Nuclear Detonation Response Training

Comparison of Response Strategies for Rad/Nuc Incidents

July 2025

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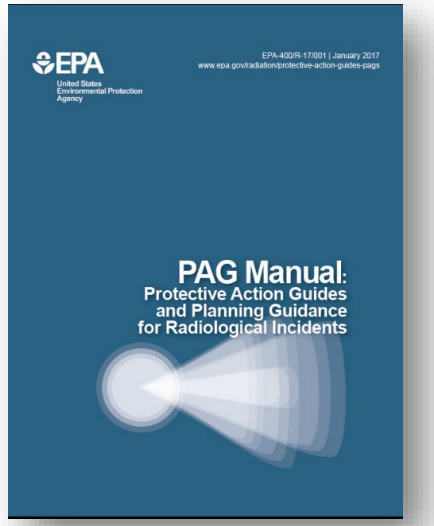
Global Security

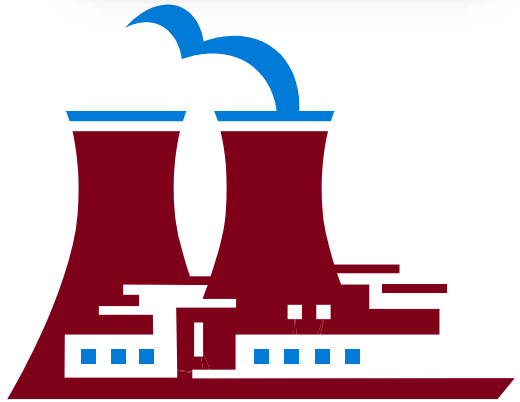
Prepared by LLNL under Contract DE-AC52-07NA27344.

Public Protective Action Guidance (PAG) Developed Primarily Based on NPP Response

- Based on the Concept of Actions taken to AVOID a potential future exposure
- The Technical Basis of Protective Action Guides are:

1. Prevent acute effects.
2. Balance protection with other important factors and ensure that actions result in more benefit than harm.
3. Reduce risk of chronic effects.

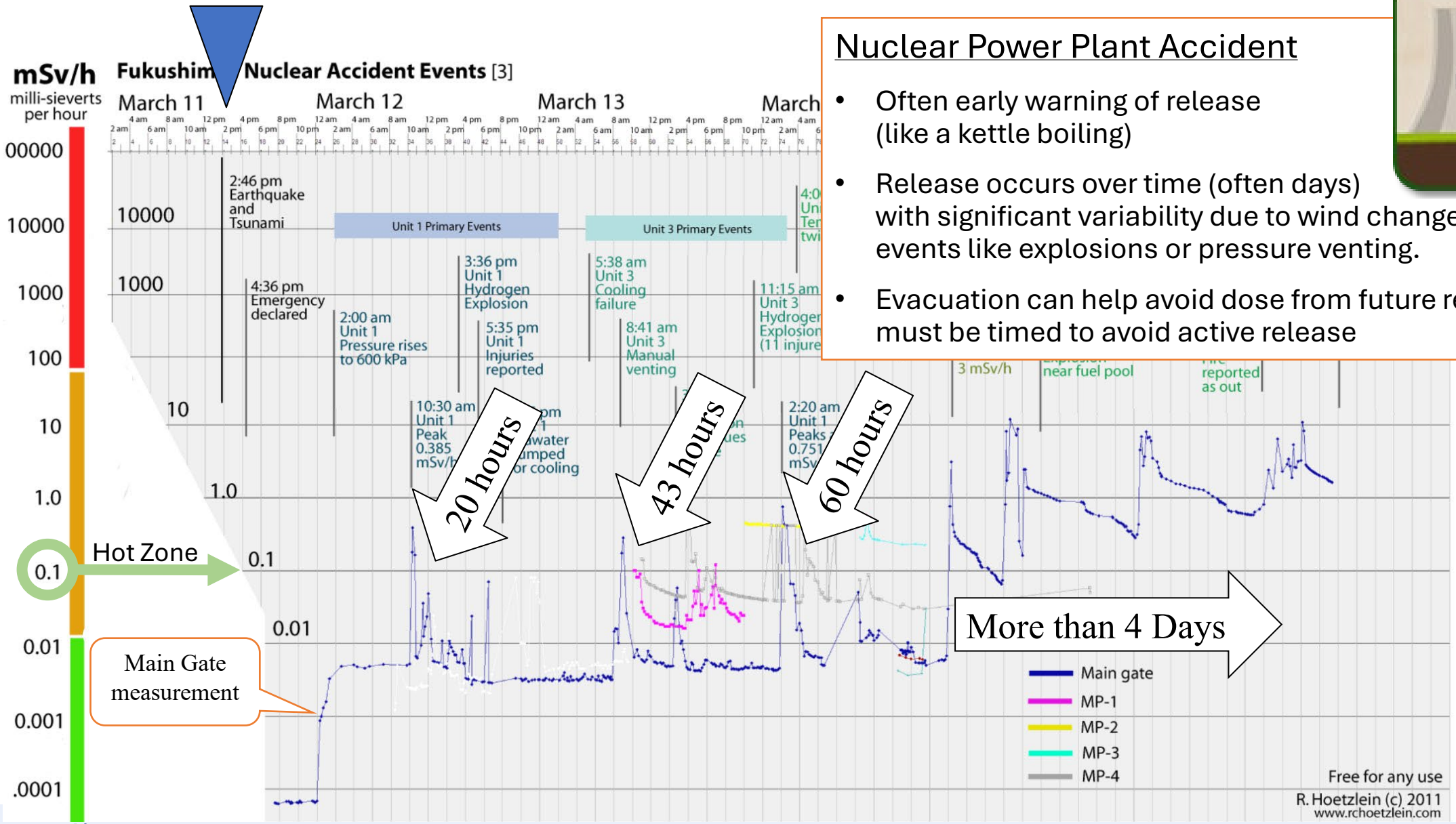




Nuclear Power Plant Accident Planning

Nuclear Power Plant Accident

- Often early warning of release (like a kettle boiling)
- Release occurs over time (often days) with significant variability due to wind changes and events like explosions or pressure venting.
- Evacuation can help avoid dose from future releases, but must be timed to avoid active release



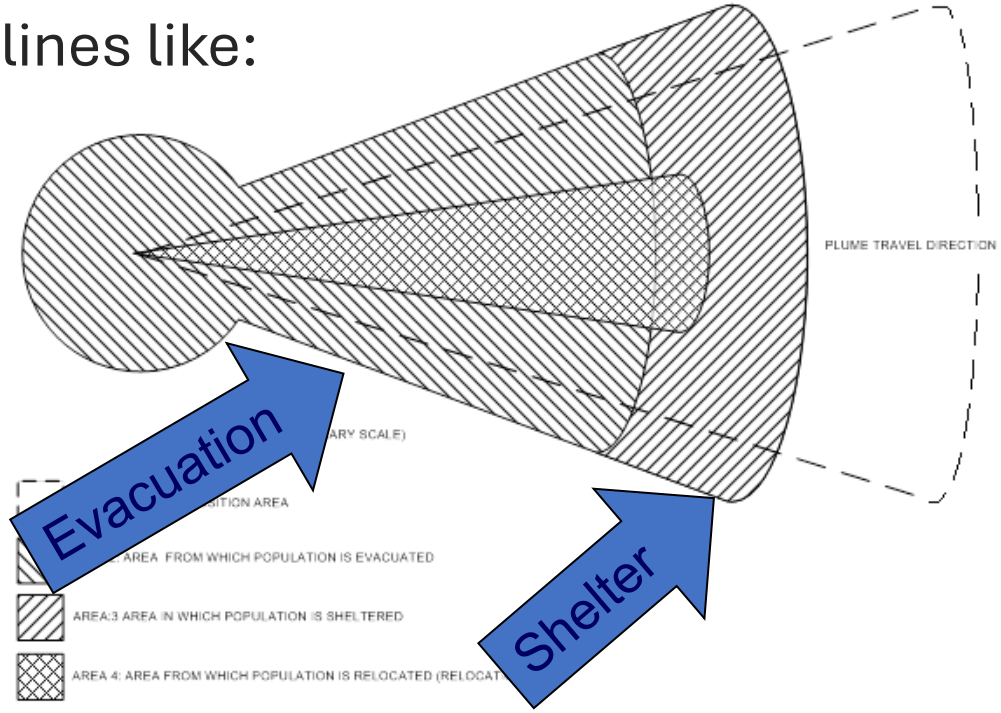
Evacuation Risks

- Evacuation, especially immediate, no notice evacuation, carries significant risks to public safety.
  - Traffic accidents
  - Inclement weather and exposure
  - Displaced population living conditions and mental health
- Vulnerable populations, such as elderly and hospital patients, are especially at risk
- These risks often far outweigh any radiation risk from low dose exposures.

Source: NBC News; Reported by Alexander Smith, NBC news contributor, 9/10/2013

Both shelter and evacuation are possible public protective actions

- Shelter is often preferred at low (potential) exposures because of the risks of evacuation. This has led general guidelines like:
  - shelter to avoid > 1 rem, &
  - evacuate to avoid > 5 rem.



- This has led to the **MISTAKEN** impression that dose mandates which action should be taken.

- Rather it is whichever action (or combination of actions) results in the lowest exposure for the majority of the population and considers non-radiological risks.

Characteristics of Different Radiological / Nuclear Events

Dirty Bomb Event

- May be No Notice
- All material released early
- 10 mSv (1 rem) area might be “a few blocks”
- Hazard comes from both breathing contaminants and direct radiation shine

Nuclear Power Plant Incident

- Often early warning of release (like a kettle boiling)
- Release occurs over time (like a smoke stack, often in “puffs”)
- Evacuation effective at reducing future exposures to releases, but must be timed to avoid “puff” release

Nuclear Detonation

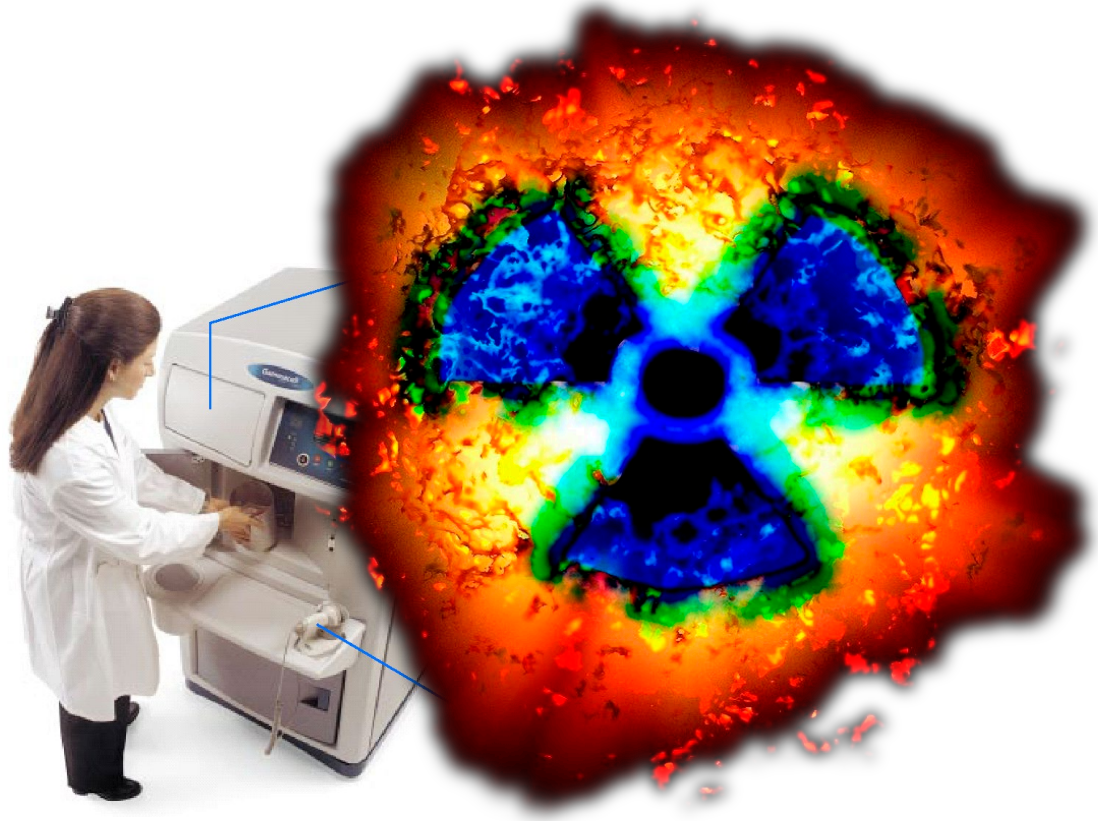
- May be No Notice
- All material released at once
- 10 mSv (1 rem) area can be 100 miles (10kT)
- Hazard is “direct shine” from fallout
- Highest hazard early (more than half the energy released in the 1st hour)

Transportation or Orphan Source

- Generally no notice or discovered after the exposure occurs
- Scene control (immediate area) often sufficient for public safety
- Generally localized, though a few cases of more widespread effected when source is breached.

Example RDD

- Dirty Bomb Configuration
  - 5,000Ci Cs-137
  - 5Lb Explosive (~ 10 sticks of dynamite)
  - Weather from noon on February 14, 2009
- DC urban area provided for scale

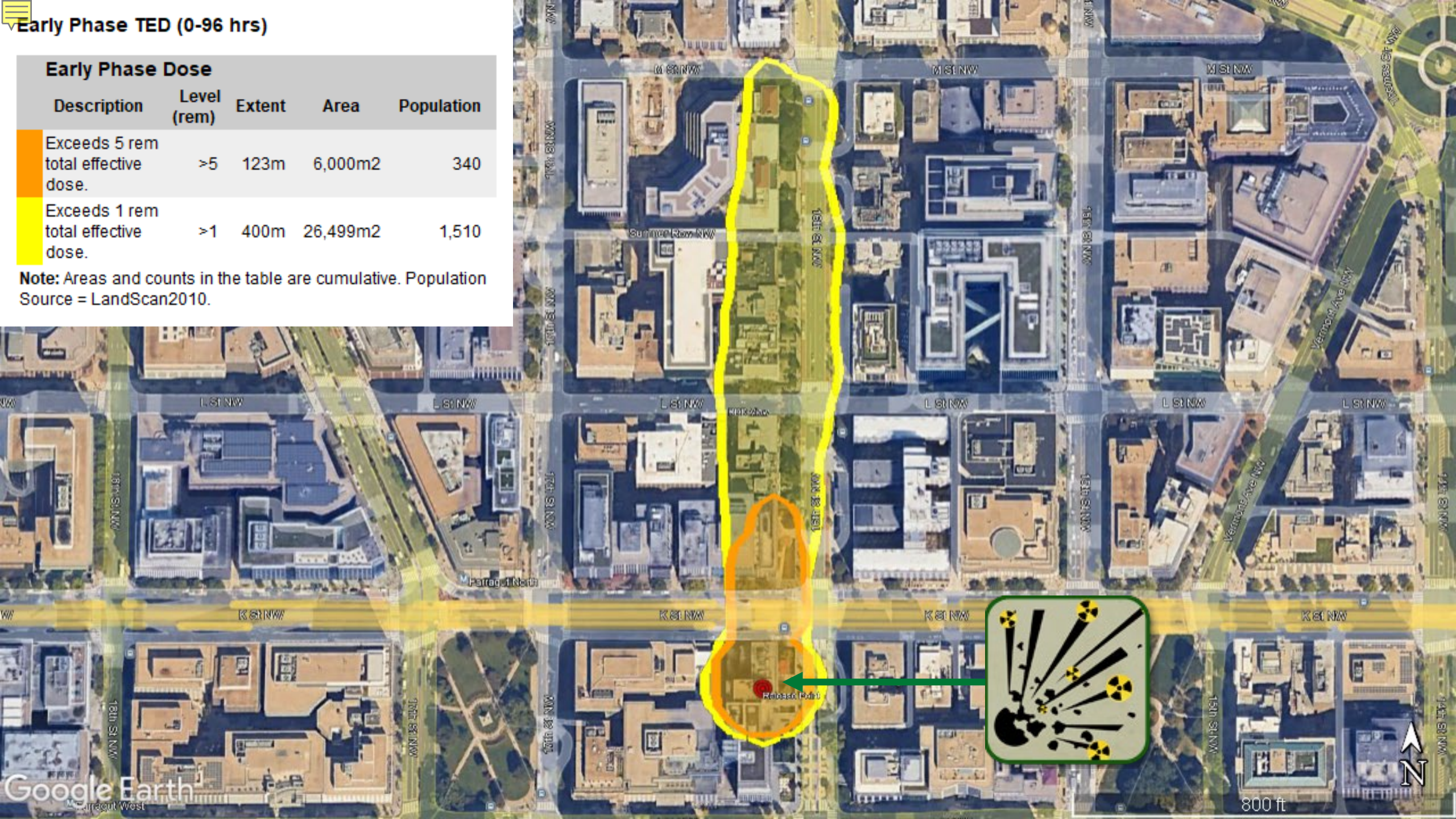


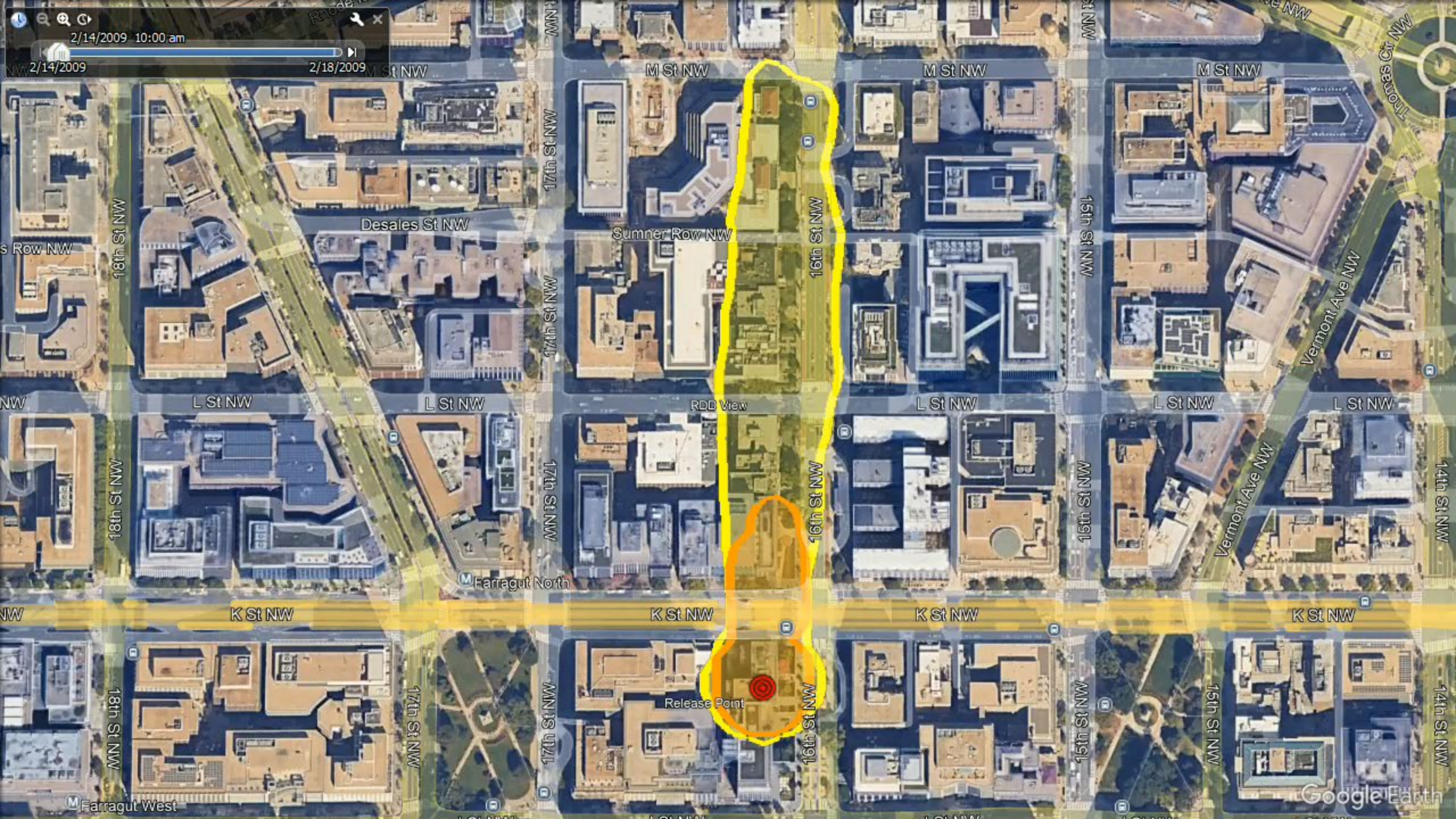
Early Phase TED (0-96 hrs)

Early Phase Dose

Description	Level (rem)	Extent	Area	Population
Exceeds 5 rem total effective dose.	>5	123m	6,000m2	340
Exceeds 1 rem total effective dose.	>1	400m	26,499m2	1,510

Note: Areas and counts in the table are cumulative. Population Source = LandScan2010.



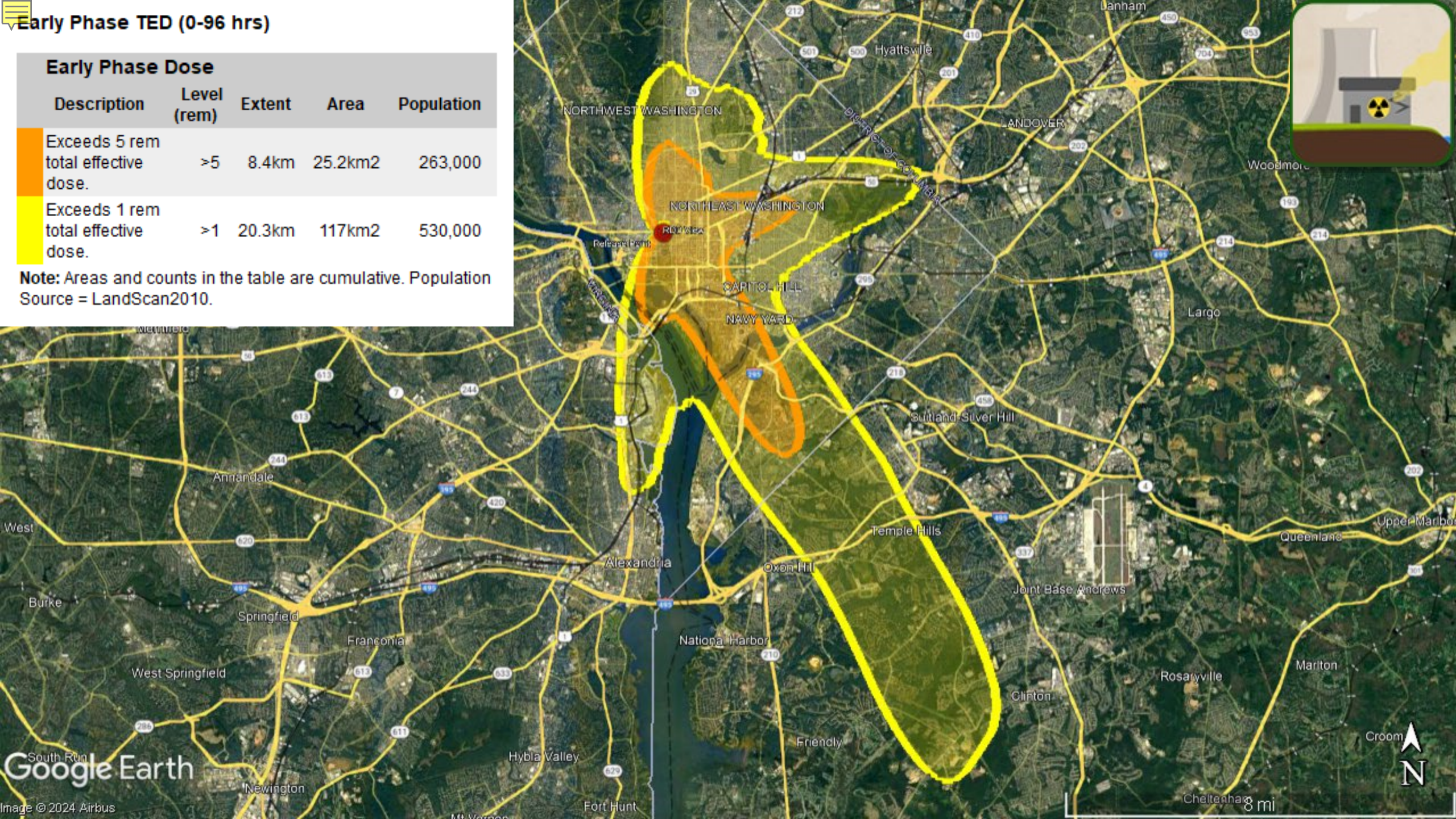

2/14/2009 10:00 am
2/14/2009
2/18/2009
M St NW
Desales St NW
Sumner Row NW
L St NW
RDD View
Farragut North
K St NW
Release Point
Farragut West
17th St NW
16th St NW
18th St NW
15th St NW
Vermont Ave NW
14th St NW
Google Earth

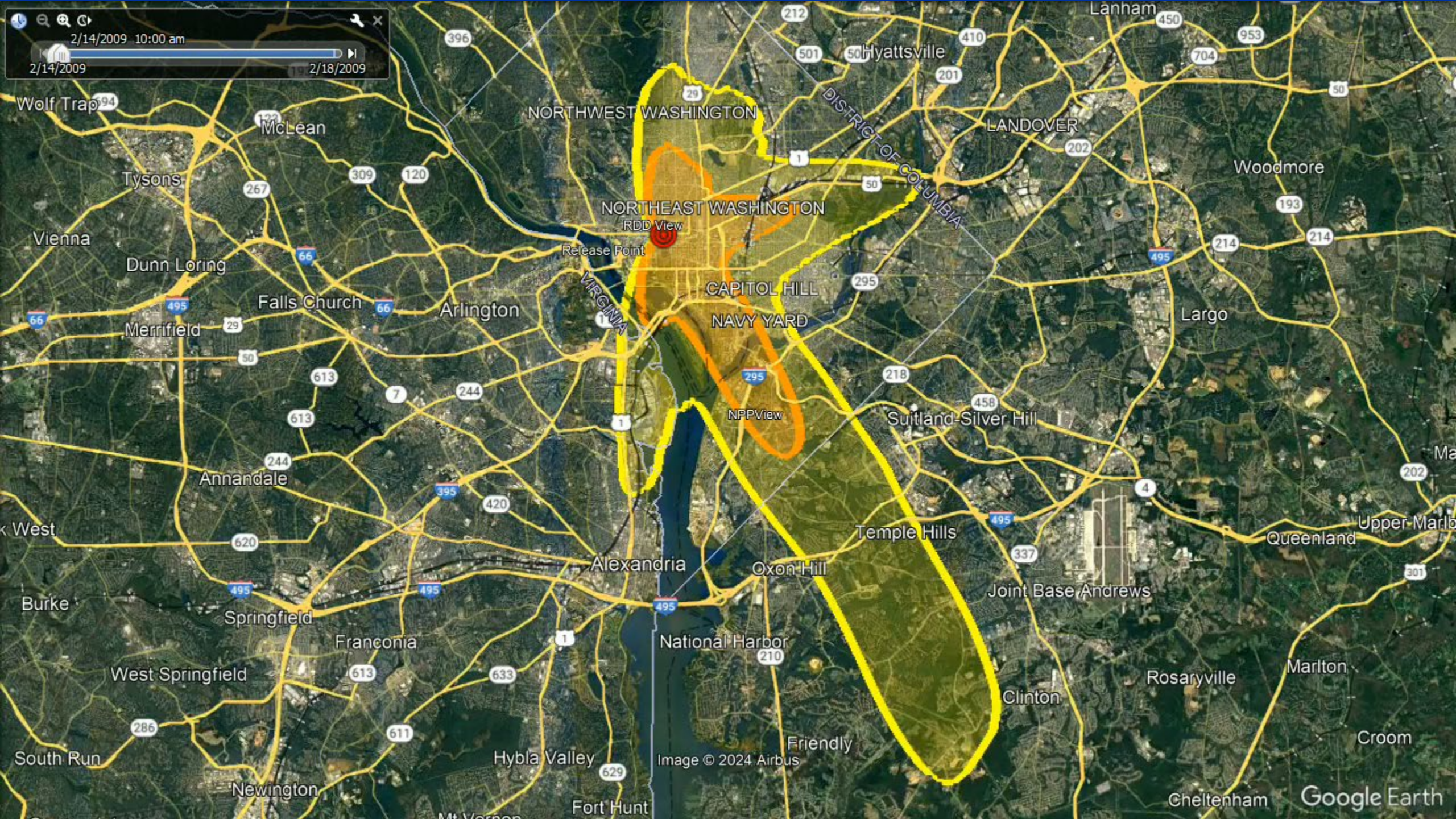
Early Phase TED (0-96 hrs)

Early Phase Dose

Description	Level (rem)	Extent	Area	Population
Exceeds 5 rem total effective dose.	>5	8.4km	25.2km2	263,000
Exceeds 1 rem total effective dose.	>1	20.3km	117km2	530,000

Note: Areas and counts in the table are cumulative. Population Source = LandScan2010.




2/14/2009 10:00 am
2/14/2009
2/18/2009
NORTHWEST WASHINGTON
NORTHEAST WASHINGTON
DISTRICT OF COLUMBIA
RDD View
Release Point
CAPITOL HILL
NAVY YARD
NPPView
VIRGINIA
Wolf Trap
McLean
Tysons
Vienna
Dunn Loring
Merrifield
Falls Church
Arlington
Annandale
Alexandria
Springfield
Burke
Franconia
West Springfield
South Run
Newington
Hybla Valley
Fort Hunt
National Harbor
Oxon Hill
Temple Hills
Joint Base Andrews
Suitland-Silver Hill
Hyattsville
LANDOVER
Lanham
Woodmore
Largo
Queenland
Clinton
Rosaryville
Marlton
Croom
Friendly
Cheltenham
Image © 2024 Airbus
Google Earth

10 kT IND Example

Early Phase Groundshine Dose (0-96 hrs)

Actions and Long-Term Effects

Description	Level (rem)	Extent	Area	Population
Exceeds 5 rem groundshine dose.	>5	109km	1,654km2	1.02E6
Exceeds 1 rem groundshine dose.	>1	200km	7,207km2	1.85E6

Note: Areas and counts in the table are cumulative. Population Source = LandScan USA V1.0.

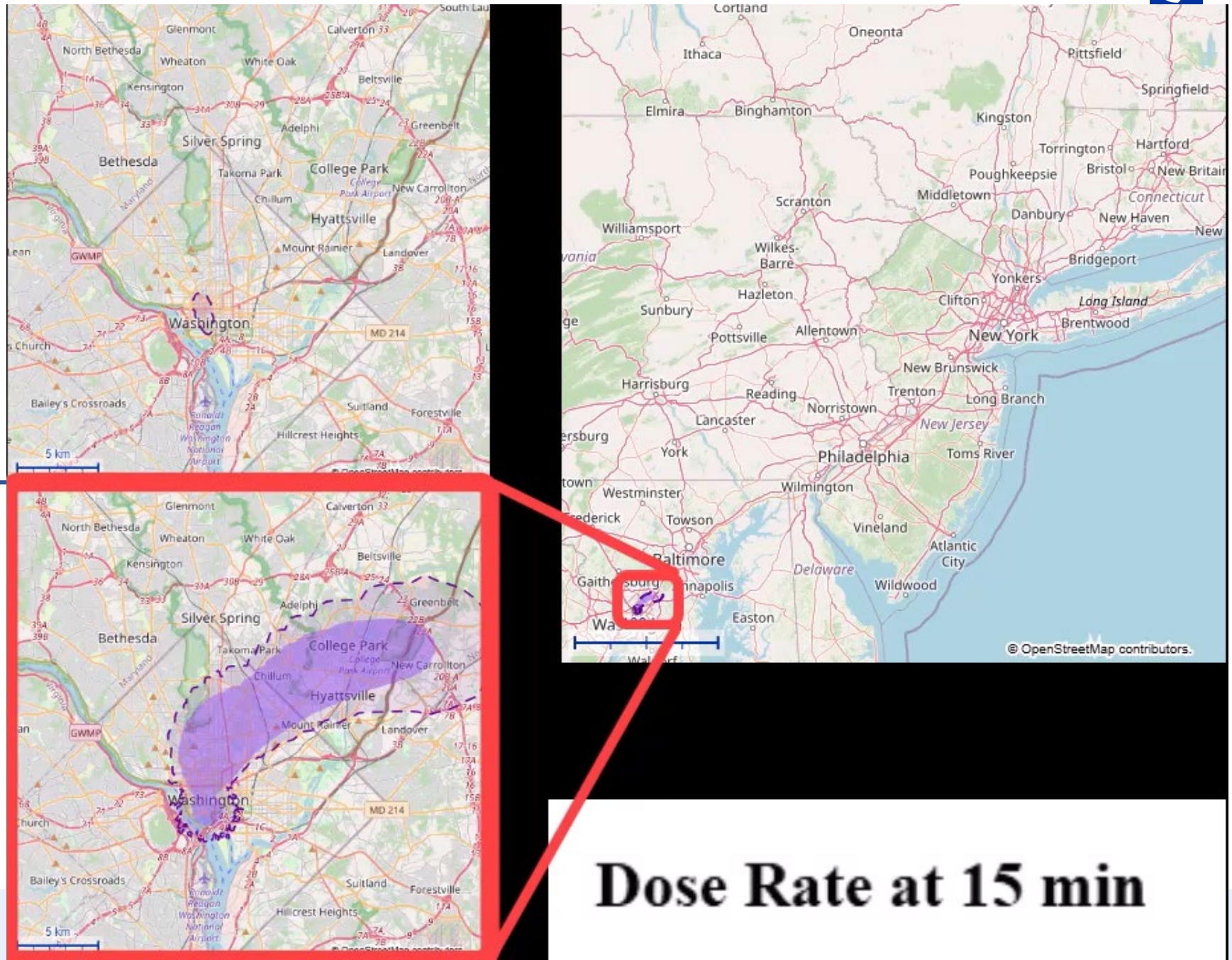
Nuclear Detonation Shelter Area

NPP Early Shelter / Evacuation Area

Timing Comparison:

NPP Release
(Fukushima Incident Source Term)

10 kt Nuclear Detonation



Dose Rate at 15 min

Updating the PAG Language…

EPA 400 (1992) Early Phase Protective Action Guides for Evacuation and Sheltering of Members of the Public

Protective Action	PAG Projected Dose Averted	Comments
Evacuation (or sheltering)	1 – 5 rem (10 to 50 mSv)	Evacuation (or, for some situations, sheltering) should normally be initiated at one rem.

Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation, based on consideration of factors such as source term characteristics, and temporal or other site-specific conditions.

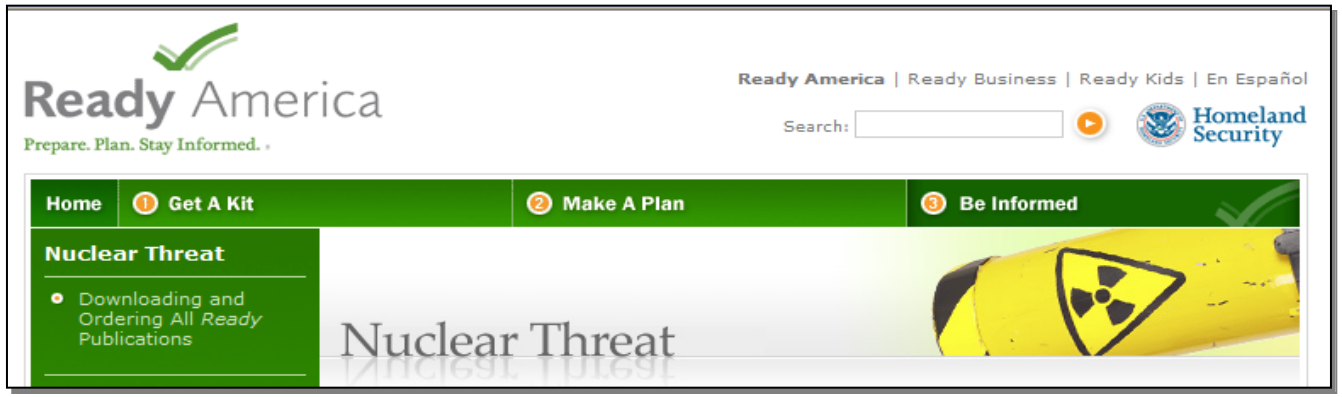
EPA (2017) PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents.

Phase	Protective Action Recommendation	Protective Action Guide or Planning Guide
Early	Sheltering-in-place or evacuation of the public [a]	1 to 5 rem (10 to 50 mSv) projected dose over four days [b]

(a) Should begin at 1 rem (10 mSv) if advantageous except when practical or safety considerations warrant using 5 rem (50 mSv); take whichever action (or combination of actions) that results in the lowest exposure for the majority of the population. Sheltering may begin at lower levels if advantageous.
(b) Projected dose is the sum of the effective dose from external radiation exposure (e.g., groundshine and plume submersion) and the committed effective dose from inhaled radioactive material.

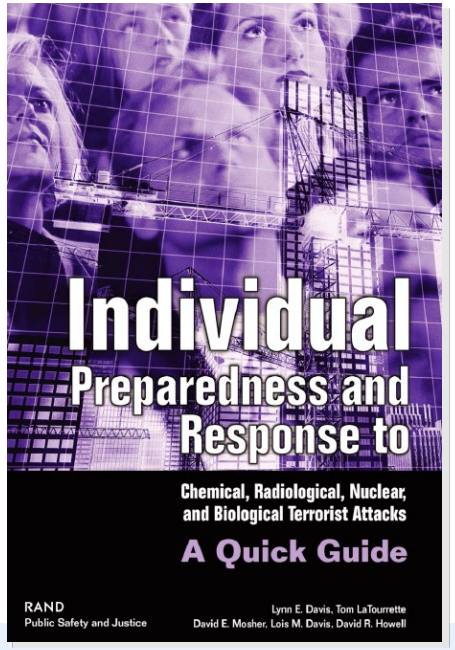
Fallout Example (NCR)

2008: Lack of Scientific Consensus on Appropriate Actions



"**Take cover** immediately, as far below ground as possible..."
~ Ready.gov (DHS)[1]

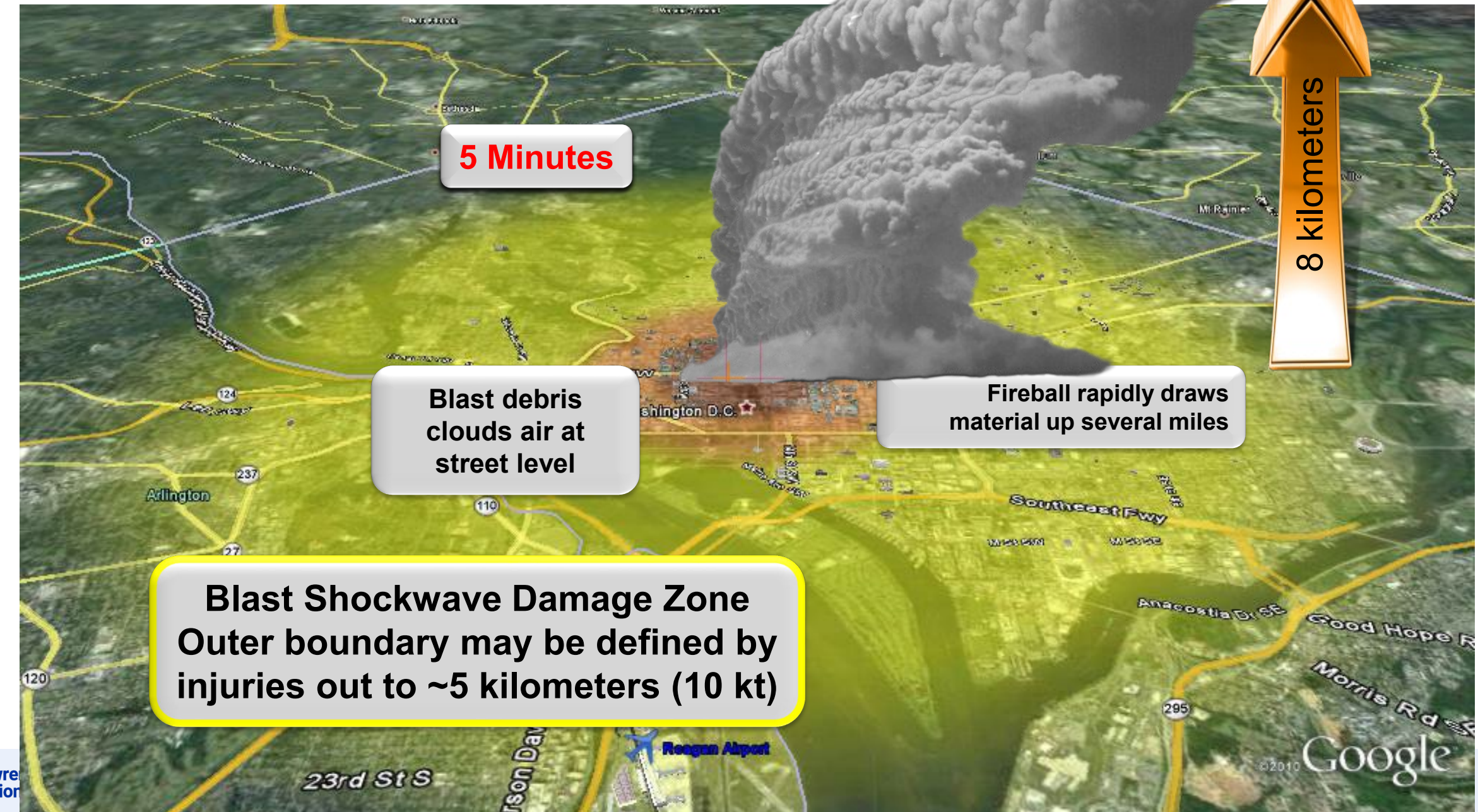
"Avoid radioactive fallout: **evacuate** the fallout zone quickly..."
~RAND[2]

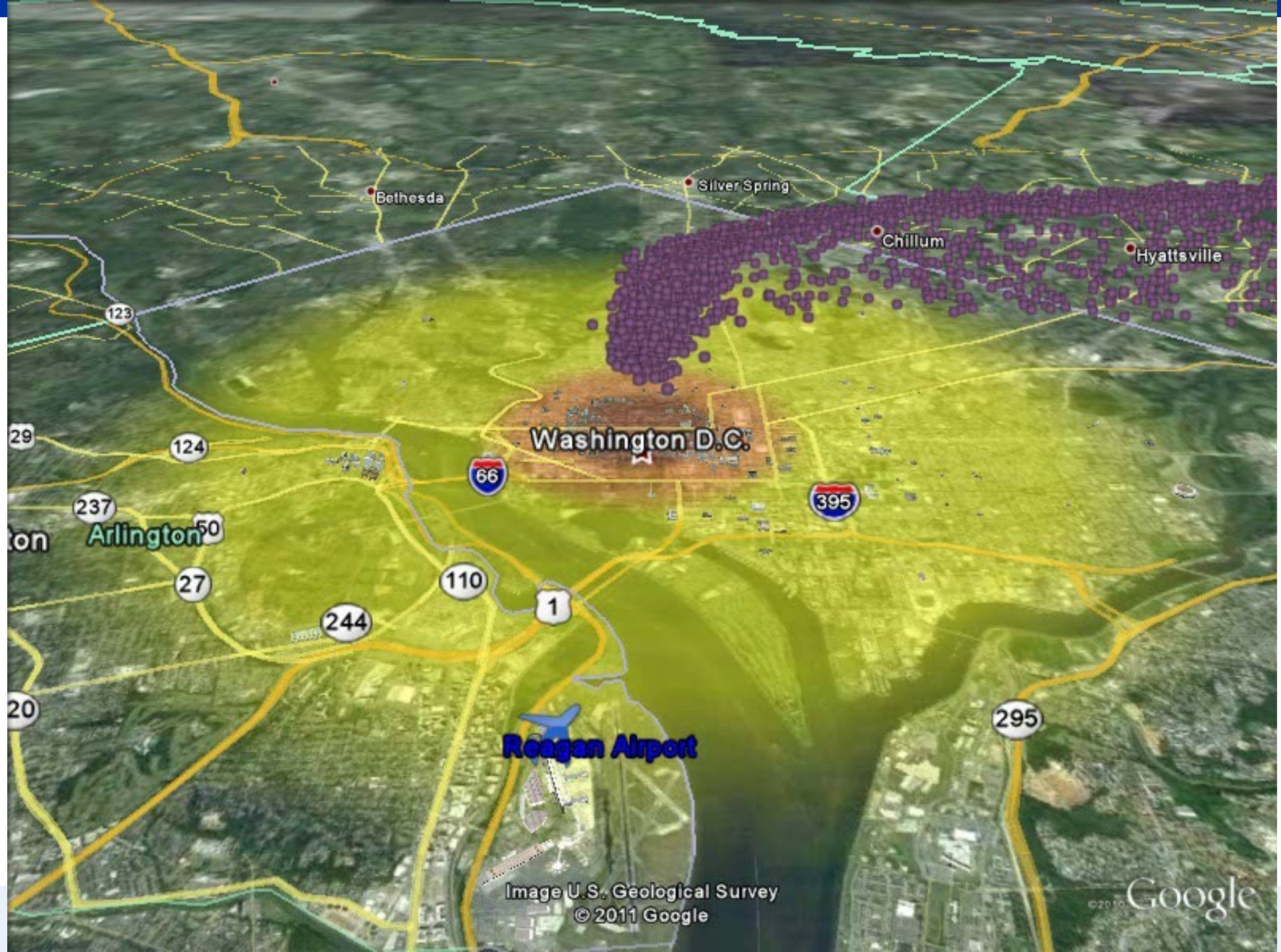


- State and Local Communities:
  - Few communities had plans for response to a nuclear detonation,
  - There was a general lack of understanding of the response needs, and
  - Uncertainty of the Federal, State, and Local roles and responsibilities

- Decisions made in the first few hours:
  - Have the greatest public health and medical impact and
  - Are *not likely to be technically informed*
    (correct actions can be counter-intuitive)

10kt Ground Level Detonation Exam




Bethesda
Silver Spring
Chillum
Hyattsville
123
29
124
Washington D.C.
66
395
237
Arlington
50
27
110
1
244
20
295
Reagan Airport
Image U.S. Geological Survey
© 2011 Google
Google


District of Columbia
Washington D.C.
Silver Hill
495
Prince George's
Andrews AFB
Radiation from Fallout on the Ground
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Image PA Department of Conservation and Natural Resources-PAMAP/USGS
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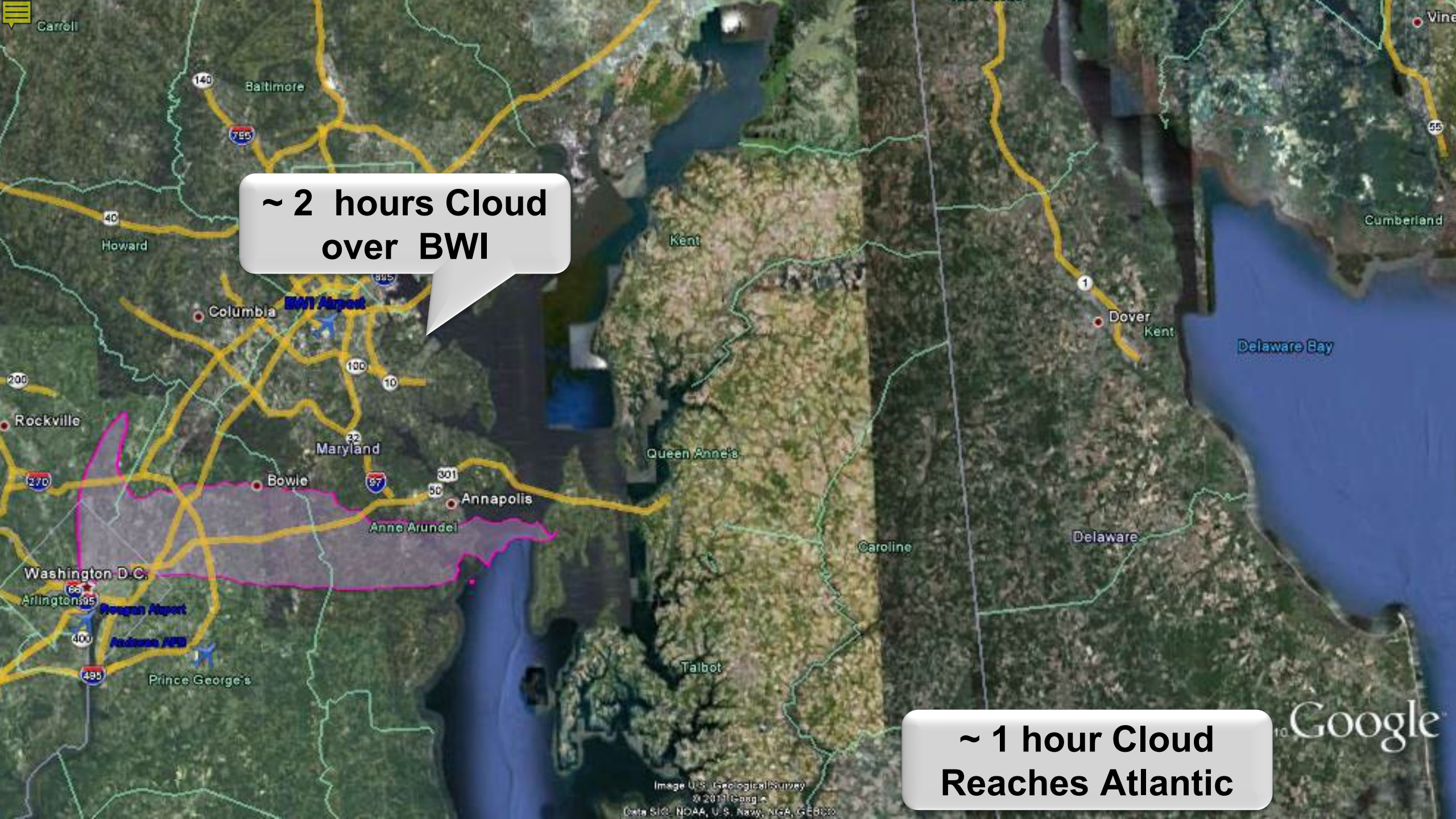
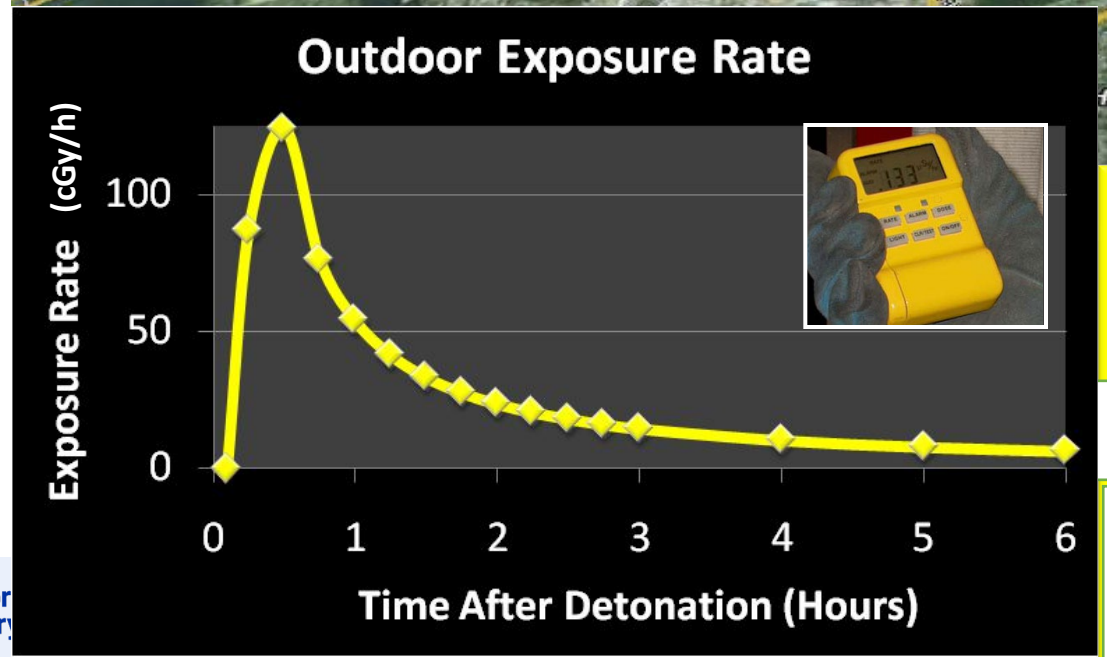
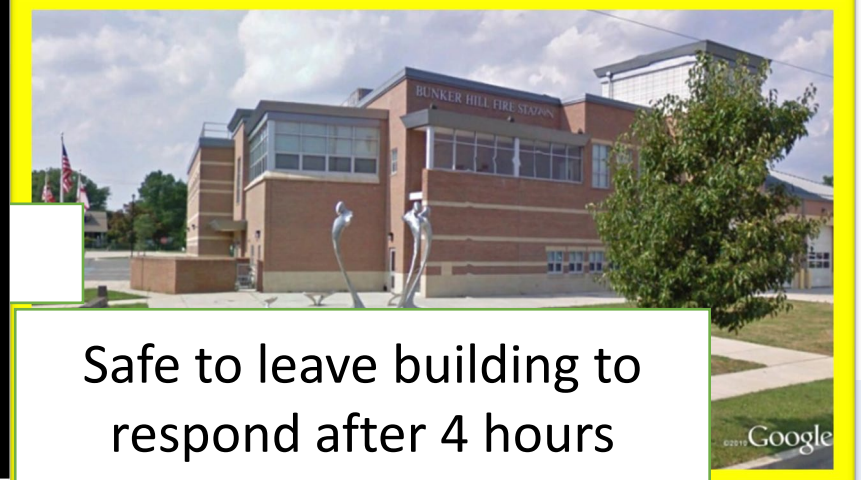

~ 2 hours Cloud over BWI
~ 1 hour Cloud Reaches Atlantic
Carroll
Baltimore
Howard
Columbia
BWI Airport
Rockville
Maryland
Bowie
Annapolis
Anne Arundel
Washington D.C.
Arlington
Reagan Airport
Andrews AFB
Prince George's
Kent
Queen Anne's
Caroline
Talbot
Dover
Kent
Delaware Bay
Delaware
Cumberland
Google

PG Station 55

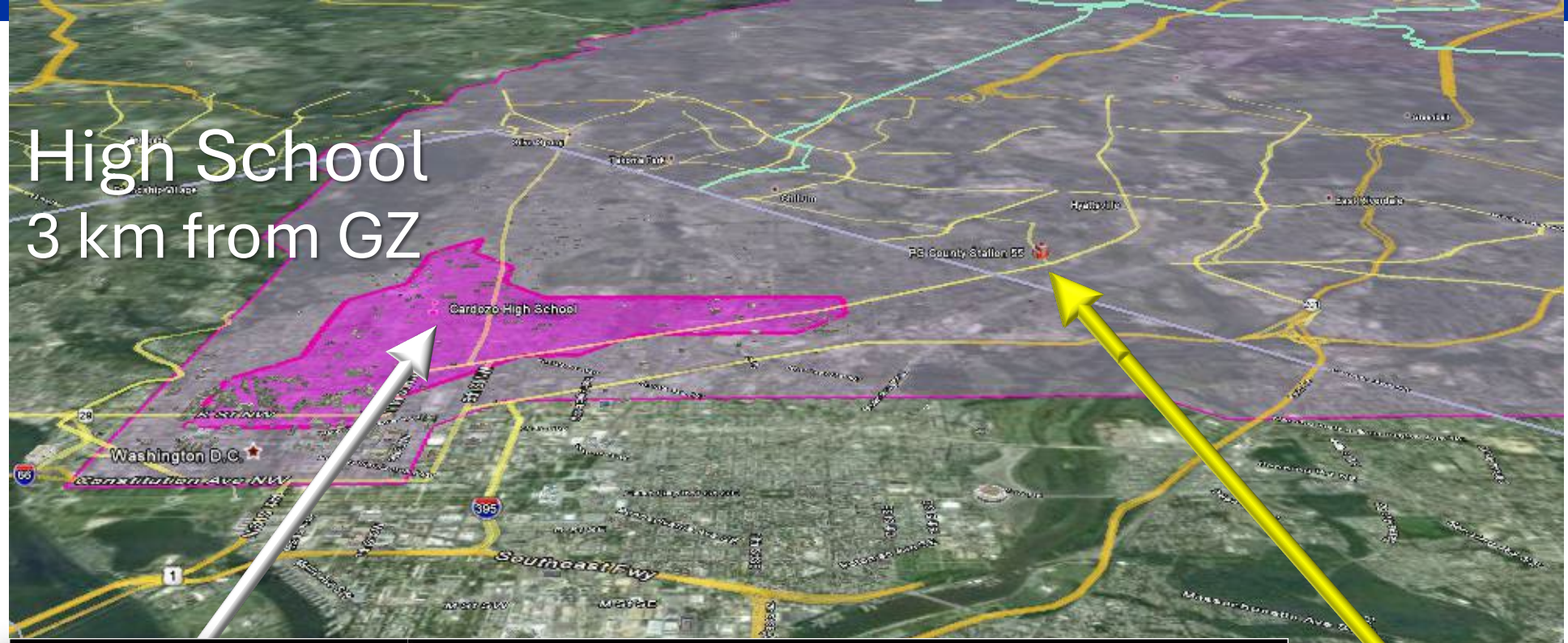
8 km from GZ

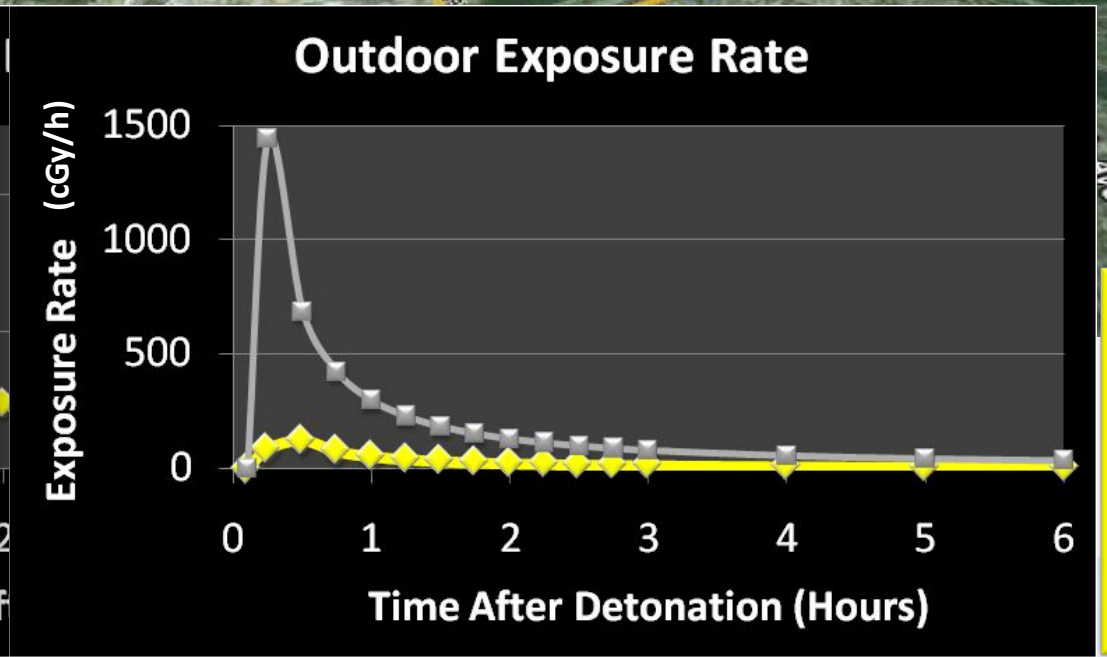




Safe to leave building to respond after 4 hours

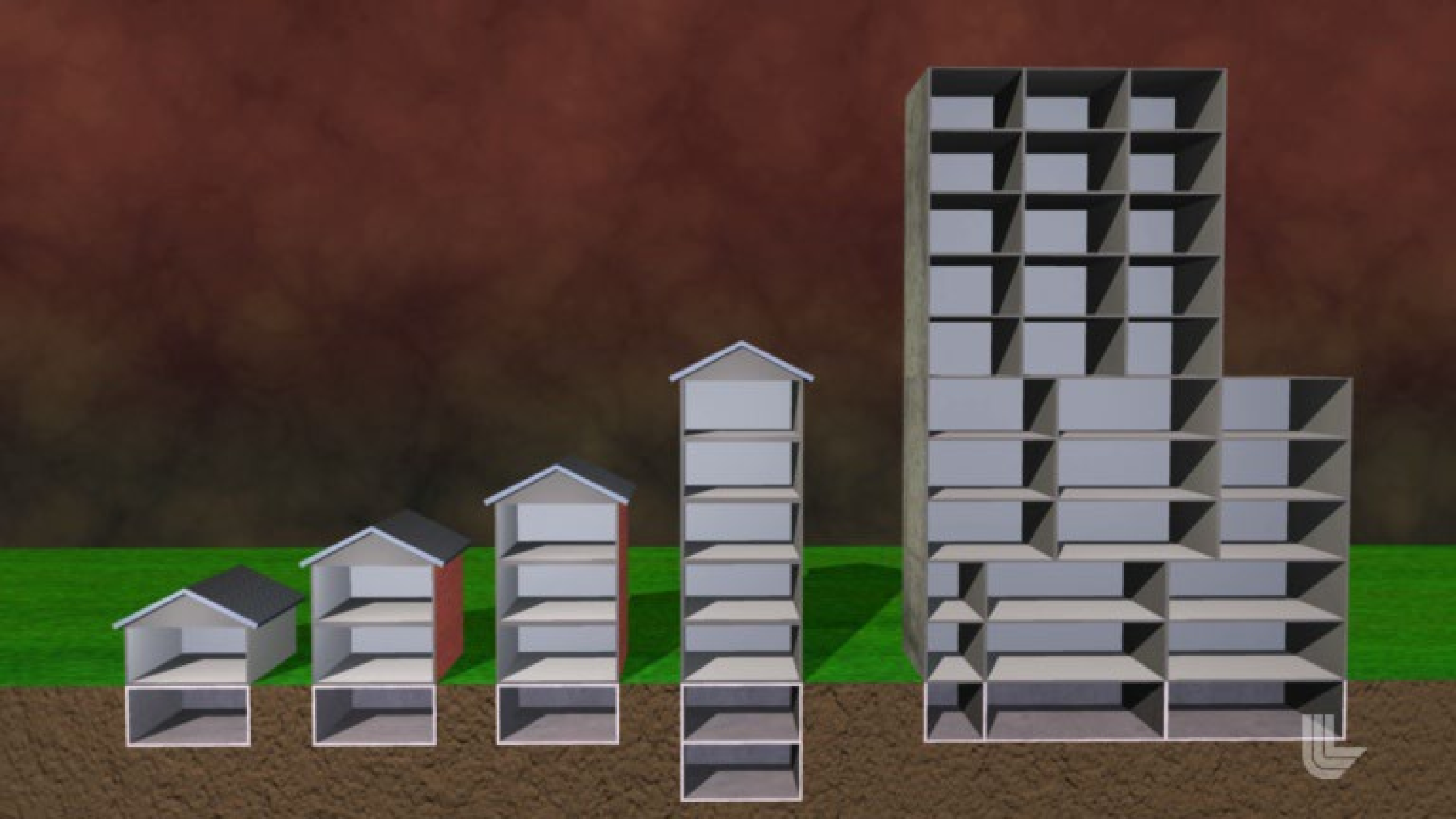
High School
3 km from GZ





Key Fallout Considerations

- Fallout Decays Rapidly (releasing more than half of its energy in the first hour)
- Primary hazard from fallout is exposure to penetrating radiation from the particles
- Fallout is not a significant inhalation hazard
- Dangerous levels of fallout is visible as it falls
- Being outside or in a car will not protect you
- The radiation penetrates through windows and walls, but exposure decreases with distance and intervening materials (shielding)




Protection Factor
Excellent > 500
Very Good 100-500
Good 40-99
Adequate 10-39
Marginal 4-9
Poor 1-3


Hyattsville
PG County Station 55
Cardozo High School
29
Washington D.C.
395
1
295
637
5
Image PA Department of Conservation and Natural Resources-PAMAP/USGS
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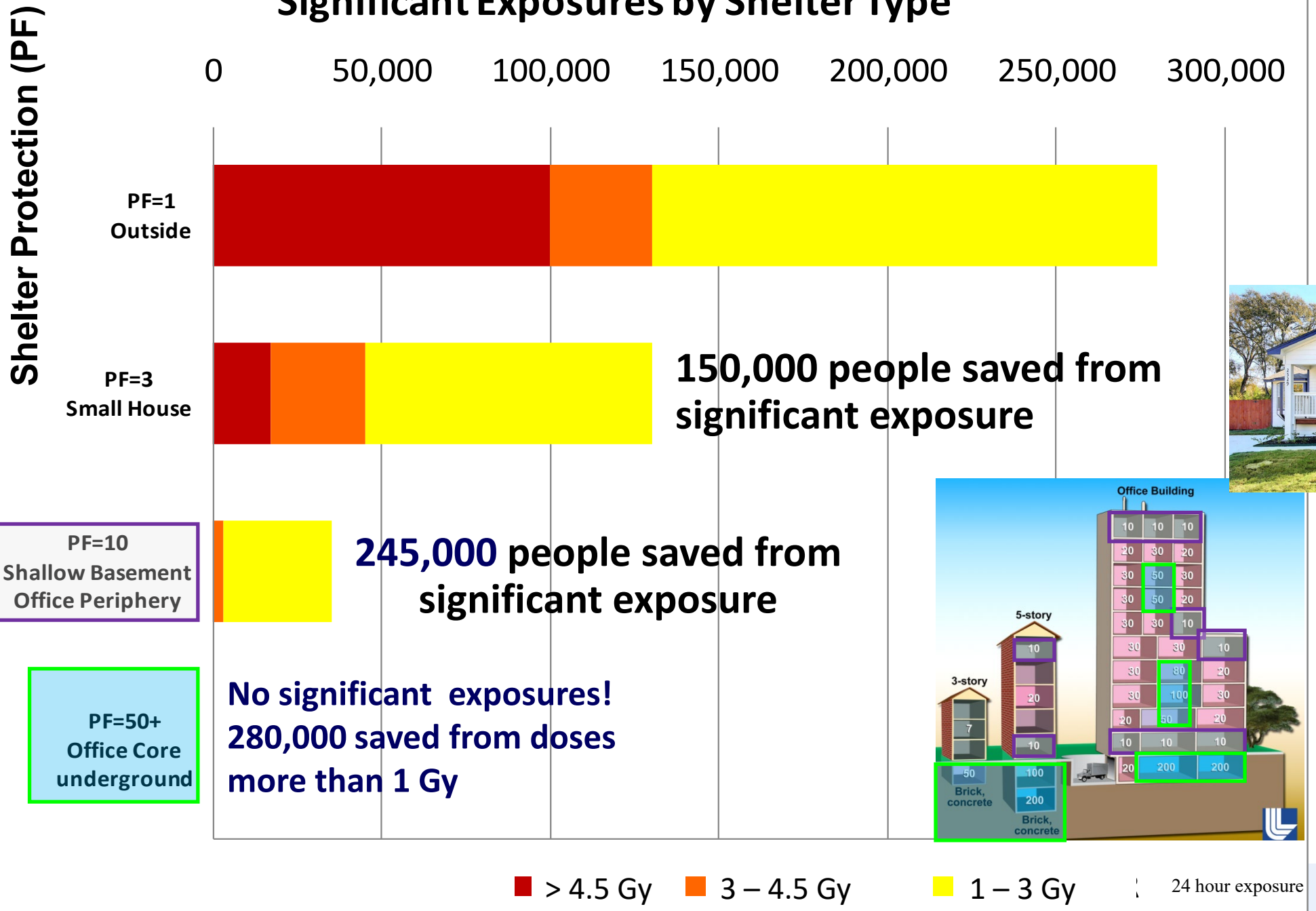
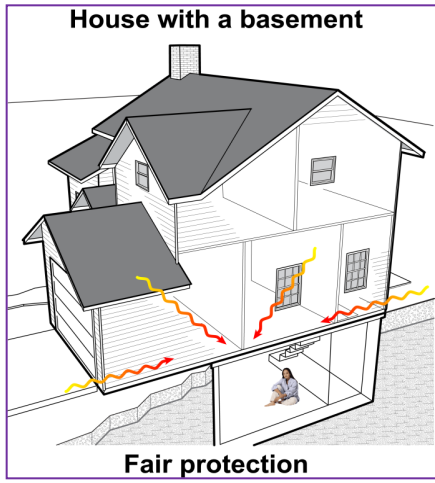
Survival Probable ▸ Increasing Risk of Death ▸ Certain Death

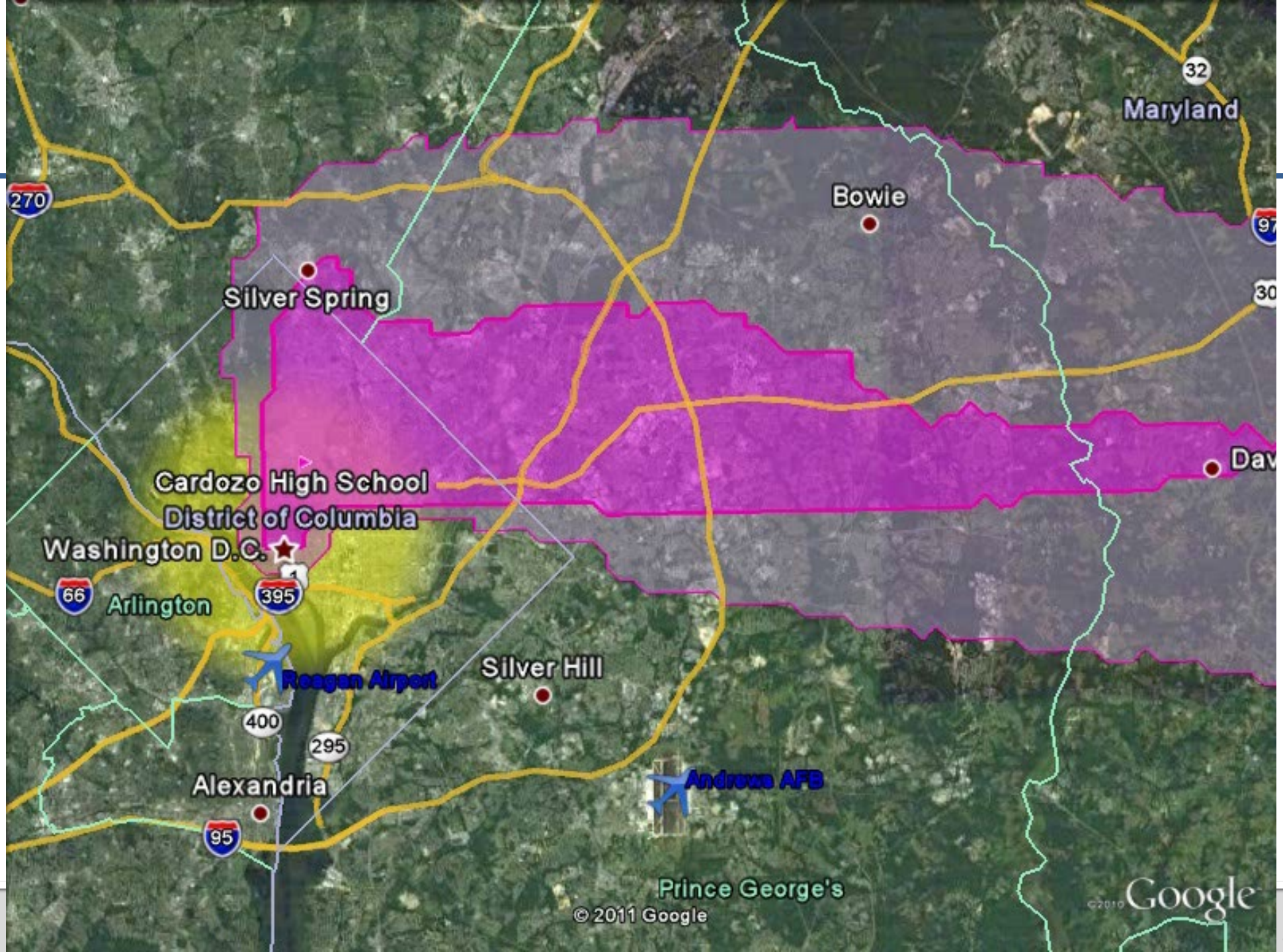
(Gy) 0.1 0.5 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Significant Exposures by Shelter Type



Outdoors




Maryland
32
270
Bowie
97
Silver Spring
30
Cardozo High School
District of Columbia
Washington D.C.
66
Arlington
395
Reagan Airport
Silver Hill
400
295
Alexandria
Andrews AFB
95
Prince George's
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Google

Example Protection Factor

PF= 50 (98% shielding)

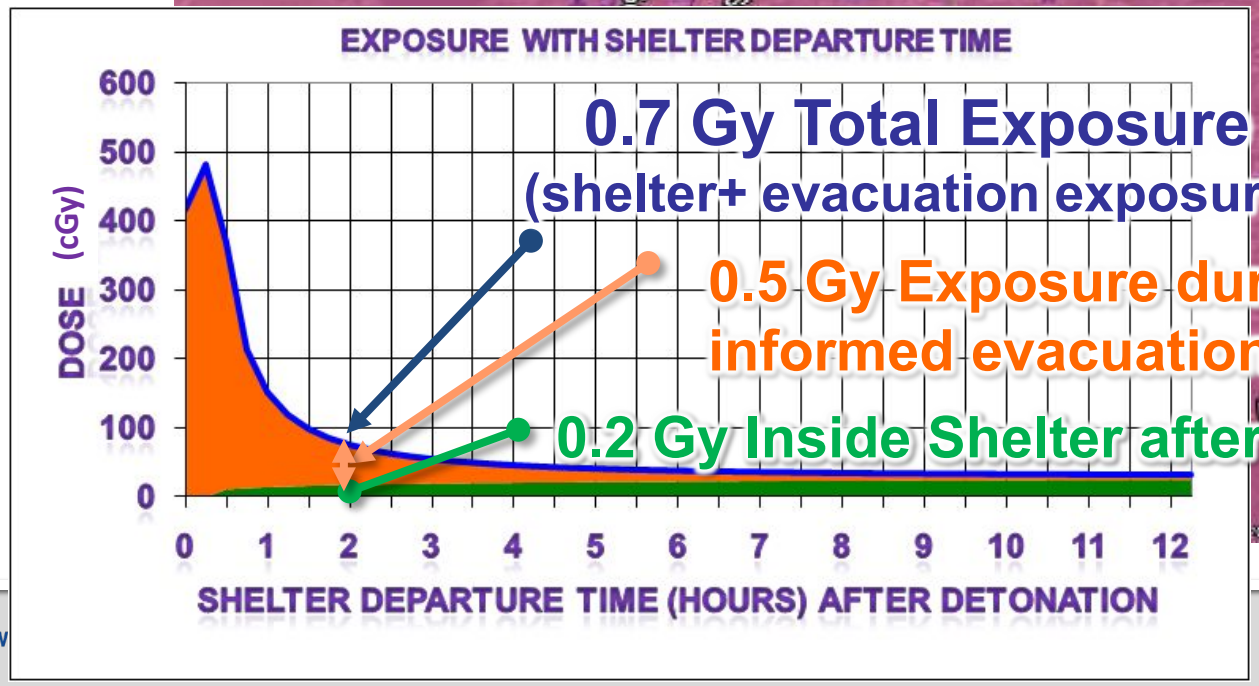
(Note: Most of the shelter locations within school would exceed PF 50)

Analysis of **fallout exposure** for this Shelter and Evacuation Path:

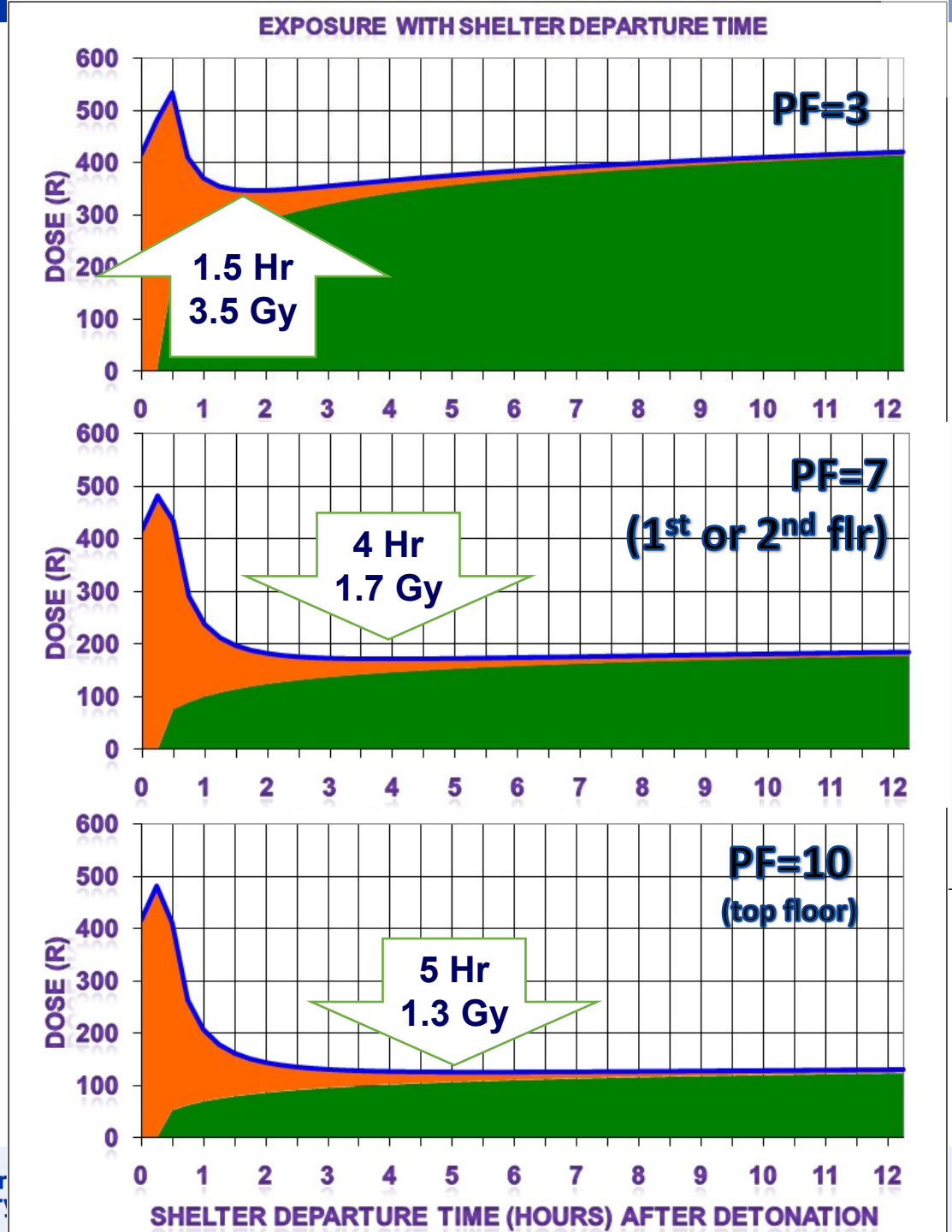
Shelter in School 25 hours followed by ***informed evacuation***

Cardozo High School

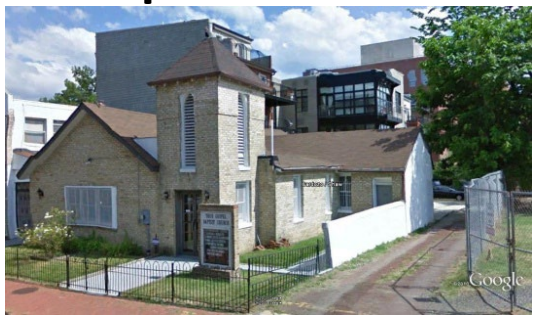
Informed Evacuation Route



Effect of Shelter Types on Departure Time and Dose



1 R = 1 cGy



Poor Shelter

Small House (PF=2-3)

Marginal Shelter

2-3 story

Stand Alone

Residential

(not incl basement)

Adequate Shelter

Adjacent Brownstones, 2-4 story office or apartments buildings

PF = 5 - 50
(not incl basement)

Key Findings

- Although a useful for Nuclear Power Plant accidents, evacuation is not an appropriate public protection measure for Nuclear Detonations.
- National protective action guidelines have been updated
- 100,000s of casualties can be significantly reduced through proper action (both individual action and leadership)
- The first hour most critical, a prepared local response community is needed (a prepared public would also be helpful)
- Public Protection Strategy: Early, adequate shelter followed by delayed, deliberate evacuation