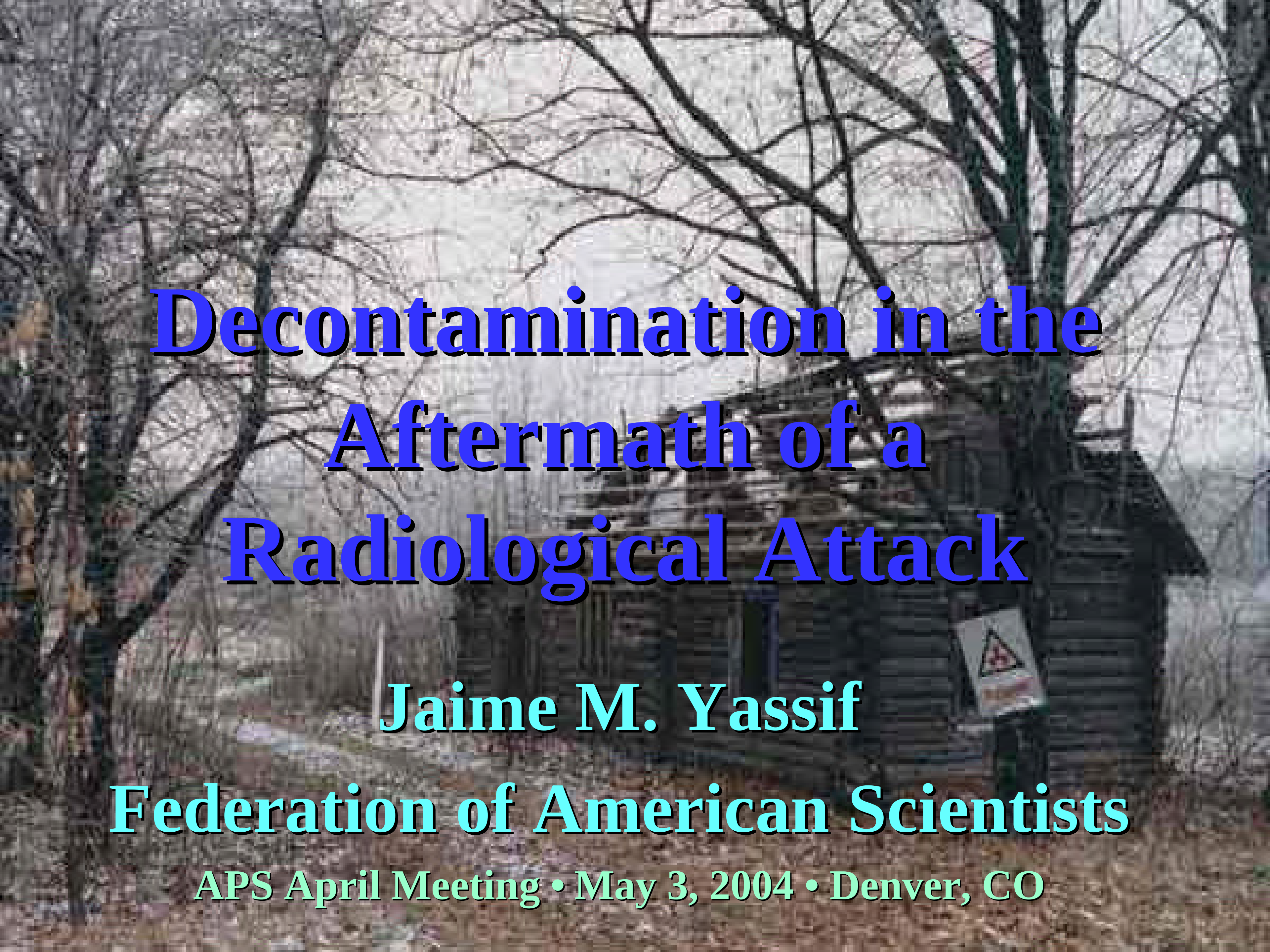

Decontamination in the Aftermath of a Radiological Attack

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Federation of American Scientists

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Why is decontamination planning important?

- **Radiological Attack = Psychological/Economic Attack**

  Public refusal to inhabit contaminated areas → halt in economic activity & steep decline in property values → access denial effect

- **Rapidly Restore Access ® Drive Down Costs ® Minimize Attack Effects**

- **No comprehensive national strategy for radiological decontamination**

Description of Urban Contamination

- **Dust**
  - » Micron scale
- **Non-homogeneous distribution**
  - » Hot-spots, not-spots, moderately contaminated areas
- **Loose vs. Fixed**
  - » Most will be "loose" superficial contamination.
  - » Dust settled on external surfaces of buildings (concrete, granite), streets (asphalt) soil and plants.
  - » Some sucked into building interiors though ventilation systems or pass through open doors and windows
- **Time Effects**
  - » W/time → contamination more "fixed."
  - » Radionuclides absorbed by porous materials (concrete, wood) & by oxide layers on metal surfaces.

Radioisotopes

Isotope	Primary Radiation	Half Life (years)	Chemical Class
^{241}Am	Alpha	432.7	Actinide
^{239}Pu	Alpha	24,390	Actinide
^{252}Cf	Alpha	2.6	Actinide
^{226}Ra	Alpha	1,602	Alkali Earth Metal
^{90}Sr	Beta	27.7	Alkali Earth Metal
^{192}Ir	Beta/Gamma	*73.83 (days)	Transition Metal (Platinum Group)
^{60}Co	Gamma	5.3	Transition Metal (Iron Group)
^{137}Cs	Gamma	30	Alkali Metal

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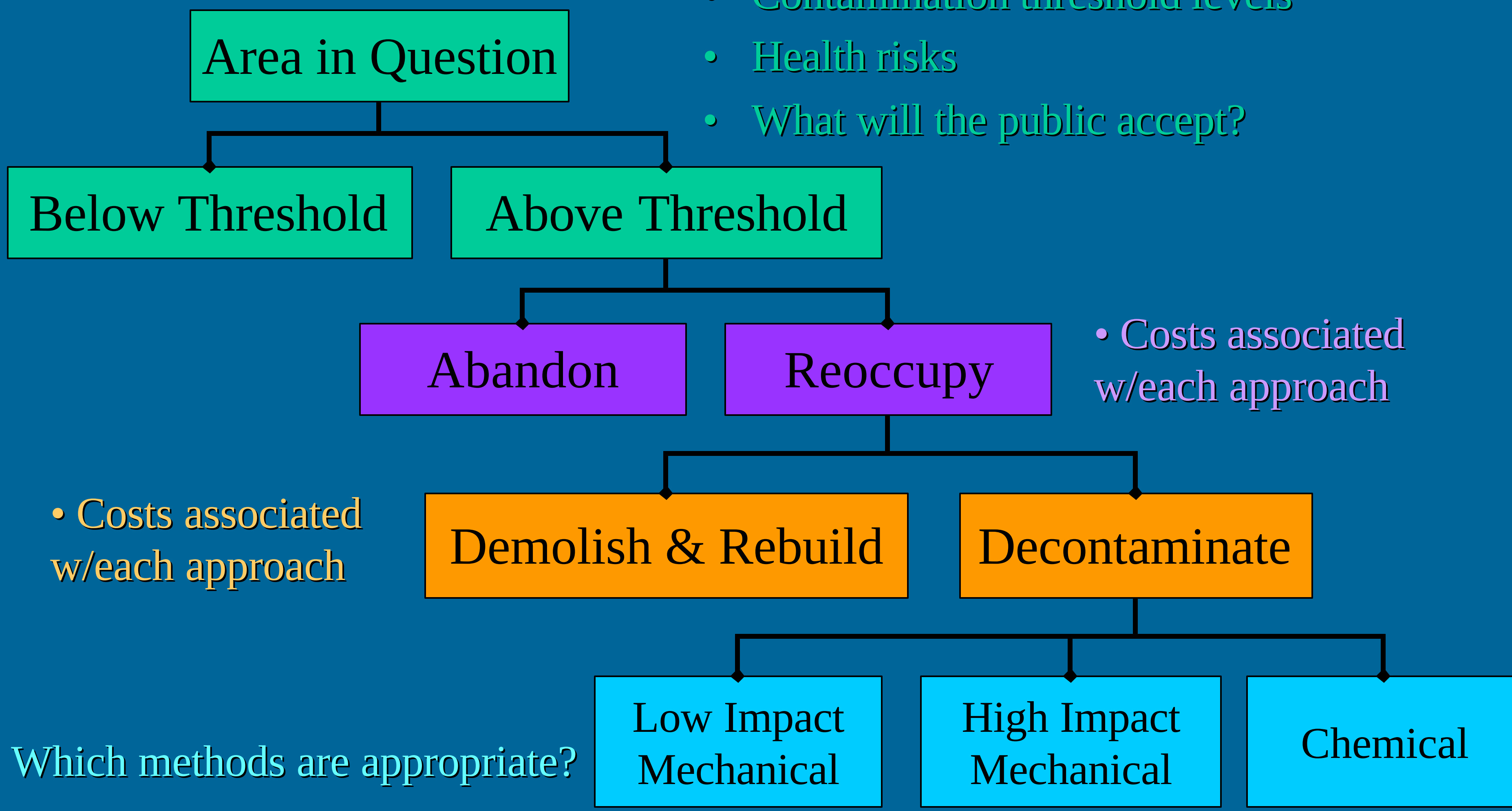
Proposed Post-Attack Decision Process

- Contamination threshold levels
- Health risks
- What will the public accept?



- Costs associated w/each approach

- Costs associated w/each approach

- Which methods are appropriate?

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Q#4 – Decontamination Methods

Decontamination Process

1. **Characterization**
   - Type of contamination (α, β, γ) and Isotope
   - Distribution of contamination
2. **Decontaminate vs. Demolish**
   - Case-by-case basis for each building or area
3. **Radionuclide Removal**
   - External: building exteriors, sidewalks, streets, parks, sewage systems
   - Building interiors: walls and floors, carpeting, ventilation ducts
   - Transport systems and water supplies
4. **Post Cleanup Survey**
   - Safe Levels?

Detection

- Both before and after decontamination
- Leverage existing technologies from nuclear nonproliferation and border security

  Gamma – easy to detect

  Beta – detectable

  Alpha – difficult to detect

  - Large particle → easily shielded
  - Particle does not travel long distances
  - Need to scan in close proximity to source, slowly & repeatedly

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Decontamination Technologies

- The national labs and private industry have developed a wide variety of decontamination technologies:

Vibratory processing	Solution-grit blasting	Light ablation	Power brushing
Sponge-jet blasting	Strippable coatings	CO_2 blasting	
Cryogenic blasting	Scabbling	Spalling	
Concrete-eating bacteria	HEPA vacuuming	Manual wiping	
Electro-kinetic concrete cleaning	Dry-blasting	Foams	Gels
Pressure washing	Oxidizers	Reductants	Chelants
Acids			

- Suitable for urban environment?

- Technologies applicable to urban decontamination need to be identified and adapted.

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Desired Characteristics for Methods Applied to Urban Decontamination

- **Effectively decontaminates urban materials**
  - concrete, granite, asphalt, metal, wood, glass, soil, vegetation, water
- **Applicable to large-scale operations**
  - Large surface area covered per unit time
  - Can be used in-situ
  - Simple methods that do not require highly specialized skills
- **Minimizes secondary waste**
  - e.g. water in pressure washing , chemicals
- **Cost effective**

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Methods : Low Impact Mechanical

Manual wiping w/moist cloth

Pressure Washing/Power Brushing

W/water collection, treatment and recycling

Collect water w/coupled vacuum system

or by tenting work area

HEPA Steam vacuuming

Superheated pressurized water

Flashes to steam upon impact

Water collected by vacuum, separated and filtered

Stripcoating

Coating sprayed onto surfaces

Mechanically locks radionuclides into polymer matrix

Removes contamination from substrate when peeled off

Methods: Low Impact Mechanical (Cont'd)

Appropriate for most contaminated areas:

- Removes loose contamination
- Large surface area / unit time
- Low cost
- Low-tech
- Waste easily processed

Methods: High Impact Mechanical

Abrasive Blasting

- Dry Blasting – e.g. sand-blasting
- Solution-Grit Blasting

Surface removal for asphalt/concrete

® Top 1mm removed majority of ^{137}Cs from asphalt

- Scabbling – pummeling resulting in chipping
- Spalling – drilling & slicing into surface

Tearing out sidewalks & streets

Removal of topsoil & vegetation

® Top 5-7 cm removed >90% ^{137}Cs from soil

May be necessary in a small subset of areas where contamination is fixed:

- Removes fixed contamination
- Small area/unit time
- High cost
- High-tech
- Waste burial costly

Methods: Chemical

- **Chemically disrupt metal oxide layer**
  ® release physically trapped radionuclides

  Oxidizers - Alkaline permanganates

  Reductants - Oxalic acid and citric acid

- **Remove from porous surfaces - concrete, granite**

  Chelants - Large organic molecules – EDTA

  + Foam – Improves surface contact

May be necessary in a small subset of areas where contamination is fixed:

- Removes contamination from metal oxides & porous materials
- Small surface area / unit time
- High cost, high-tech
- Waste difficult to process

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Decontamination Methods Summary

- Low-impact mechanical – most areas
- Chemical & High-impact mechanical – few small areas
- Time passes → contamination becomes fixed → rigorous methods
- Low decontamination thresholds → High DF → rigorous methods

Method	**Low-Impact Mechanical**	**High-Impact Mechanical**	**Chemical**
Contamination Type	Loose	Fixed	Fixed
Rate	Fast	Slow	Slow
Effectiveness	Low DF	High DF	High DF
Cost	Low Cost	High Cost	High Cost
Waste	2° - Liquid Water or solid polymer * Easily Treated	1° - Solids (concrete, asphalt) * Buried	2° - Liquid chemical waste *Difficult to process

Related Concerns

Worker Safety

- Protective suits & respiration gear
- High costs associated with personnel hours and hazard pay

Rain

Would <u>not</u> obviate the need to decontaminate

- Would not remove fixed contamination
- Large quantities of contaminated water could flow out to nearby lakes and rivers

Additional Research Required

- Appropriate for large-scale urban operations?
  - Test existing technologies: rate, cost & DF on urban materials
  - Same experimental conditions – RDD conditions
- Decontamination Models
  - Determine which methods for which tasks
- Improved alpha detection systems
  - Improve sampling
- Adapt existing technologies
  - e.g. Pressure washing system w/coupled water collection, microbial scabbling

Proposed Post-Attack Decision Process

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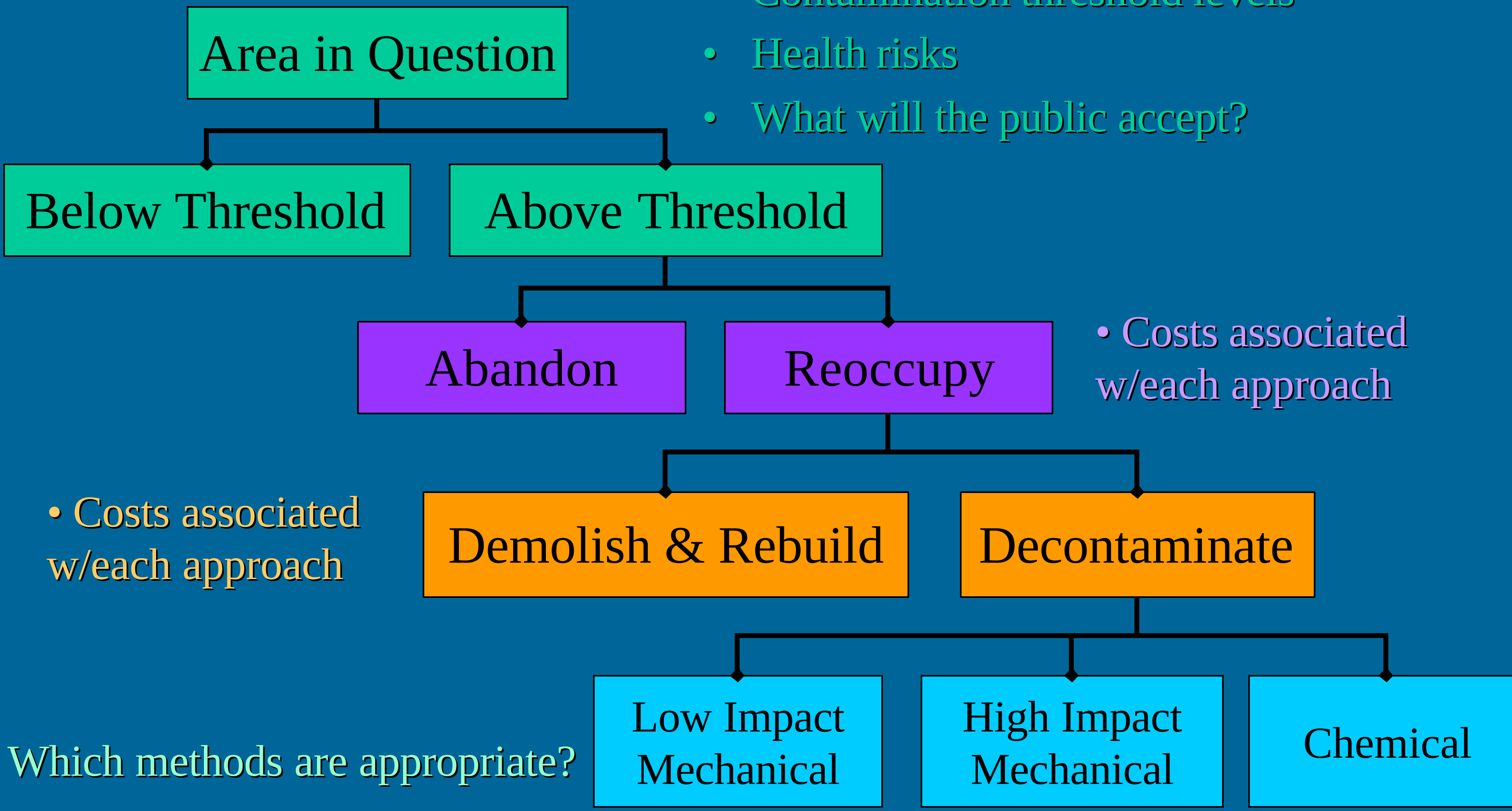

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Q#3 Demolish vs. Decontaminate

What are the costs associated with each option?

Option A: Demolish and Rebuild

Costs (C_{DR}): Demolition, solid waste disposition, rebuilding, social value

12 story office building (30,000 ft^2) ~ $50M

Option B: Decontaminate

Costs (C_{DE}): Labor, protective gear, equipment, materials, liquid waste processing, solid waste disposition

12 story office building (30,000 ft^2) ~ $5M

Modeling the decision process:

If $C_{DR} > C_{DE}$ decontaminate

If $C_{DR} < C_{DE}$ demolish and rebuild

Q#2 Abandon vs. Reoccupy

What are the costs associated with each option?

Option A: Abandon

Costs (C_{AB}): property value, lost economic activity, social value

Property value of Boston = ~$83B

Annual economic activity = ~$70B

Option B: Reoccupy

Costs (C_{RE}): decontamination costs

costs of demolishing and rebuilding

Modeling the decision process:

If $C_{AB} > C_{RE}$ Reoccupy

If $C_{AB} < C_{RE}$ Abandon

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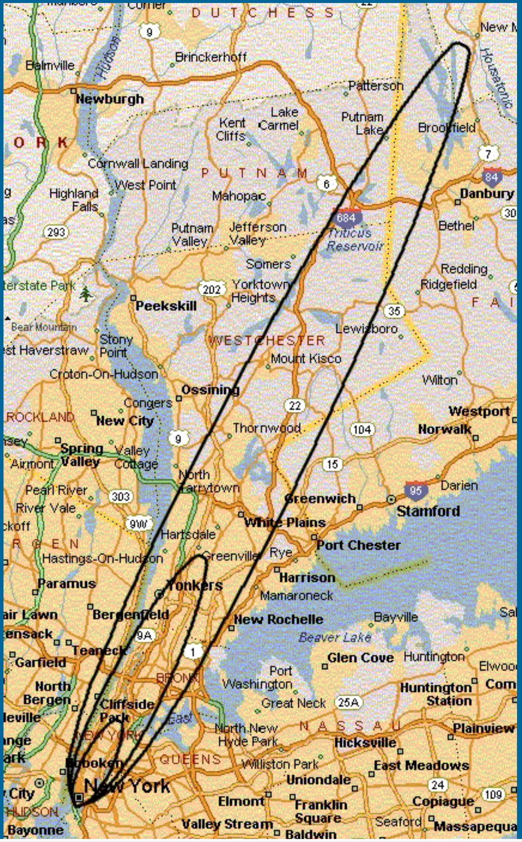
Q#1 What areas to address

- What are the health risks associated with contamination?

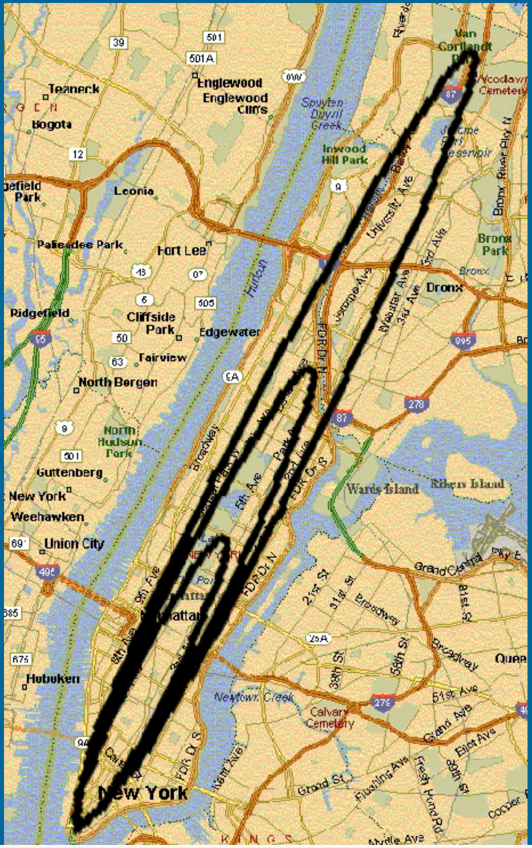
- What are the existing contamination threshold levels?
  - EPA thresholds were designed to keep corporate polluters accountable
  - Need to develop separate set of thresholds for security purposes.

Q#1 What areas to address (cont'd)

Comparison of EPA and Chernobyl standards



Inner Ring: One cancer death per 100 people due to remaining radiation
Middle Ring: One cancer death per 1,000 people due to remaining radiation
Outer Ring: One cancer death per 10,000 people due to remaining radiation
EPA recommends decontamination or destruction



Inner Ring: Same radiation level as *permanently closed* zone around Chernobyl
Middle Ring: Same radiation level as *permanently controlled* zone around Chernobyl
Outer Ring: Same radiation level as *periodically controlled* zone around Chernobyl

Q#1 What areas to address (cont’d)

Entry point into zone of exclusion in Chernobyl

What will the public accept?

Technical

What has been done?

- Detection and decontamination technologies (national labs and private industry)
- RDD decon. technology development (DHS)
- Studies in Chernobyl
- Field Manual 3-5 (military manual on NBC decon.)

What needs to be done?

- Test and modify technologies for urban RDD scenario
- Create urban decontamination & cost/benefit models
- Create urban database so variables can be plugged rapidly into flexible models

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Policy

What has been done?

- Federal Radiological Emergency Response Plan
- TOPOFF emergency response simulation
- DHS interagency working group

What needs to be done?

Develop comprehensive national strategy:

- Identifies exposure limits
- Prioritizes decontamination tasks
- Assigns authority & responsibility

The Bottom Line

- We need to develop a comprehensive national decontamination strategy now so it can be implemented as rapidly as possible in the event of an attack.

- Planning will require technical research.
- Planning will need to address policy questions.