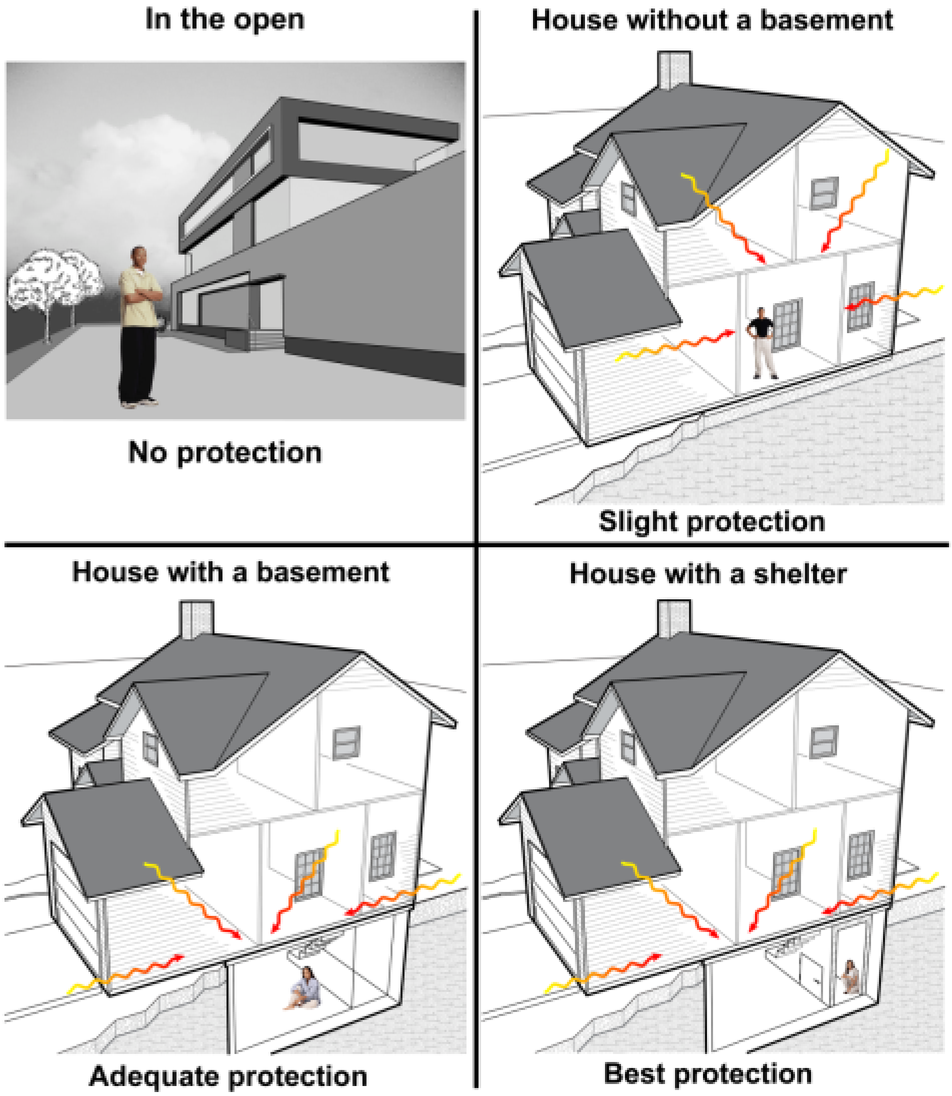

Student Guide: Shelter and Evacuation Strategies (NCR)

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FEMA

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National Nuclear Security Administration

Instructional Goal

By the end of this presentation, the student should be aware of the shelter and evacuation strategies following a detonation of an improvised nuclear device (IND). Knowing what to do before the event is critical. By having these plans in place, 100,000s of people can be saved through proper action by both individual action and leadership. This module will include information on sheltering and the basics of informed evacuation. Situational awareness, communication, and independent responder actions are essential in preventing unnecessary loss of lives.

Purpose

The purpose of this presentation is to inform the student about the shelter and evacuation strategies following the detonation of an IND. By the end of this module, students should be familiar with the different sheltering and evacuation strategies, as well as how many lives these strategies have the potential to save.

Module Objectives

•Provide basic information about how and where to shelter.

•Define the dangerous fallout zone.

•Give figures and explanations for why sheltering works.

•Explain the concept of informed evacuation.

•Discuss the best public strategy options.

Please provide feedback for these draft documents to brooke2@llnl.gov
If using parts of this presentation or the information contained in the presentation, please cite: B. R. Buddemeier, Lawrence Livermore National Laboratory, LLNL-PRES-492025 (Aug 2011)

Notes

Key Fallout Considerations

•Fallout decays rapidly (releasing more than half of its energy in the first hour)

➢The radiation levels are very high initially, but over 50% of the energy is given off in the first hour. Over 80% in the first day.

•The primary hazard from fallout is being exposed to penetrating radiation from the particles

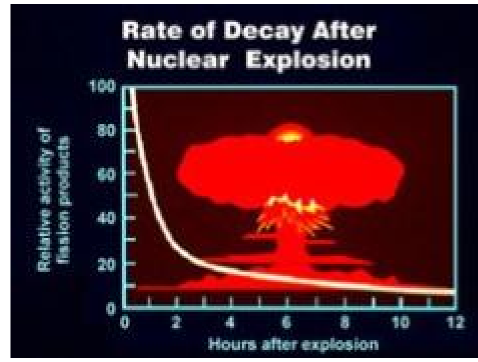
➢The hazard is the penetrating radiation energy given off by the fallout particles. Getting as much distance and mass between you and the particles is the best protection. By remaining indoors and seeking the best possible shelter in their structure, people can dramatically cut down the radiation dose they are exposed to.

•Dangerous levels of fallout are readily visible as they fall

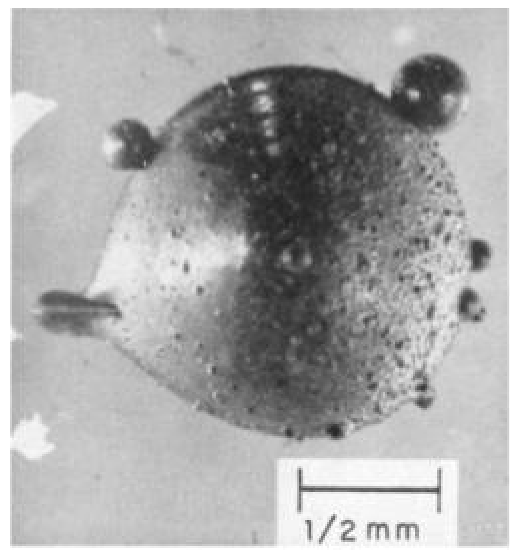
➢Dangerous levels of fallout are not invisible; there will be visible quantities of material raining down, often the size of salt or sand.

•Fallout is not a significant inhalation hazard

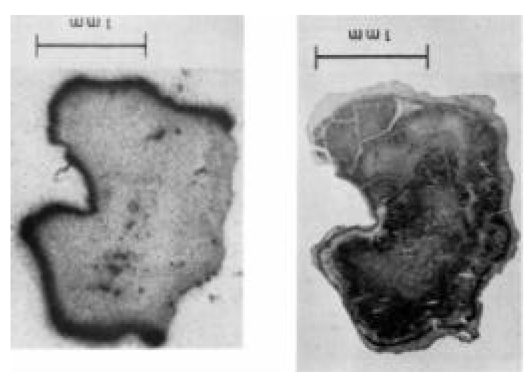
➢Because they are so large, breathing in the particles is not very likely and is a much lower concern than the external exposure from the particles on the ground.



Images courtesy of Armed Forces Radiobiological Research Institute



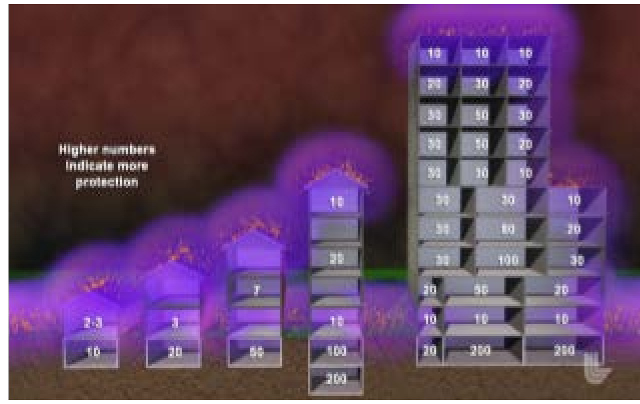
...G. 1. A radioactive fallout particle from a tower shot in Nevada. The particle has a dull, metallic luster and shows numerous adhering small particles.



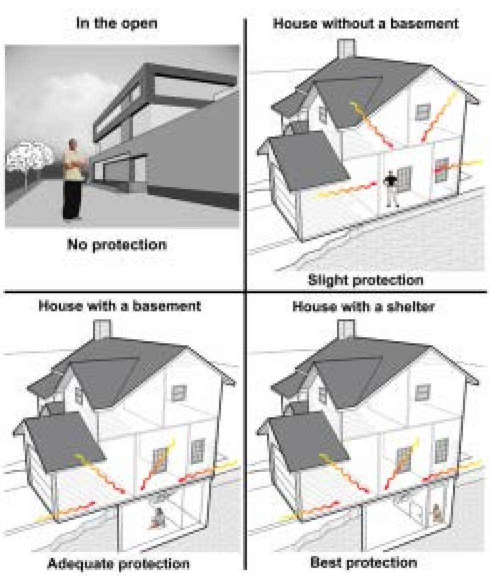
Fallout Images from:
G. R. CROCKER, J. D. O'CONNOR and E. C. FREILING, PHYSICAL AND RADIOCHEMICAL PROPERTIES OF FALLOUT PARTICLES, *Health Physics Pergamon Press, 1966. Vol. 12, pp. 1099-1 104.*

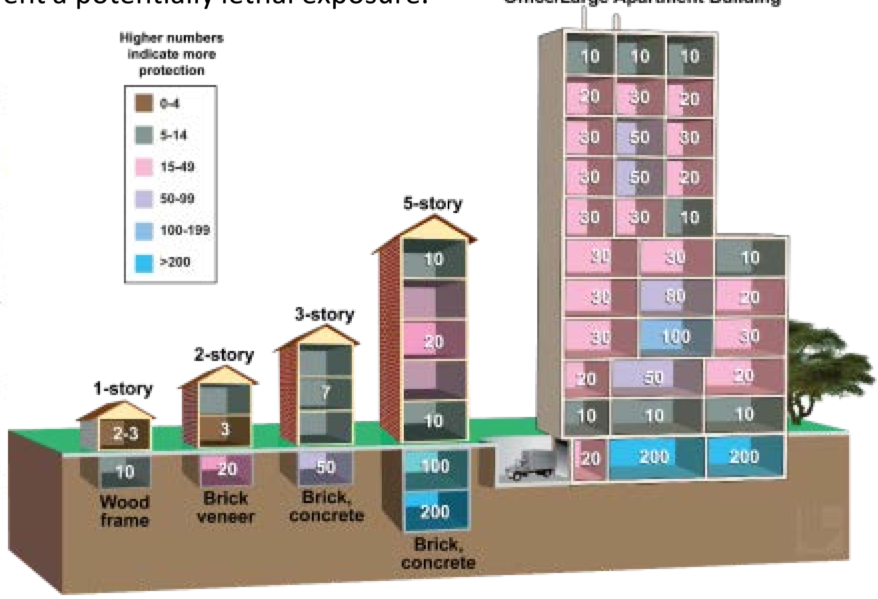
Key Fallout Considerations

- **Protection factors**
  - ➢As can be seen by this animation, the particles coat the ground and rooftops. The hazard areas are near the places where the fallout accumulates. The radiation penetrates through windows and walls, but exposure decreases with distance and intervening materials.



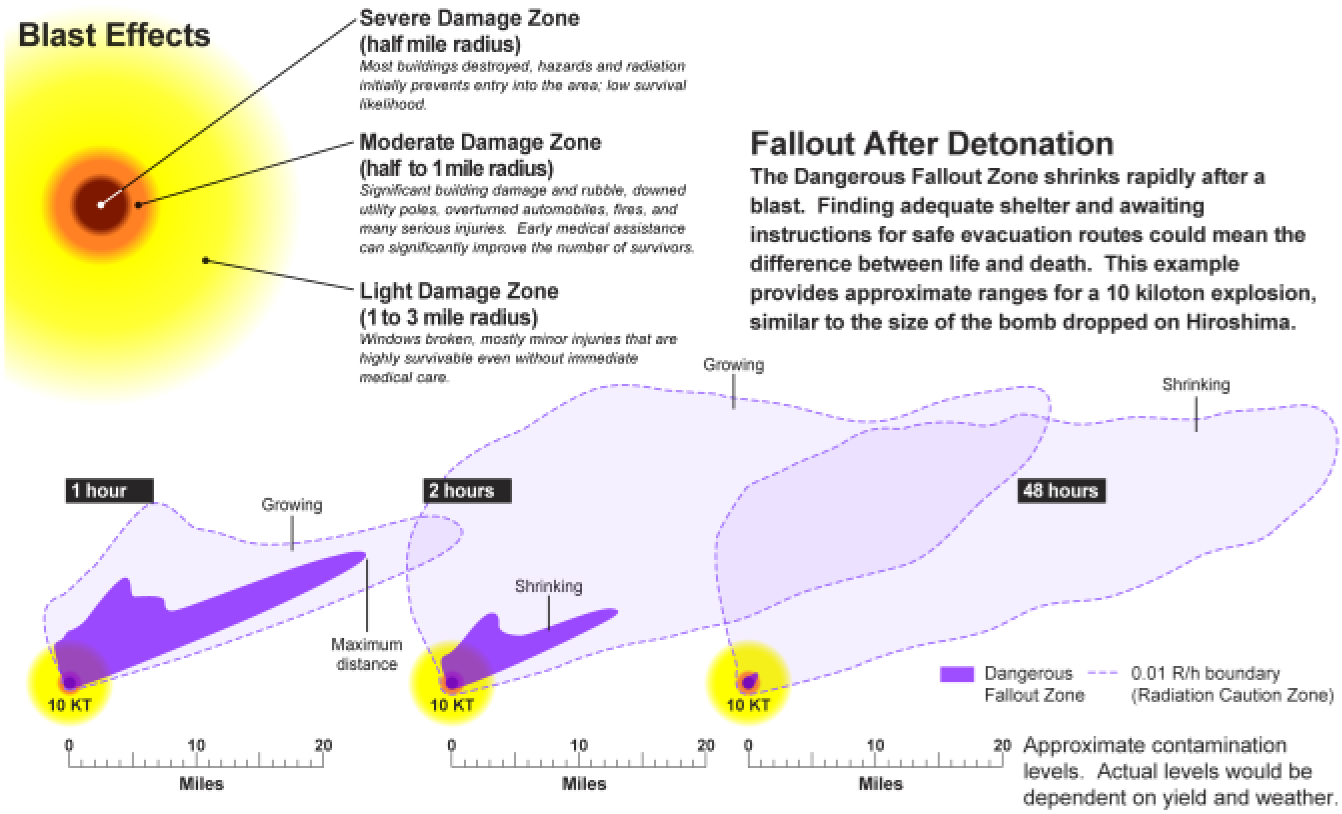
Similar to the SPF of sunscreen; the higher the Protection Factor (PF), the lower the exposure that a sheltered person would receive compared to an unsheltered person in the same area. To obtain the sheltered exposure, divide the outdoor exposure by the PF. This Figure demonstrates presumed protection factors for a variety of buildings and the location within the building. For example, a person top floor or periphery of a ground level of the office building pictured would have a protection factor (PF) of 10 and would receive only 1/10th (or 10%) of the exposure that someone outside would receive. Whereas someone in the core of the building halfway up would have a PF of 100 and receive only receive 1/100th (or 1%) of the outdoor exposure. In fallout areas, knowing locations with adequate protection factors could prevent a potentially lethal exposure.





- **A protection factor of just 10 or higher is considered adequate protection against fallout radiation**. For simple, wood frame houses, just going into a basement is enough to offer adequate protection. For those in large office or apartment buildings, going into the center of the building or deep underground offers very high levels of protection against radiation.

Review the Planning Guidance Zones



Example Neighborhood

- To help illustrate the type of buildings you would find in a typical DC neighborhood, the animation on the PowerPoint focuses on a neighborhood around the Cardozo High School.

  ✓This area is ~ 1.5 miles from the detonation and in the light damage zone.

  ✓The area is also in the Dangerous Fallout Zone

Fallout Exposure Reduction

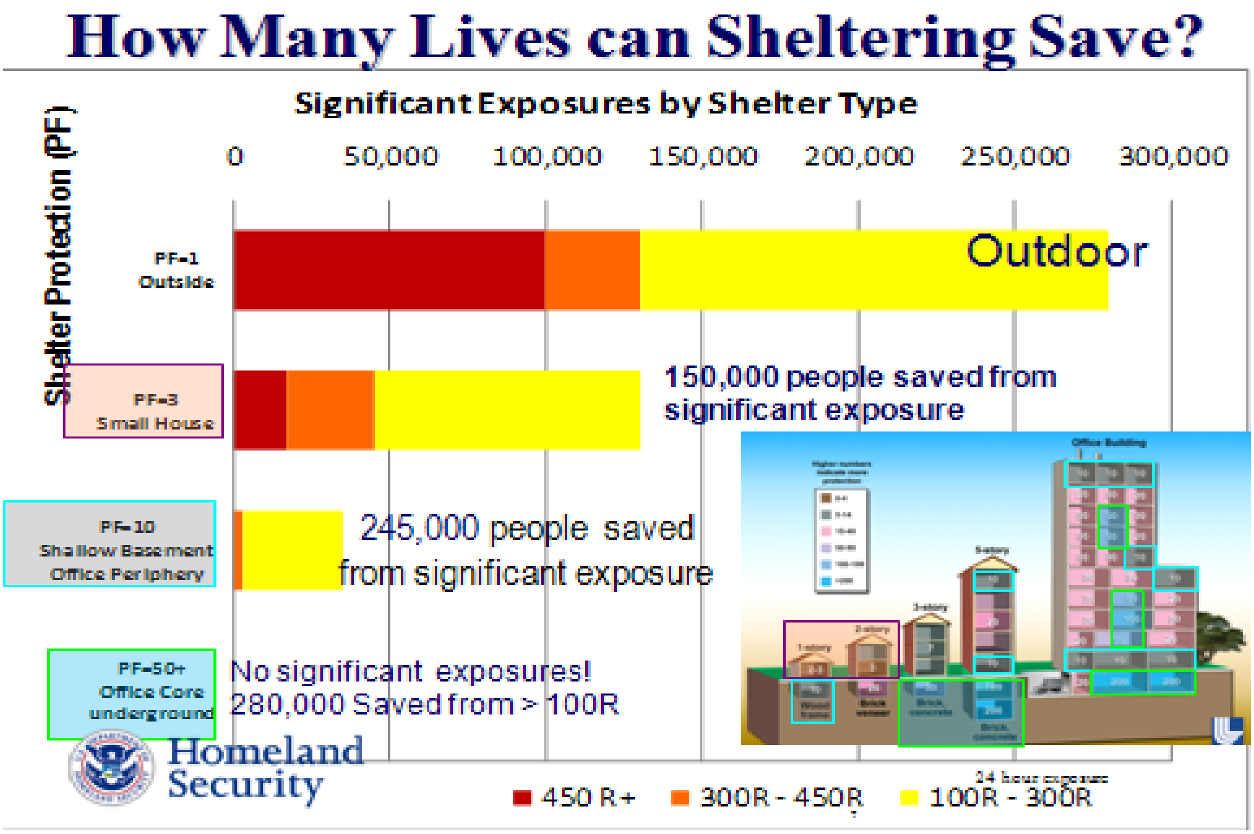
- For anyone simply standing outside in the first 12 hours following detonation, their dose rate would be 2,000 rem.

- As you can see, a dose that high would be enough to almost certainly kill you.

  - If the only available shelter was a 1-2 story wood-frame house with no basement, there would still be a reduction in dose. However, at this particular location, it is not enough to prevent a significant exposure.
  Note: single story wood frame houses are very rare in this DC neighborhood.

- Those seeking shelter in a brick residential location, like the brownstone row homes pictured, or smaller commercial facility could find protection factors up to 50.
  Top Floor: PF of 5 - 15
  1st & 2nd Floor: PF 10 -50
  English Basement: PF 20 - 50
  People in these types of structures will have survivable exposures.

- For those who can find shelter in a large, multi-story commercial building, such as the high school, their radiation dose will be so minimal that they would not likely experience any acute symptoms from the radiation.



Sandia National Laboratories conducted an analysis of the potential exposures from a variety of sheltering options for the first 24 hours after the detonation of a 10KT. These are only fallout injuries outside of the moderate damage zone.

- If everyone in this area just stood outside for the first 24 hours, ~280,000 people would receive enough radiation exposure to either make them sick (yellow / orange) or kill them (red). Protection Factor of 1.

- Even if everyone went into an inadequate structure like a car or small house, 150,000 people would be saved from significant exposure levels. Protection factor of 1-3.

- If everyone goes into a “just adequate” shelter like a shallow basement, 245,000 people (out of 280,000) would be saved from significant exposure. Also, of the 40,000 remaining exposures, they are in the “sick, but not dead” category. This is why PF=10 is considered adequate. Protection factor of = 10.

- Finally, if everyone could get to the core of an office or an underground basement, there would be no significant exposures to deadly radiation levels. Protection Factor of 50+.

Dangerous Fallout Zone Changes with Time

Here are the Dangerous Fallout and Hot Zones 15 minutes after detonation

For a 10kT, the Dangerous Fallout Zone reaches its maximum extent. After about 1 hour

The yellow border represents the max extent of the DFZ. Lets watch what happens as time progresses.

The DFZ continues to shrink, and after a few days the zone actually disappears.

So the key question is "how long should people remain in their shelter?"

Optimum Shelter/Departure Example

- Most people in the Dangerous Fallout zone will likely receive some exposure to fallout; this is, unfortunately, unavoidable. However, knowing how long to shelter and the direction to evacuate can significantly lower the exposure.

- This example presumes an informed evacuation. In this case the best possible route out of the area is West across Rock Creek Park. Unfortunately the victims in this area would not know that without outside help as other routes (away from the blast to the North) would look just as viable, but result in much higher evacuation exposures.

Optimum Shelter/ Departure Example

This graph shows the total radiation dose received by someone sheltering inside a School with a protection factor of 50 (98 percent shielding). Dose rates will continue to rise depending on how long the person remains inside the School.

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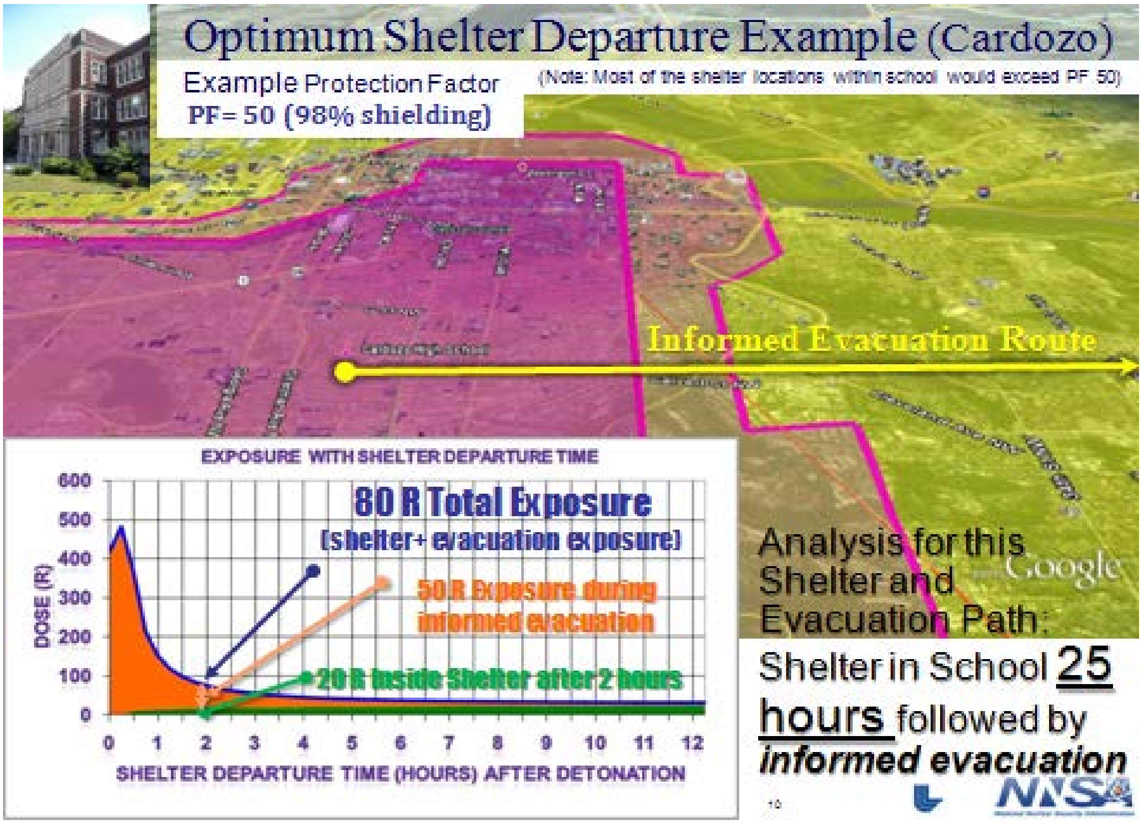


- The orange on the graph represents the additional exposure the person would receive while trying to evacuate the area ***at the time specified.***

- Notice how high the evacuation dose is if they where to leave in the first hour. That is because they are trying to evacuate while the radiation levels are highest outside.

- In this example, by waiting four hours to evacuate (the optimum departure time in this case), the person receives the lowest possible dose of radiation.

- Although there is an apparent minimum dose around four or five hours, the slight increase of exposure with time after this point is minimal compared with the hazards of early evacuation.

Optimum Shelter Departure Time
Depends on Shelter and Evacuation Route

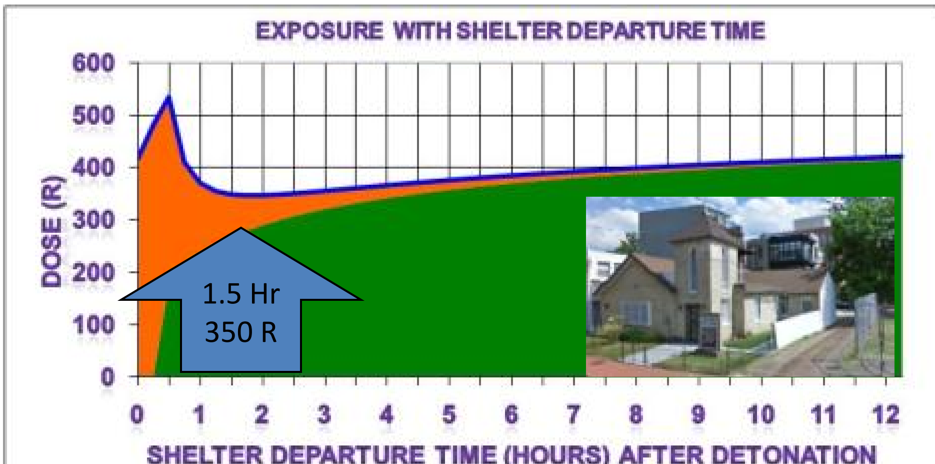
- When to evacuate a shelter depends on how much protection a person is getting from the structure, and how long it will take an average person to complete the evacuation route. Knowing the answer to both of these is crucial to creating informed evacuation routes.

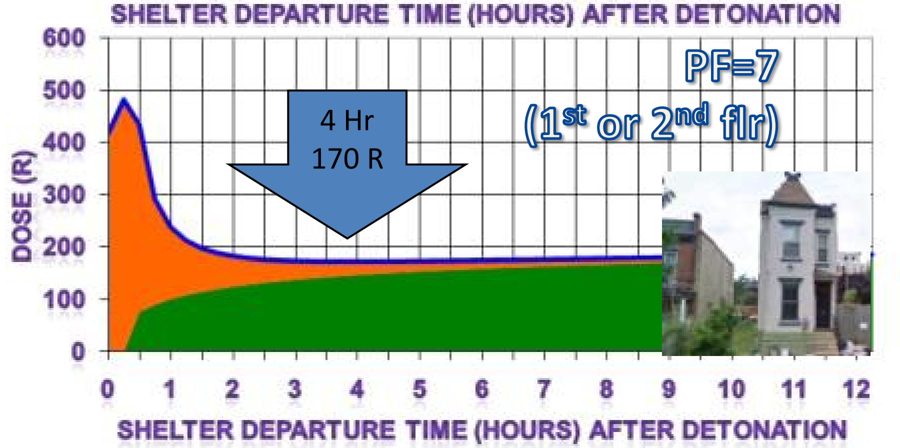
- In this example, the wood frame house offers poor protection. Although it does reduce the outside exposure by a factor of three, it is still not enough to warrant staying in the structure for very long. In fact, if the opportunity arises they should consider moving to a structure with more shielding.

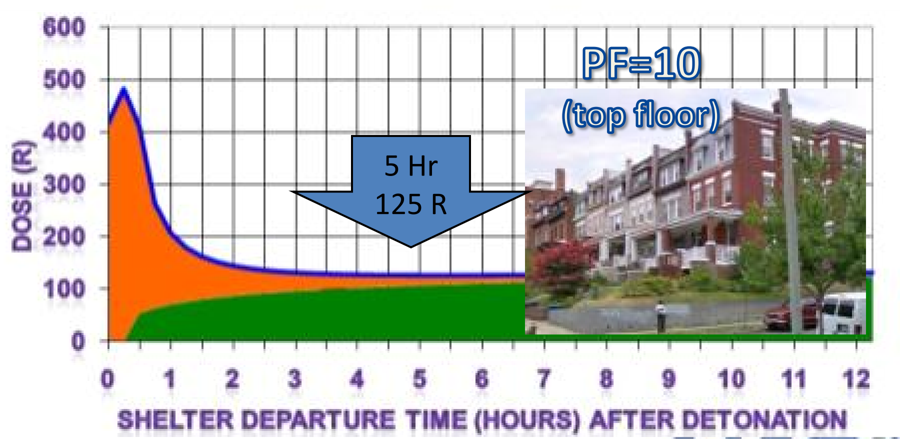
- Inadequate Shelter (2-3 story) Stand Alone Residential (not incl basement) might only offer a PF =7, which would have an optimized evacuation of 4 hours

- Although Brownstones offer PF greater than 10 in the middle floors or English basement, a PF of 10 (adequate shelter) was considered for this analysis and resulted in a 5 hour departure time.

NOTE: whether you wait for 5 hours or three days, the difference in exposure is slight compared to the dangerous evacuation doses you would receive in the first few hours.







Evacuation Considerations

Even during the initial (most dangerous) phases of the event, we need to make sure that we do not have "tunnel vision" regarding the radiation hazard and look at all the life safety issues. In particular, it does no good to shelter from the radiation if your shelter collapses on you or is on fire. Be sure that the public knows that other life threatening hazards can take priority.

AFTER THE DFZ IS ESTABLISHED

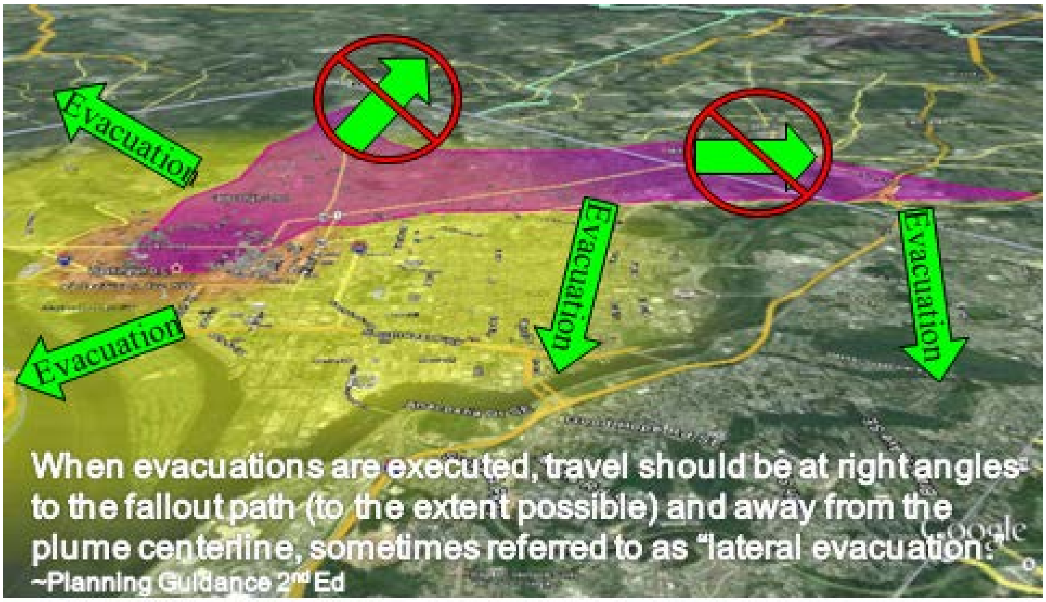
Evacuation planning can begin

- Evacuation routes should be cleared if possible
- Routes that take advantage of sheltered passage (subways, underground connectors, through building lobbies) should be used if possible
- Execution should be phased to reduce the time spent transiting through fallout areas

Evacuation Planning

As stated in the planning guidance:

- When evacuations are executed, travel should be at right angles to the fallout path (to the extent possible) and away from the plume centerline, sometimes referred to as "lateral evacuation."
- For more complex fallout patterns like the one pictured here, ensure that evacuations **do not** move people down the length of the fallout pattern or into another fallout contamination area.



Preliminary Shelter/Evacuation Analysis

Spending the first hour in an urban shelter (multi-story building) can keep exposures non-lethal:

Public Protection Strategy: Early, adequate shelter followed by informed, delayed evacuation. This includes:

- Adequate shelter includes houses with basements, large-multi-story structures, and underground spaces like parking garages or tunnels
- Sheltering the first hour in an adequate shelter can keep exposures non-lethal
- Optimal shelter departure time will vary by shelter quality and evacuation path
- Informed evacuation helps ensure rapid exit of the dangerous fallout zone

Knowing what to do before the event is critical
By having response plans in place, and knowing where the best shelter is, many lives can be saved.

- **Presuming informed evacuation routes and optimum length of shelter stay depends on shelter quality and time required to evaluate the area:**

➢Based on what type of shelter a person is in, certain guidelines should be followed:

❑-First few hours in a poor shelter (small homes without basements)

❑-Several hours to a day in moderate shelters (residential basement, office buildings, small commercial buildings)

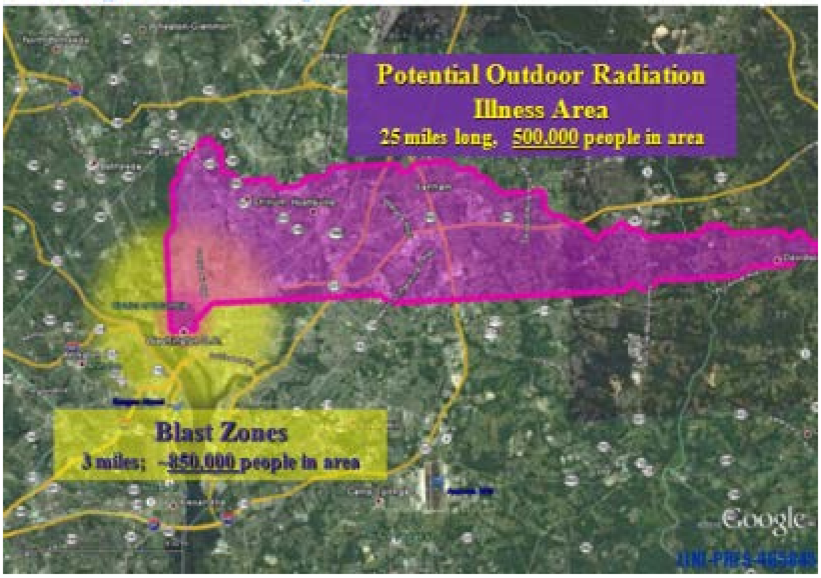
❑-Several days in good shelters (underground garages, office buildings, deep basements)

However, additional city specific analysis must be performed that takes into account the types of structures and ease of evacuation to be used for planning purposes.

Putting it into Perspective

- This slide demonstrates the areas that can lead to acute effects, the initial blast zones where there could be injuries from flying glass and debris out to 3 miles, and the dangerous fallout area could extend for 10-20 miles.

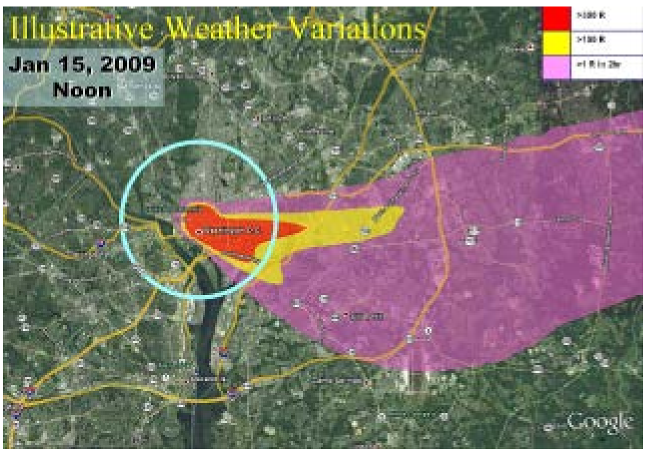
Putting It Into Perspective

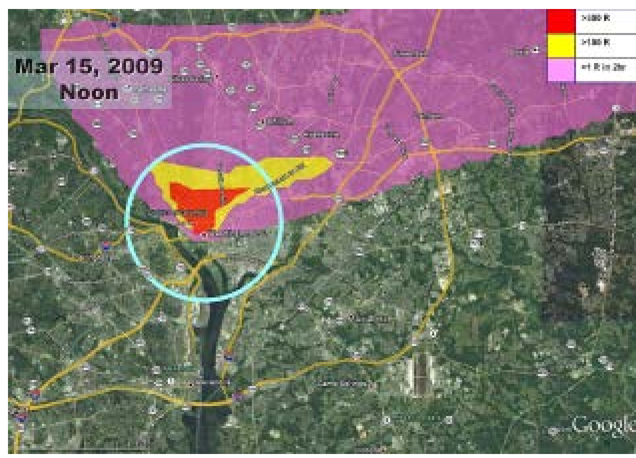


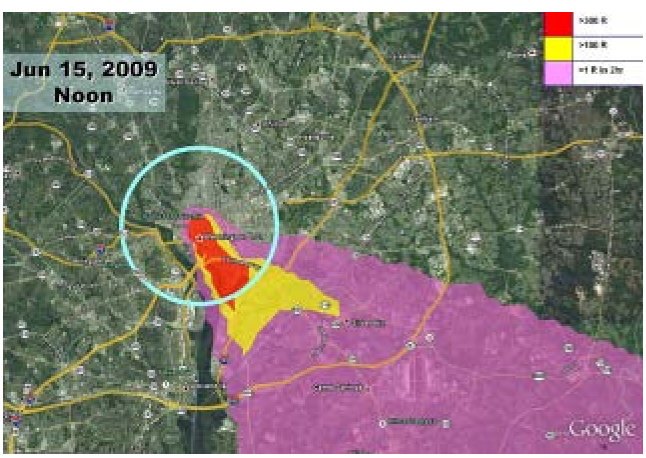
- As you can see, the areas of potential injury are small when compared to the resources of the area. While it will still be devastating, it is not the "nuclear end-all" situation that many people envision when they think about a nuclear bomb and there are a lot of resources in the surrounding area that can safely help save and sustain lives… If they know what to do!

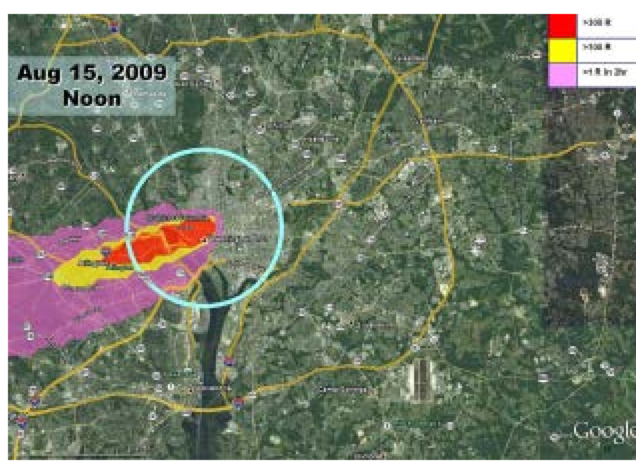
Weather Matters

- No IND response can be completely preplanned. Weather and yield will greatly affect the direction, extent, and shape of the fallout pattern. As can be seen by the following animation, which demonstrated the fallout pattern from a 10KT modeled using weather from the 15th of each month in 2009, these effects can by highly variable.









Conclusion

- **Public Protection Strategy: Early, adequate shelter followed by informed, phased evacuation**
  - With planning, residents can be aware of the dangers of a nuclear detonation, as well as what to do if it happens. People can be made aware that seeking an adequate shelter and waiting for evacuation instructions can save their lives.
- **Response Strategy:**
  - *Rapid identification of hazard areas and safe evacuation routes*
    - Being able to quickly know where the Dangerous Fallout Zone is, and the best routes based on that, is key to saving lives.
  - *Establish public communication (Emergency Alert System)*
    - Reestablishing emergency communication channels and immediately broadcasting safety messages is important to public safety.
  - *Identify priority candidates for early shelter departure*
    - Residents in inadequate shelters should be given priority when planning evacuation routes, as they will need to begin evacuation first to avoid lethal doses.
- **First hour most critical**
  - Residents need to know to immediately seek shelter.
- **100,000s of people can be saved through proper action**
  - Having informed evacuation plans in place will save many people from significant radiation doses.
- **Situation awareness, communication and independent responder actions is essential**
  - Knowing what do when an IND detonates is important and will save lives.
- **Knowing what to do before the event is critical**
  - Having response plans, knowledge about fallout, and training will save countless lives after an IND detonation.

Check Your Understanding

1. What is a protection factor and how is it used?

2. When are the radiation levels highest outside?

3. What does the optimum shelter departure time depend on?

4. What is the best action to take to avoid lethal radiation exposure?

5. How and why does the weather matter?