Responding to anthrax contamination:
Listening to surfaces and talking to people

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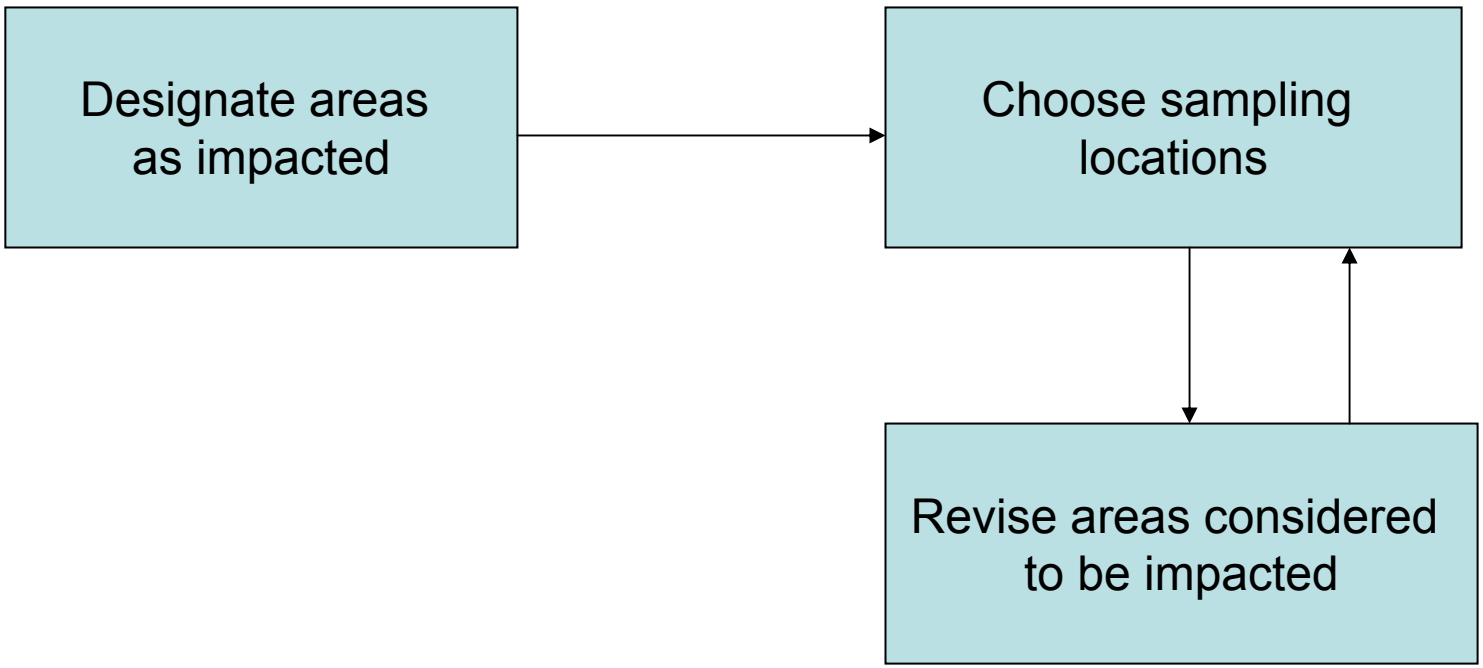
Objectives

- Consider a subset of decisions that responders would face
- Try to identify both technical and public perception elements of decision making
- Example calculations to structure problem

Areas addressed here

- Buildings: even an outdoor release may penetrate into the indoor environment
  - Indoor environment will offer protection from UV, most persistent problem (Wein et al. 2005)

The Decisions



Decision #1: What's hot?

- This decision is driven by specifics of the event
- Likely not informed by detailed modeling or sampling

Decision #2

- Where do I sample?
- What do I want to learn?
- Option A: identify release amount, location, and release time, model dispersion
- Option B: sample like crazy, classify areas as hot or not based on results, repeat
- Option A sounds better but
  - Are we really that good?
  - Will we have all the inputs we need?

Option B

- How would we assess the overall risk at a location or person based on sampling?
- Surface deposition will record time integrated air concentration -> dose->risk

- Of course we really want to do both A and B

What are the right surfaces to sample?

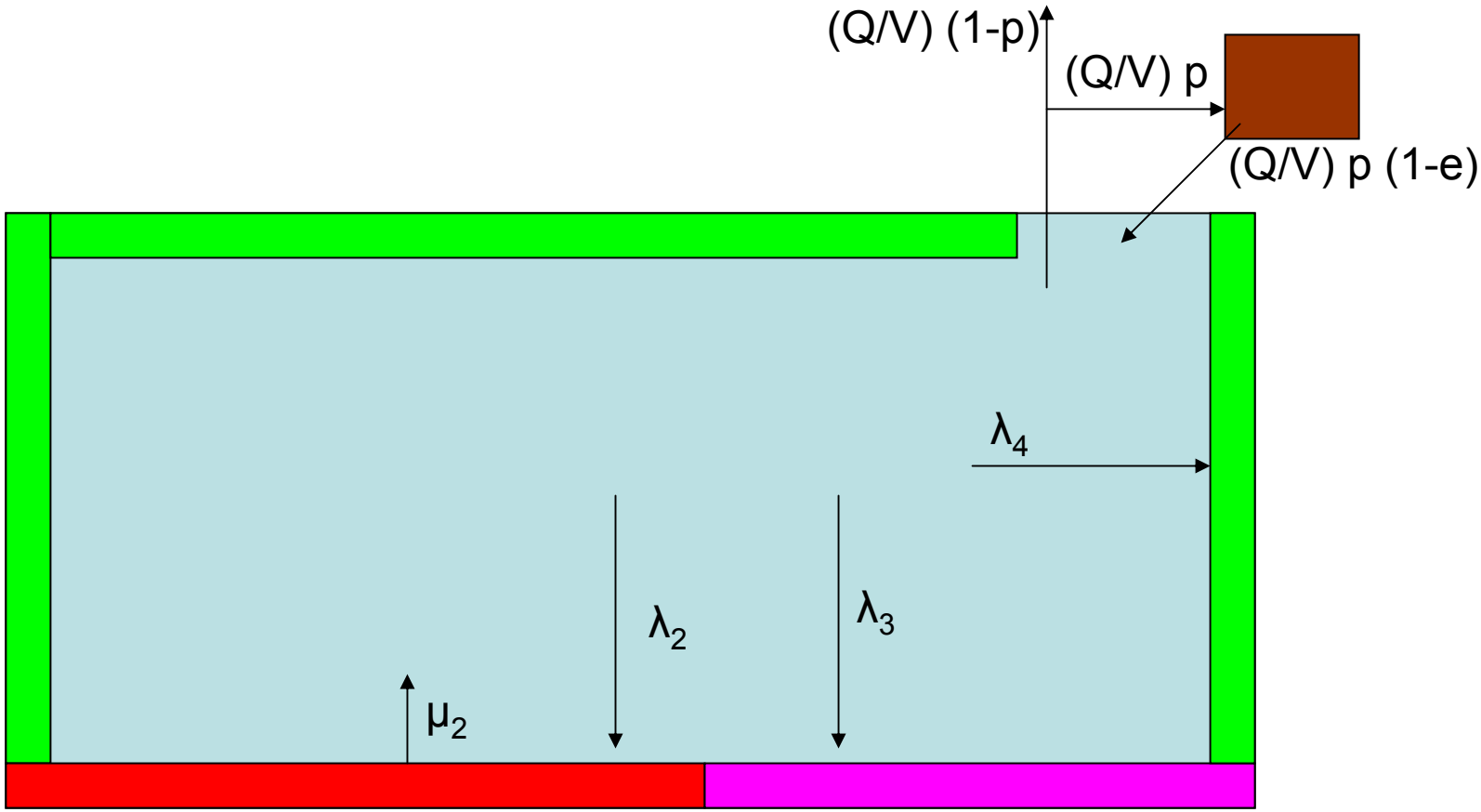
- Concentration of anthrax
  - An important factor but not the only factor
- Want an accurate record
  - Standardized material so that recovery can be determined in laboratory experiments
  - Component of manufactured system?

- First let's think about how we would make the correspondence between what we measure after the fact and risk

Modeling Objective

- Simulate a release of anthrax in a well-mixed compartment
  - can be indoor or outdoor source
- Identify where different size fractions end up
- Map risk due to air exposure with amount of anthrax on surfaces

Schematic of Model



Following Sextro et al. 2002 for both structure and parameters

Modeling Approach

Can express as a system of coupled ordinary differential equations

$$\begin{pmatrix} \dot{M}_1 \\ \dot{M}_2 \\ \dot{M}_3 \\ \dot{M}_4 \\ \dot{M}_5 \end{pmatrix} = \begin{pmatrix} [(1-e)p-1]\frac{Q}{V} - (\lambda_2+\lambda_3+\lambda_4) & \mu_2 & 0 & 0 & 0 \\ \lambda_2 & -\mu_2 & 0 & 0 & 0 \\ \lambda_3 & 0 & 0 & 0 & 0 \\ \lambda_4 & 0 & 0 & 0 & 0 \\ ep\frac{Q}{V} & 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} M_1 \\ M_2 \\ M_3 \\ M_4 \\ M_5 \end{pmatrix}$$

Can be extended to arbitrary number of compartments

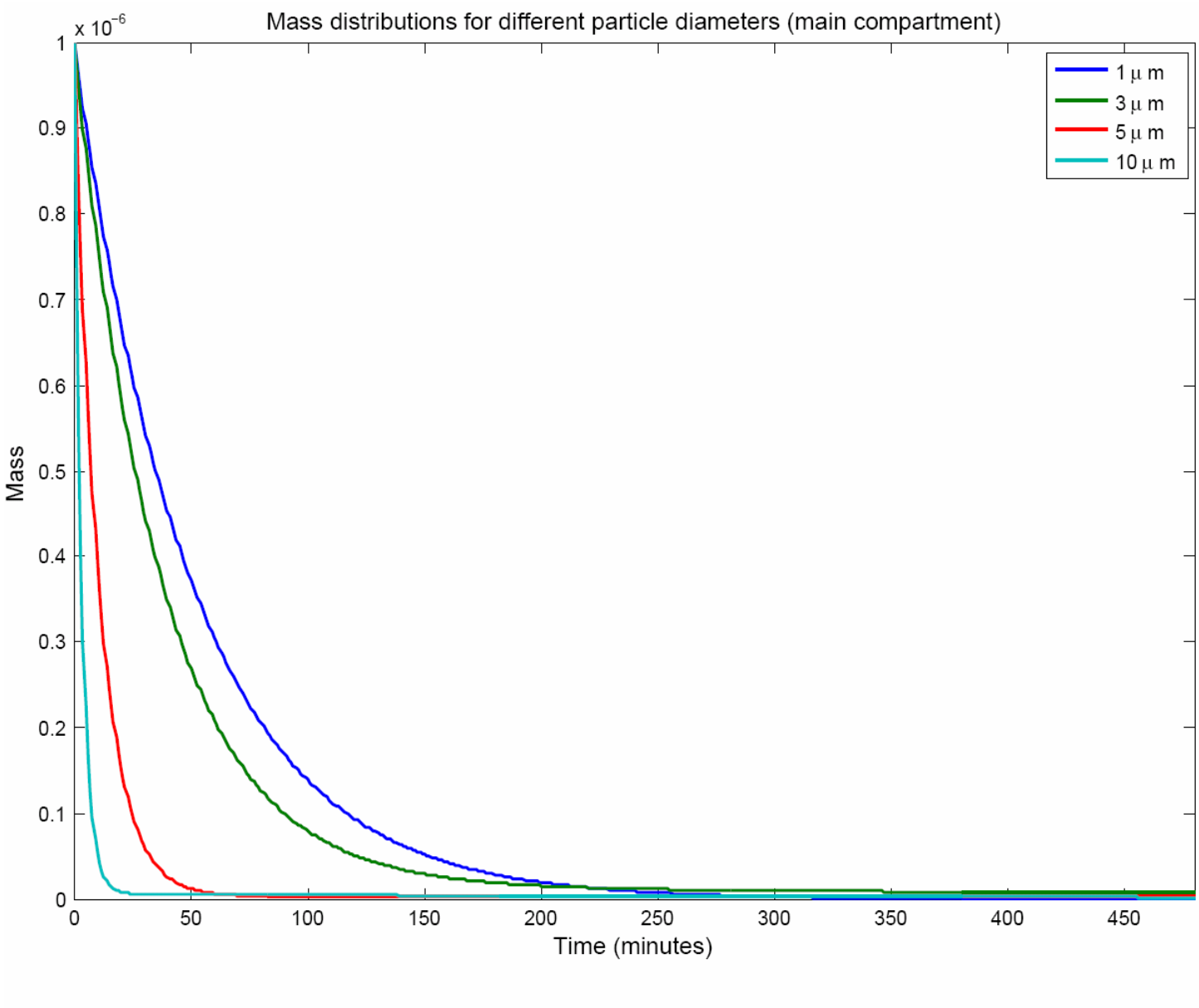
Analytical solutions available

Parameters

	1 μM	3 μM	5 μM	10 μM
Resusp	1.2×10^{-4}	1.9×10^{-3}	0.8×10^{-3}	0.4×10^{-2}
Dep (floor)	0.1	0.6	2.0	8.1
Dep (walls & ceiling)	0.1	0.4	0.8	0.9
Filter Efficiency	0.098	0.49	0.74	0.88

From Sextro et al. 2002

Time scale ~ hours

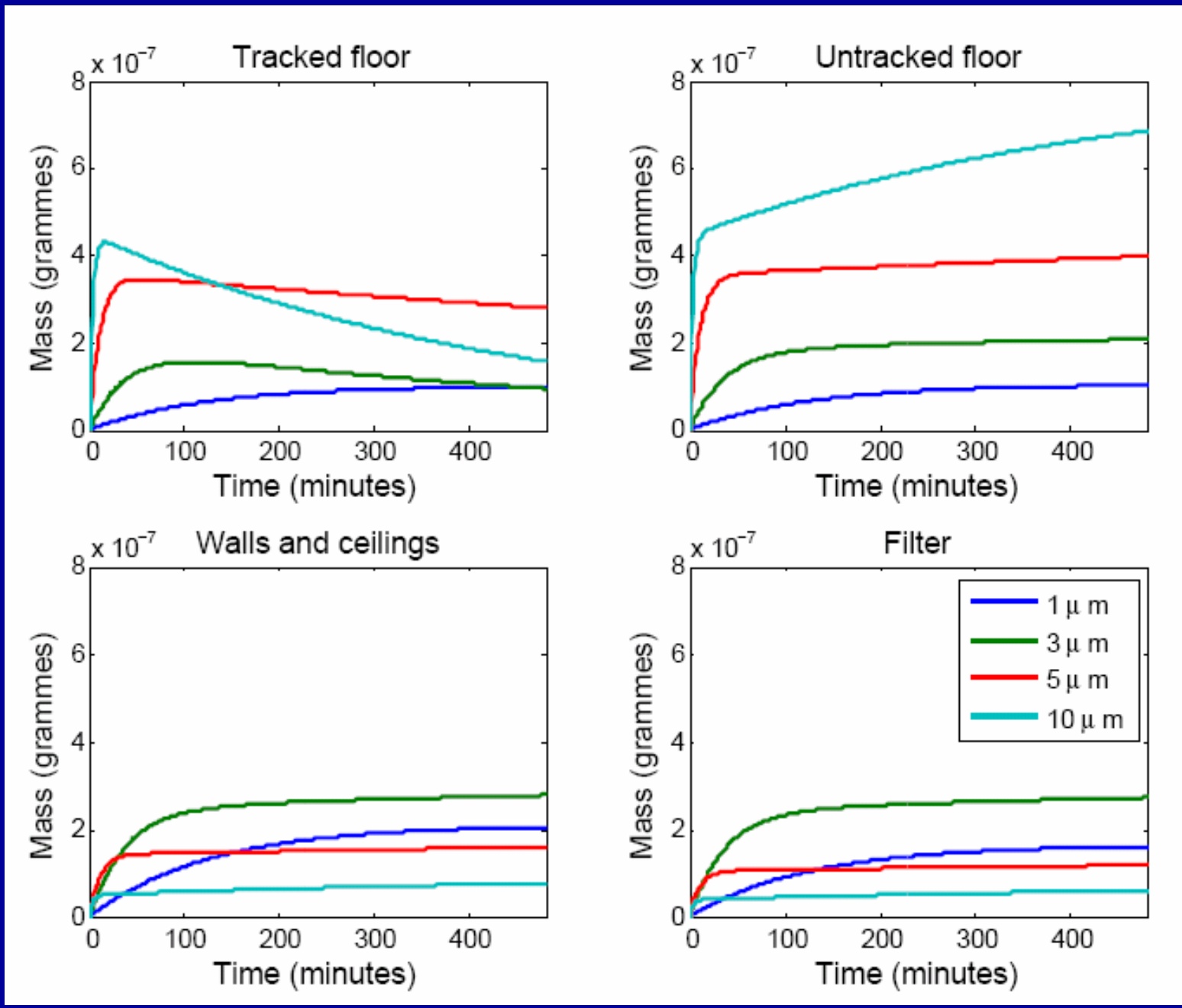


Time scale

- If we choose 8 hours as a time period then the initial release has dissipated: “pseudo-equilibrium”
- Ongoing low level air concentrations due to re-suspension

Surface deposition

- Consider each surface
- How much of each size fraction of anthrax is on the surface?
- How good is the “pseudo-equilibrium” assumption?
  - Need this to hold for our surface concentrations to be indicative of dose


Tracked floor
Untracked floor
Walls and ceilings
Filter
x 10^-7
Mass (grammes)
Time (minutes)
0
2
4
6
8
0
100
200
300
400
1 μ m
3 μ m
5 μ m
10 μ m

Potential to link surface concentrations with risk

- Correlating surface concentrations with risk seems most promising for smaller size fractions
  - 10 μM fraction is more subject to re-suspension
  - Also will deposit in the shortest time so may not be present in the downwind areas of interest here

Where to sample?

- Filters look promising
  - But PCR inhibition is likely to be a problem
- For the smaller size fractions walls may be better than floor
- Horizontal surfaces may be more problematic than vertical
  - Not as clear a “pseudo-equilibrium”

Decision #3

- Revising areas considered “hot”
- Ideally just compare sample results to threshold
  - This is our *decision threshold*, not a biological threshold on infectivity
- Problems:
  - sample size, recovery, detection limit, confidence level
  - two kinds of “hot”: prospective and retrospective

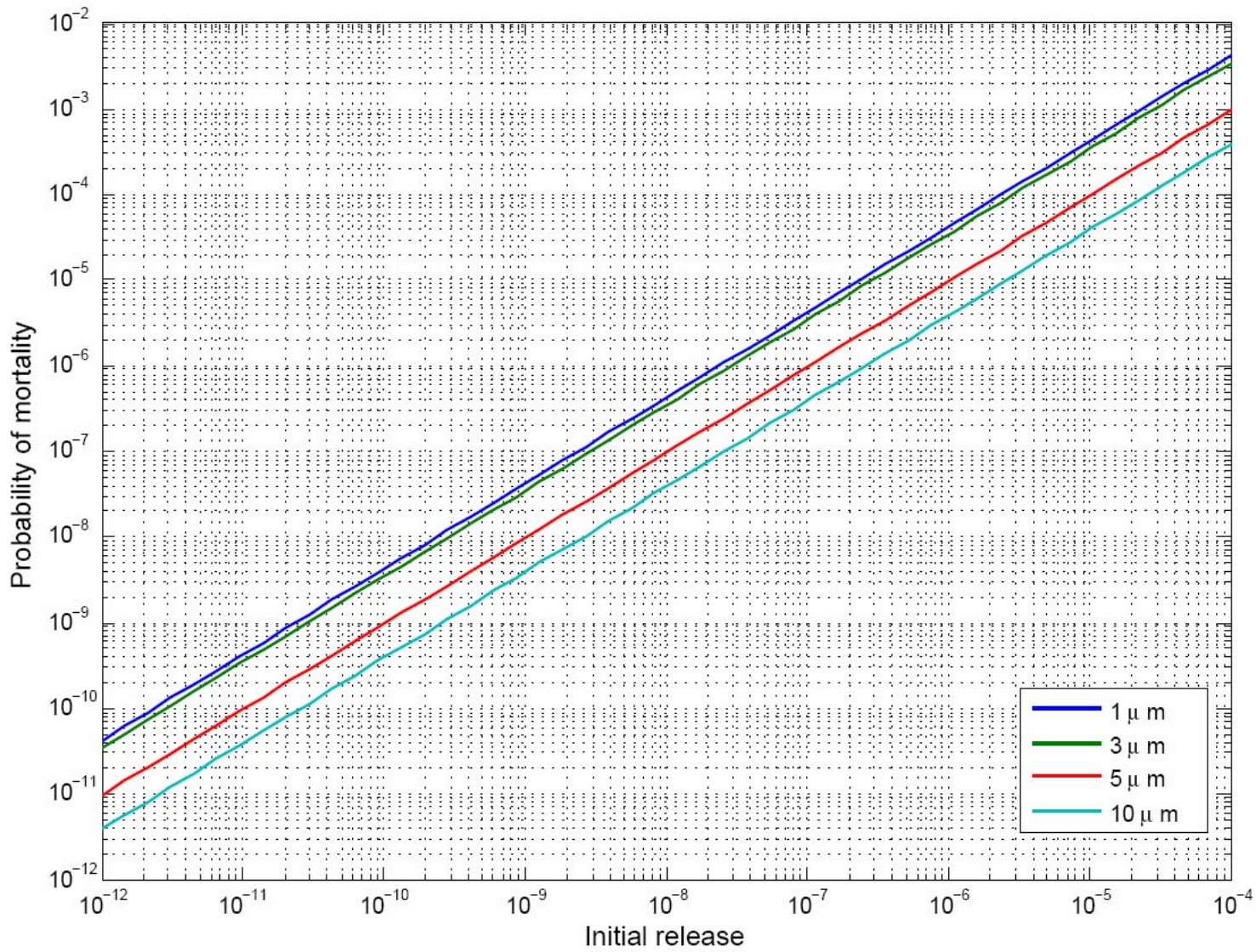
An example calculation for wall concentrations

Diameter, μM	1	3	5	10
1 in a million retrospective risk, *B. anthracis* /m^2	0.03	0.08	0.08*	0.04*

~2-5 bugs/office, *assumes respirable

No HVAC filter, Druett/Glassman k (Haas 2002)

For low doses risk is linear



How about 1 in 1000?

Diameter, μM	1	3	5	10
1 in 1000 retrospective risk, *B. anthracis* /m^2	30	80	80*	40*

2,000-5,000 bugs/office, *assumes respirable

No HVAC filter, Druett/Glassman k (Haas 2002)

Retrospectively hot

- Were people in an area exposed to harmful concentrations of anthrax?
  - Administer antibiotics
  - Possibly vaccinate

Prospectively hot

- Will people in an area be exposed to harmful anthrax concentrations in the future?
  - Remove building from use
  - Disinfect
  - Clear for reoccupation
    - Vaccinated reoccupation?
    - Monitored reoccupation?

Comparing prospective and retrospective thresholds

- Let's assume that deposited fraction will eventually be aerosolized
- In immediate vicinity of release we have mostly large particles
  - Little difference between prospective and retrospective thresholds

For smaller particles

- For areas removed from the initial release, small particles will account for a large portion of risk
  - Prospective threshold will be higher than retrospective threshold because only a small percentage of original airborne mass/risk is recovered when re-aerosolized

Public communication issues

- Particularly downwind it may make sense to treat for retrospective risk but not prospective risk
- Sampling clearly is limited in its ability to detect low risks
- Need to communicate this so that public understands and accepts approach

Additional work

- Compare with re-suspension observed by Weis et al. 2002.
- Critically review parameter values
- Uncertainty/sensitivity analysis
  - Different geometries (surface area to volume ratios
  - Different HVAC parameters Q/V, p, e
  - What are robust indicators of risk?

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