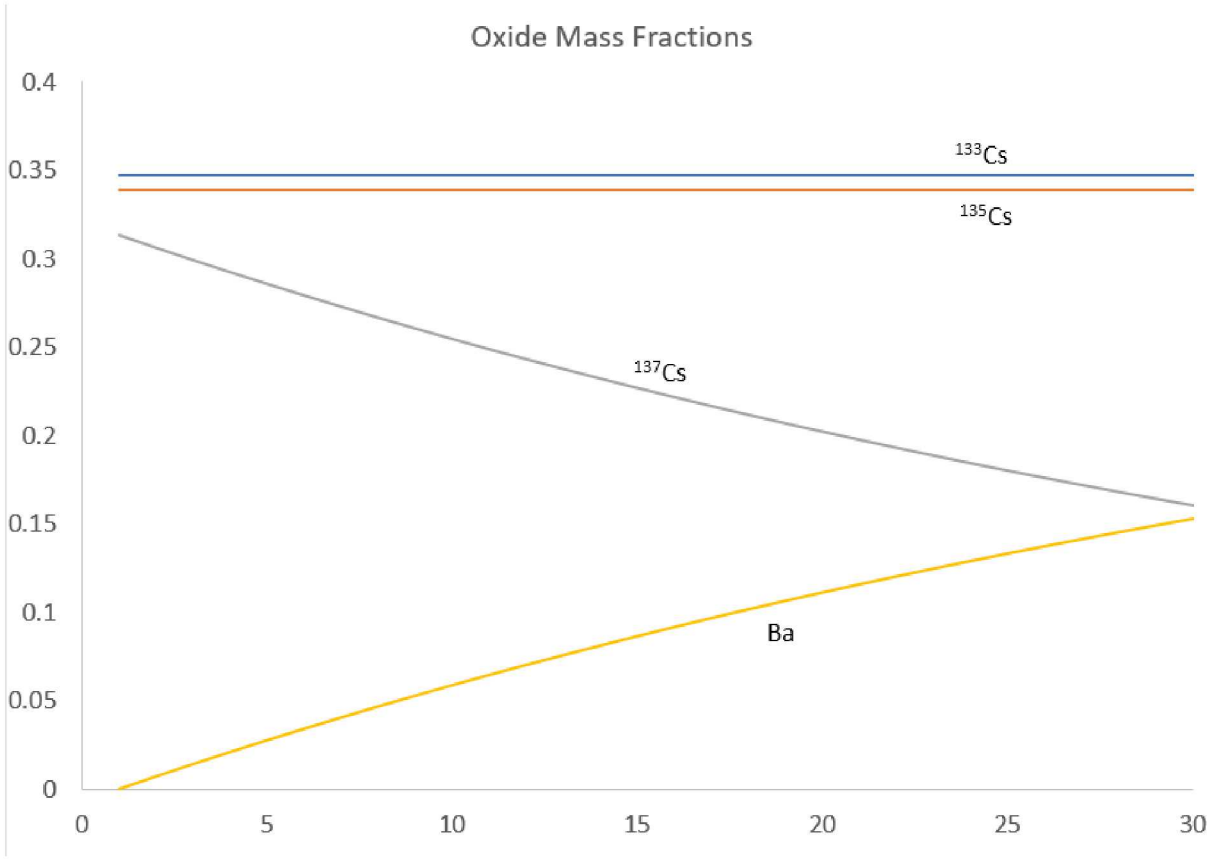
BEIR VII

Table 1. Detriment-adjusted nominal risk coefficients (10^{-2} Sv^{-1}) for stochastic effects after exposure to radiation at low dose rate.

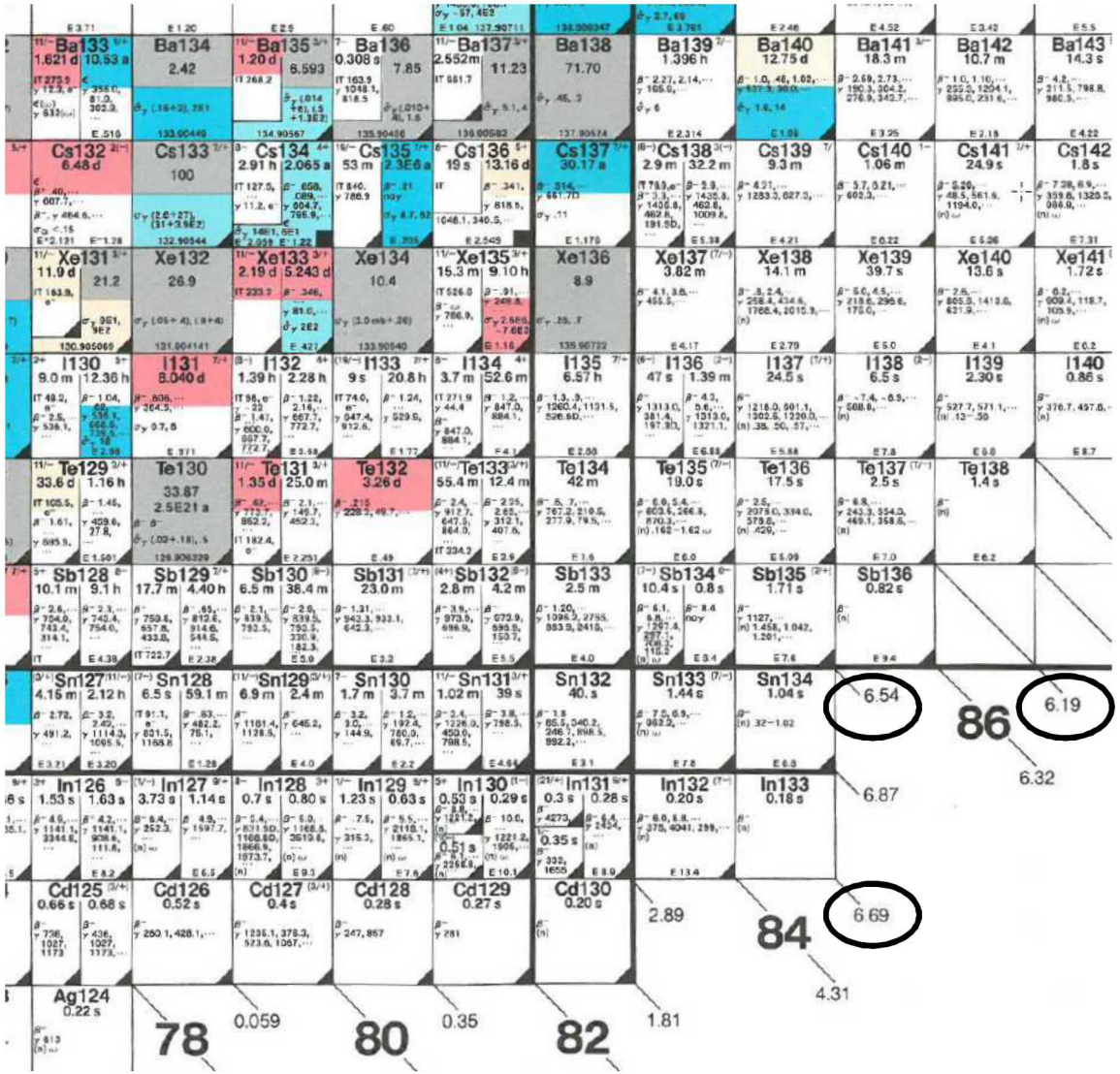
Exposed population	Cancer		Heritable effects		Total	
	Present[1]	*Publ. 60*	Present[1]	*Publ. 60*	Present[1]	*Publ. 60*
Whole	5.5	6.0	0.2	1.3	5.7	7.3
Adult	4.1	4.8	0.1	0.8	4.2	5.6

ICRP-103

Specific activity is of great importance, both in analyzing the threat and consequences.



SA ^{137}Cs 88 Ci/g → ~20 Ci/g at 10 yrs with other isotopes



Conservatism in prospective dose parameters promotes improper action and scares the public.

United States Government Accountability Office

GAO

Report to the Permanent Subcommittee on Investigations, Committee on Homeland Security and Governmental Affairs, U.S. Senate

June 2008

NUCLEAR SECURITY

NRC and DHS Need to Take Additional Steps to Better Track and Detect Radioactive Materials

GAO

Accountability * Integrity * Reliability

GAO-08-598

Table 3: Potential Contamination from an RDD

	Amount of radioactive material (cesium-137)		
Thresholds for concern (based on 1 year of exposure)	Category 3 threshold (2.7 curies)	Category 2 threshold (27 curies)	Category 1 threshold (2,700 curies)
EPA recommends relocation (2 rem)[a]	15.1 acres	150.7 acres	15,012 acres
Potential observable health effects (100 rem)	0.3 acre	3 acres	300 acres

Source: GAO.

Notes: Calculations based on the Department of Energy's Federal Regulatory Monitoring and Assessment Center dose assessment methodology. The potential area contamination figures assume uniform ground deposition of radioactive material, which is difficult to accomplish and may not be realistic.

[a]A rem is a term scientists use to describe how much radiation the body absorbs, multiplied by a quality factor for the various types of radiation (e.g., alpha, beta, gamma, or neutron). For example, scientists estimate that the average person receives 360 millirem (0.36 rem) every year from natural (such as radon gas) and manufactured radiation sources (such as exposure to radioactive isotopes used in some medical procedures).

Physical, chemical, and radiological properties matter for the understanding of radiological consequences.

When considering the radiological threat, we do not *and should not* consider every possible scenario.

- Is material available in large enough quantities?
- Can it be dispersed or otherwise used for radiological exposure?
- Do the dose rates preclude working with the material?
- Does the chemistry or chemical form affect dispersability, resuspension, or metabolism (lung class) of the radionuclide?

Unreasonable cleanup standards and protective action guides could result in economic and human impact.

Health physicists have the responsibility to understand the holistic risk from the use of radioactive material and explain it to members of the public.