Case Study: Seattle Financial District Post Anthrax Attack

CAMRA QMRA Summer Institute Research Team

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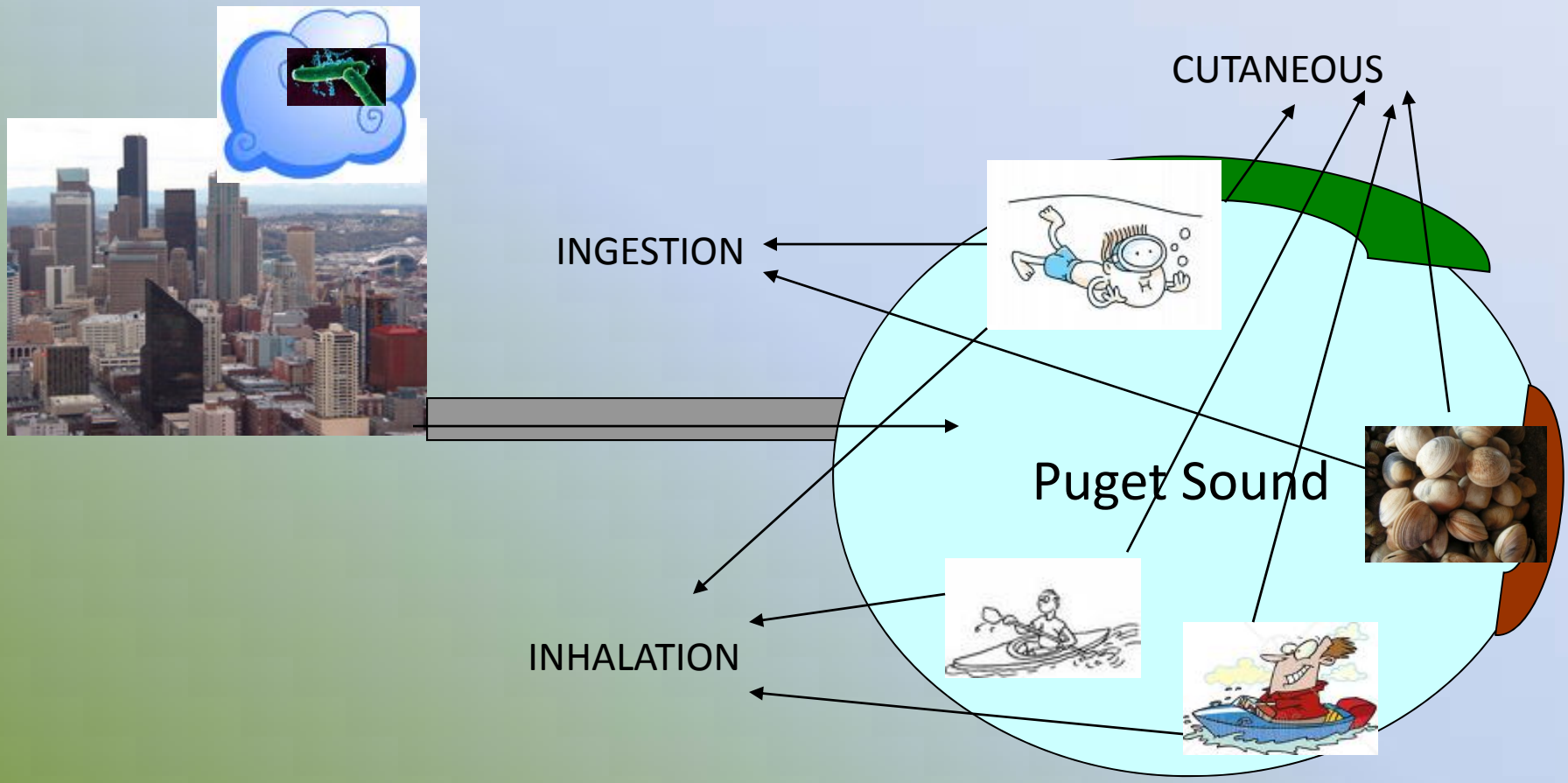
Hypothetical Case

- Situation
  - Financial district, Seattle Washington USA
  - Attack has already commenced
  - Evacuation and building lock down
  - Decontamination
    - Washing external walls and sidewalks
- Task
  - Evaluate risks to users of Puget Sound
  - Risks to consumers of shellfish from Puget Sound

Attack and Decontamination Site

- 16 Buildings
- Surface Area of buildings
- Surface Area of sidewalks

Means of Exposure



Images from: http://www.drawingcoach.com/cartoon-clouds.htm; google maps; http://srs.dl.ac.uk/Annual_Reports/AnRep01_02/anthrax-bacteria.jpg; http://www.testriffic.com/resultfiles/7643stewie_evil.jpg; www.steinbach.ca; http://images.clipartof.com/small/5731-Happy-Man-Driving-A-Motor-Boat-On-A-Lake-Clipart-Illustration.jpg; http://upload.wikimedia.org/wikipedia/commons/0/0b/Shellfish.jpg

Information

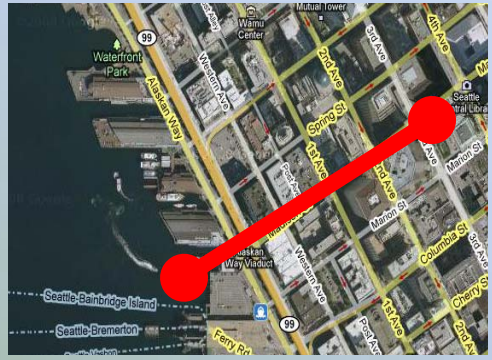
Total number of spores may be uncertain – triangular distribution

Min	$2.68(10^{12})$
Likeliest	$6(10^{15})$
Max	$2.68(10^{17})$

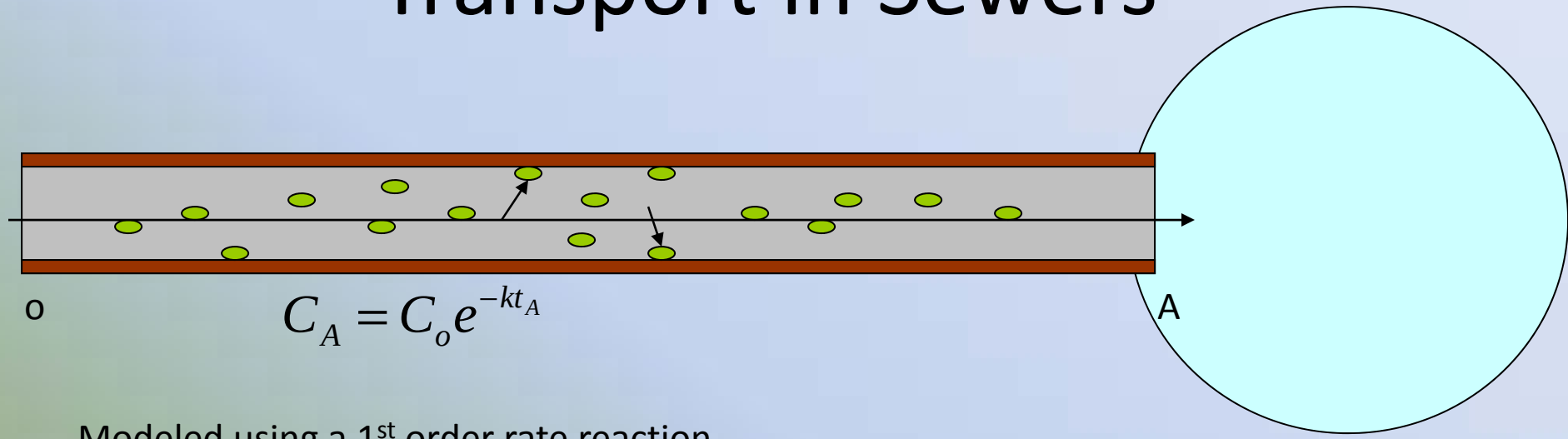
- Amount of Water used for cleanup
- **Surface area (exterior walls + sidewalks):** 468 246 m^2
- **Amount of water needed**: 0.0034m^3/m^2
- **Total amount of washing water**: 1592 m^3

- Dose Response
- Exponential model (Bartrand *et al.*, 2008)
  - Particle size affects relationship
  - Inhalation $1-\exp(-k \cdot dose)$
    - k = $7.15(10^{-6})$
  - Cutaneous and Ingestion
    - Surrogate required – *Clostridium perfringes*
    - k: $1.59(10^{-9}) < 3.63(10^{-9}) < 2.05(10^{-5})$
    - Further work showed need for better surrogate

- Pipe
  - 4 ft diameter Reinforced concrete
  - Length = 1 km = 3281 ft



Transport in Sewers



$$C_A = C_o e^{-kt_A}$$

Modeled using a 1st order rate reaction

where:

C_A = Concentration of spores at point A (at end of pipe) CFU/ m3

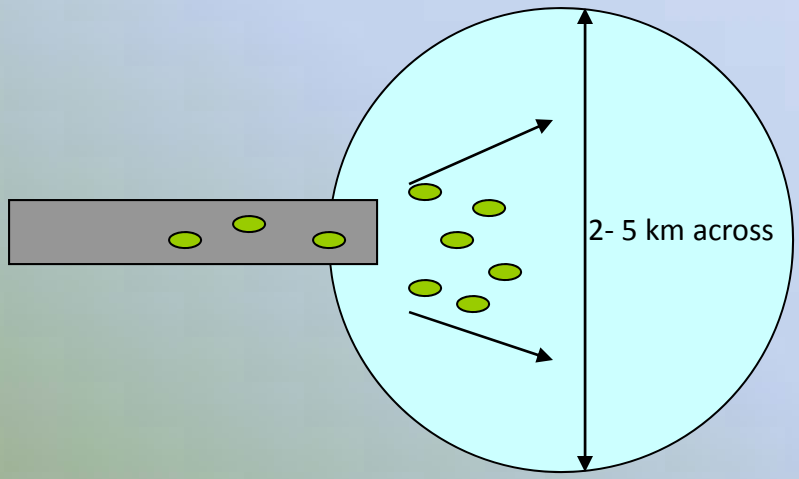
C_o= Initial concentration of spores at point O (wash water leaving Seattle) CFU/ m3

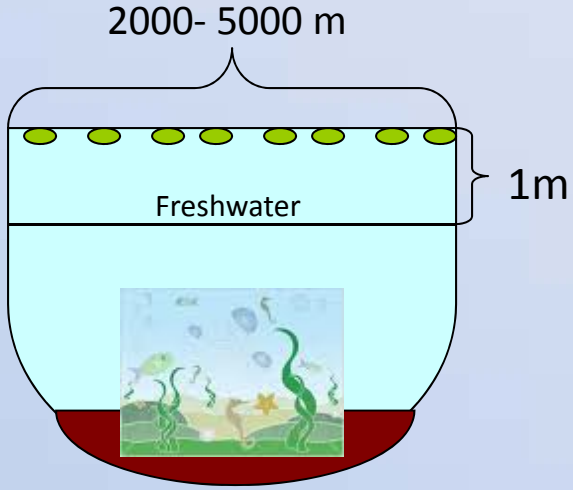
k= rate of attachment of spores to the biofilm in the pipe (k= 9.49*10^-9 /s)

t_A= time it takes for water to reach the end of the pipe (s) (flowrate/ volume of pipe)

- Assuming
  - Ready adherence of spores to biofilms
  - Constant decay rate too long for travel time of sewer

Spores in the Estuary





$$U_f C_o = D\frac{\partial C_o}{\partial x} \xrightarrow{\text{CALCULUS}} C_f = -e^{\frac{U_f(x_f - x_o)}{D}} + C_o$$

where:

U_f= Flowrate/ Cross Sectional Area of Estuary

X_o = initial distance at end of pipe (0m)

C_f= concentration of spores in estuary (CFU/ m^3)

x_f = final distance in estuary (m)

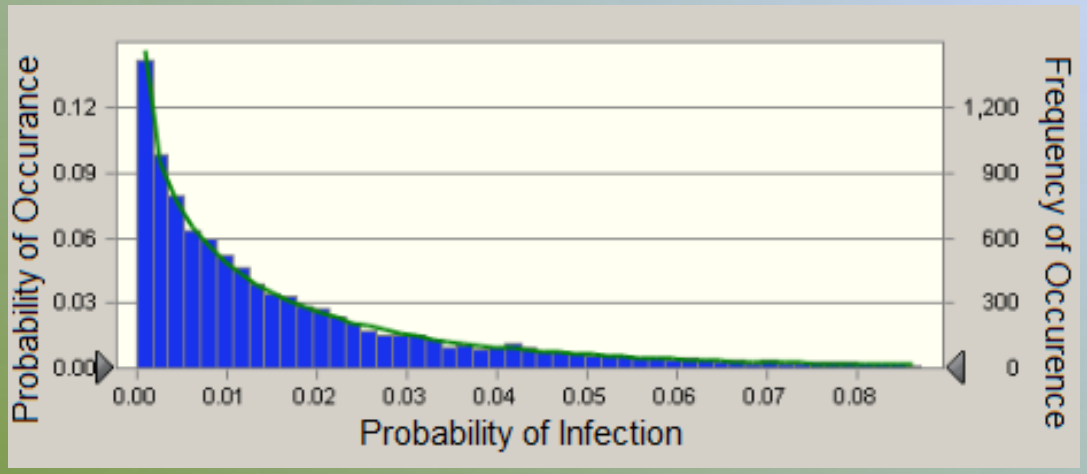
C_o= concentration of spores leaving pipe (CFU/ m^3)

D= longitudinal dispersion coefficient (50-200 m^2/s)

- Assuming
  - Buoyant spores
  - Freshwater for washing, ∴ Longitudinal Dispersion
  - Constant decay rate too long for travel time of sewer

Risk from Inhaling Aerosols

- Aerosols
  - Water-shore interface
  - Uniform density, concentration of aerosols in droplets ≈ $7.0(10^{-7}) – 8.0(10^{-7})$ kg/m^3
  - Using typical inhalation rates
    - Spores inhaled over time ≈ $2.07(10^3)$ cfu/m^3 in air



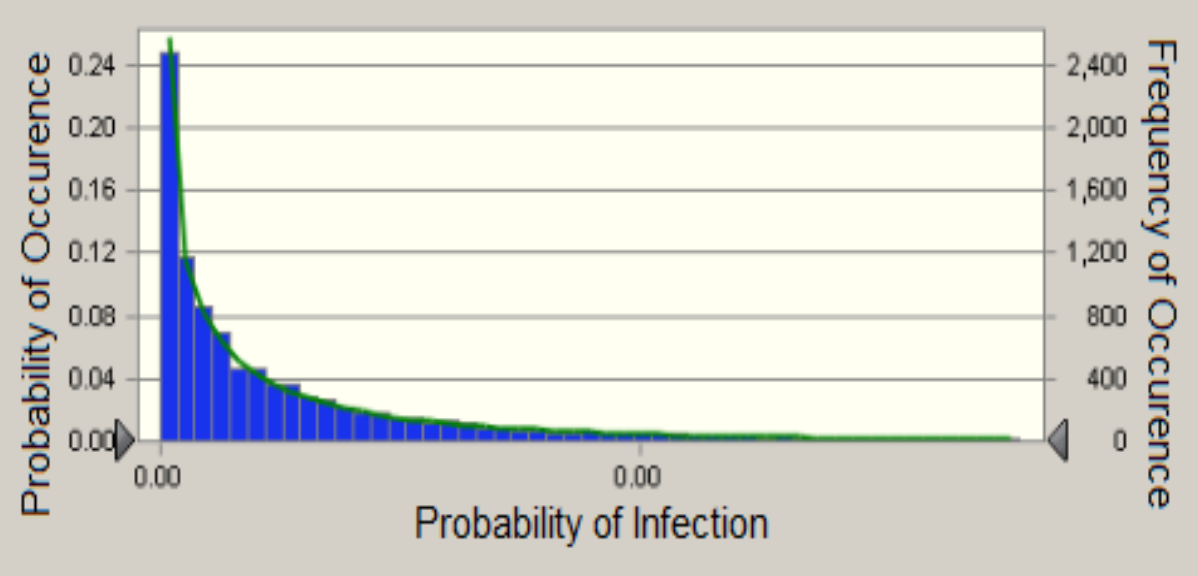
- Tolerable risk = 1 in 1,000,000
- Current risk = 11,000 in 1,000,000

∴ Intervention Required

Intervention

- Decontamination / Reduction of Spores
- Before entrance to Puget Sound
  - Germination Agent
    - Amino acif L-alanine and nucleoside lnosine
  - Chlorine or Chlorine-Dioxide
    - Allows 2 – 4 log reduction
  - GAC to prevent impacting environment

Results of Intervention



- Overall reduction of risk
  - Tolerable risk = $1.00(10^{-6})$
  - Current risk = $3.65(10^{-6})$

$\therefore$ Intervention will require adaptation but vast improvement

Conclusions Determined

- Risk is unacceptable to Puget Sound users
- Risk can be reduced from intervention
- Data and information gaps recognized
  - Especially improved surrogates for ingestion and cutaneous exposure
    - Likeliest routes of exposure and more vulnerable to recreational users and consumers
- More work beyond dry aerosol exposure

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