TITLE:	Fallout Effects (LA Version)
REQUIREMENT:	Personnel will be informed on the basic principles of fallout as well as how to remain safe when working in these conditions.
TARGET GROUP:	Radiological emergency responders and planners at the local, state and federal levels
TIME ALLOTTED:	30 minutes
INSTRUCTOR (s):	Health Physicist with Response Background
METHOD OF INSTRUCTION:	Presentation

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Date: *July 2011*

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Instructional Goal

This module gives an introduction to the basic principles of fallout, how it changes in time and space, as well as the planning guidance zones and .and definitions

Instructional Objectives

1. Define fallout and explain how it is created

2. Explain how fallout spreads
3. Explain the decay rate of fallout
4. Define Planning Guidance Zones

At the completion of training, the trainee will be familiar with:

How fallout works and how to remain safe when conducting response efforts in areas where fallout may be present.

Handouts

Student Guide

References

National Response Framework, Department of Homeland Security, January 2008.

Planning Guidance for Response to a Nuclear Detonation, Developed by the Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness & Response to Radiological and Nuclear Threats, First Edition, January 15, 2009.

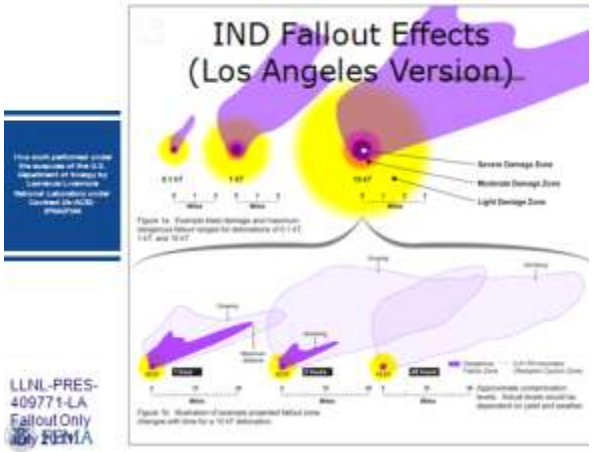
Trainee Preparation

This presentation is the third in a series, Previously covered material Includes:

- Nuclear Detonation Modeling and Response Planning

IND Prompt Effects

0- INTRODUCTION – Introduce Presenter and summarize experience and qualification



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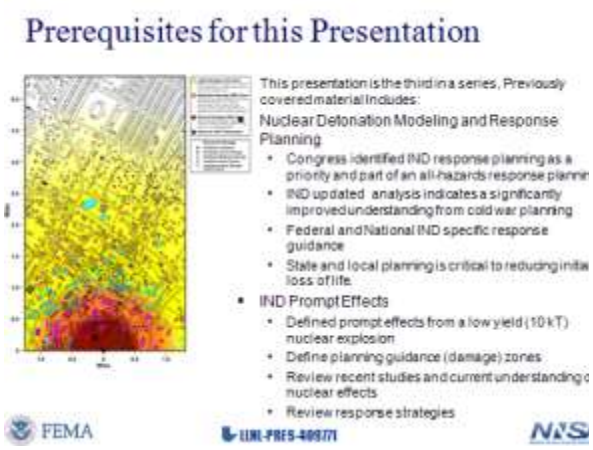
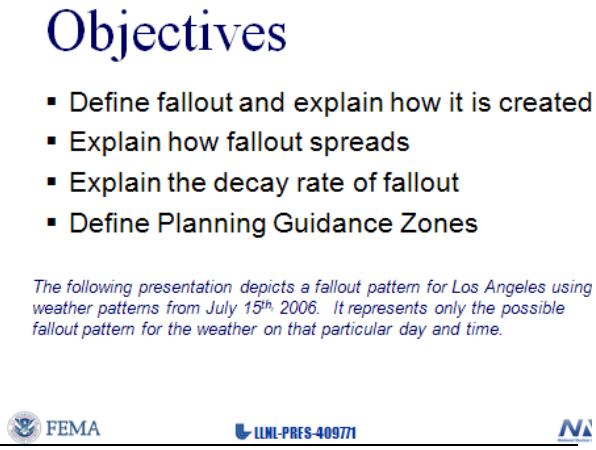
- **IND Prompt Effects**



Presentation Objectives

State Training objectives

The following presentation depicts a fallout pattern for Los Angeles using weather patterns from July 15th, 2006. It represents only the possible fallout pattern for the weather on that particular day and time.



1- Explanation of Fallout

Optional first slide. If possible, start with the slide containing the fallout movie.

The primary delayed effect from a ground-level nuclear detonation is from "fallout." Fallout is generated when the dust and debris excavated by the explosion is combined with radioactive fission products and drawn upward by the heat of the event. This cloud rapidly climbs through the atmosphere, up to five miles high for a 10kt, and highly radioactive particles coalesce and drop back down to earth as they cool.

The hazard from fallout comes not from breathing in the particles, but being exposed to the ionizing radiation they give off after they have settled on the ground and building roofs. Radiation levels from these particles will drop off quickly, with most (55%) of the potential exposure occurring in the first hour and 80% occurring within the first day. Although it is highly dependent on weather conditions, the most dangerous concentrations of fallout particles (i.e., potentially fatal to those outside) occur within 10 miles downwind of the event and are clearly visible as they fall, often the size of fine sand or table salt.

Click –Next slide; video of fallout cloud begins

This video gives a quick introduction on how dangerous radiation is formed within a fallout cloud. Fallout begins to form immediately following the detonation.

For a 10 KT detonation, Nevada Tests predict it will rise five miles into the upper-atmosphere.

Fallout clouds are not like smokestack "plumes". Rather, they are tons of material lifted by the heat of the explosion that fall back to earth as particles the size of table salt and cover flat surfaces. The radiation coming from these particles is the dangerous aspect; not breathing it.

Fallout

Blast effects are the damages/injuries done to structures/people following detonation. The severity of the effects changes based on set zones. The zones are defined by proximity to "ground zero" and are categorized by amount of damage, radiation, injury level, etc.

- **Click –Blue range line appears**

This line outlines the light damage zone (~ 3miles).

- **Click –Fireball/Mushroom cloud appear**

The fireball will quickly gather material from the ground and head upwards into the atmosphere.

Fallout Particles Move Away in Various Directions and Speeds

This image represents how fallout travels over a period of about six hours. Depending on weather conditions and wind speed, dangerous fallout particles will move away from the initial blast site in different directions at different speeds.

As this animation unfolds for the first six hours after a 10KT detonation, you will see two things:

(1) The purple balls represent the fallout cloud movement
(2) The colored contours on the ground represent the different radiation levels being given off by the particles that have fallen on the ground.

- **Click –Animation of the fallout cloud's initial movement begins.**

The upper atmosphere winds push it off to the northeast while parts of the fallout in the lower atmosphere push it off to the northwest. The different colors represent fallout levels on the ground. After just the first hour, the cloud moves away, but the dangerous radiation remains present on the ground.

- **Click –Animation continues, showing the remainder of a six-hour period.**

It is important to remember that even though you might not be able to see any type of cloud after the first hour, dangerous radiation levels will remain. Understanding how radiation remains behind following the detonation is a key response issue.

Fallout Clouds Spread Rapidly

- **Slide Transition –Animation begins showing the fallout cloud over a larger area.**

Note how the radiation level on the ground lag significantly behind the movement of the fallout cloud. This is because the fallout particles have to fall from several miles in the upper atmosphere.

First 45 minutes: LA Basin

The cloud moves away quickly, but has already deposited dangerous levels of radiation over areas near the detonation site. At 45 minutes the cloud reaches the edge of the LA basin

2 hours: over Palmdale

The cloud continues to move away from the detonation site and continues to deposit some fallout.

Animation continues to show the spread of the fallout cloud

Even though the cloud continues to spread over large areas, the radiation dose to areas below continues to lessen.

The good news about fallout is that it does decay quickly. This means that as the cloud moves farther away, the radiation levels in areas where the fallout has already been deposited will lessen over time.

DHS and EPA Guidelines on Exposure Levels

Although there are current guidelines for shelter or evacuation, they were designed for slowly evolving events like a possible nuclear power accident.

These recommendations indicate that you should ***consider*** shelter or evacuation when a four day outdoor exposure would exceed one rem, and shelter or evacuation is warranted if expected exposure exceeds five rem.

Unfortunately it fails to actually tell you which (shelter or evacuation) is the better option, instead stating that you should choose the option that leads to the lowest possible exposure and leaves the evaluation to be performed on the fly.

These figures demonstrate why having response plans is so crucial to saving lives, as figuring out what to do with several million people after the detonation is likely to be impossible.

2- Fallout Effects

Dose Rates Decay Quickly

- **Click – Animation showing detail of detonation area begins**

Simply understanding how fallout works is not enough. It is important to understand what the event will look like from a first person perspective of the event.

- **Click – View from Hollywood Hills appears**

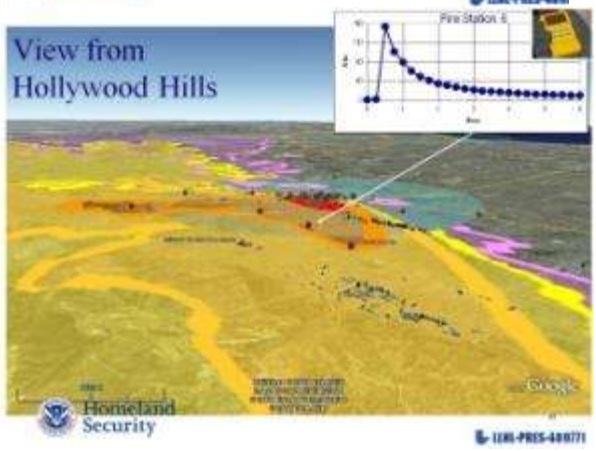
This animation shows what things will look like from someone around the Hollywood Hills area.

- **Click – Fire stations around detonation site appear**

These red areas represent fire stations outside of the more severe damage zones. These stations have a good chance of not being destroyed from the blast itself, but are in the path of the fallout cloud, and thus susceptible to dangerous radiation levels.

- **Click – Fireball reappears, and dose rate monitoring for Fire Station 6 appears**

This example tracks the outdoor exposure rate at Fire Station Number Six. You don't need to focus on the actual numbers, but, rather, look at the trend of the dose rate.



- **Click – Fallout cloud appears; dose rate in first 15 minutes appears**

The fallout cloud is already overhead, but not enough fallout has reached the ground, so the radiation levels will stay negligible for several minutes. As the cloud reaches them, dose rates will shoot up to 160 R/hr at the half hour mark. This is over 10 times the 10 R/hr of the Dangerous Fallout Zone.

- **Click –Animation continues showing dispersing fallout cloud and different dose rates**

While initial dose rates are high, look how fast the rates

begin to drop. This is because radiation has an extremely short half-life; it decays very quickly. Over half of the dangerous radiation dose comes from the first hour of exposure.

Key Fallout Considerations

- **Click –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 comes off in the first hour.

- **Click –Animation starts/The primary hazard from fallout is being exposed to penetrating radiation from the particles**

The hazard is the "waves" of 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.

- **Click –Dangerous levels of fallout are readily visible as they fall**

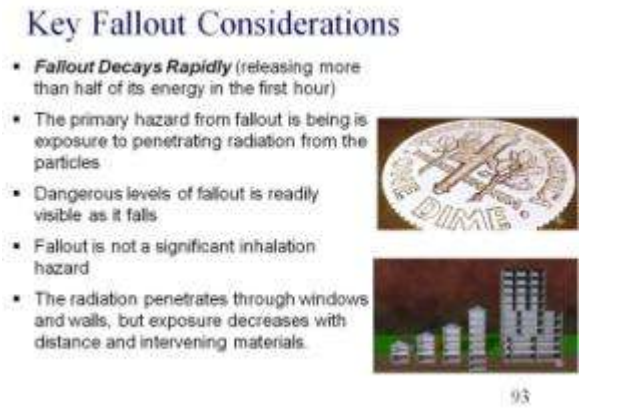
Dangerous levels of fallout are not invisible; there will be visible quantities of material raining down, often the size of salt or sand.

- **Click –Fallout is not a significant inhalation hazard**

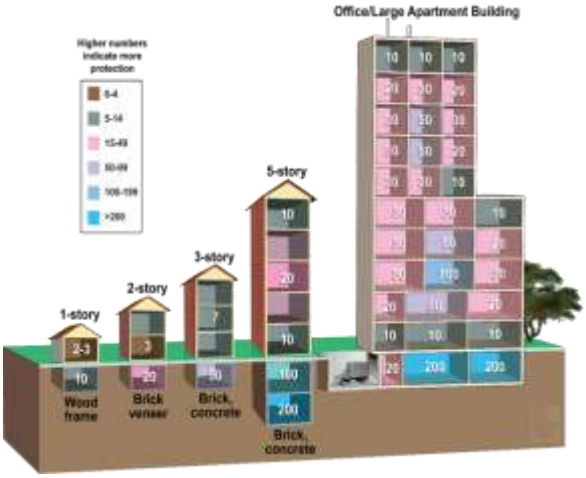
Because they are so large, breathing in the particles is not very likely and is a much lower concern than the external exposure from the particles on the ground.

- **Click –Animation of shelter protection factors begins**

As can be seen by this animation, the particles coat the ground and rooftops. The hazard areas are the ones by 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.



3- The Dangerous Fallout Zone

More Information on the DFZ

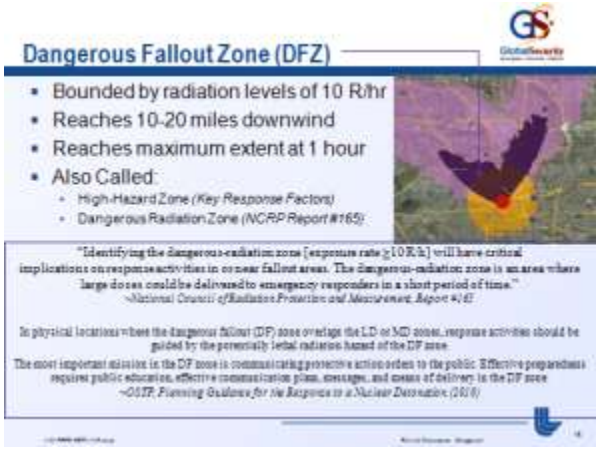
Here is some more crucial information about the DFZ:

- **Bounded by radiation levels of 10R/hr** – determining dose rates early on helps to identify the perimeters of the DFZ

  • Could reach 10-20 miles downwind before the decay of the radiation causes this zone to shrink

- **Also called**:
  - ✓ High-Hazard Zone
  - ✓ And the Inner Perimeter

After establishing the perimeter of the DFZ, everyone should be aware that entering that area can cause acute radiation injuries or death. Responders should enter this area only voluntarily, and only after being fully informed of the risks.



The DFZ Changes Rapidly with Time

The 'Silver Lining' of radiation is the short half-life; it decays extremely rapidly.

This animation shows how fallout reaches its peak after about an hour, than begins to recede.

Click –Animation begins

This shows the first six hours after the detonation.

Click -24 hours appears

The DFZ has already less than half its original size.

Click -48 hours appears

After 48 hours, nearly all of the LDZ is safe to enter.

Radiation Zones Take Precedent

This graphic illustrates the maximum extent for several different low yield, ground-level explosions. Note how smaller yields create much smaller DFZs. The timing will also be accelerated and the fallout will reach the maximum extent much quicker.

When determining damage zones, radiation levels must also be taken into account. After determining the path of the dangerous radiation zone from fallout, certain rules will apply. These are:

- **The dangerous radiation zone from fallout will overlap damage zones**

- **When zones overlap, radiation precautions take precedent** – even if responders know there are victims within the moderate and light damage zones, they should not enter until dangerous radiation levels are no longer present

- **Initial efforts should focus on the portions of the damage zones that are outside the dangerous radiation areas** – responders should initially wait to enter areas within the light and moderate damage zones, and focus on responding to areas

outside of the dangerous fallout zone

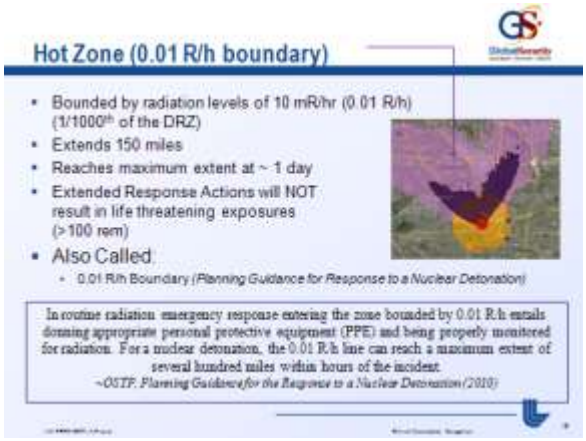
4. Secondary Response Concerns

Hot Zone

The 0.01 R/h boundaries, often referred to as the Hot Zone, are areas extending from the DFZ that have radiation levels of 10mR/hr, only 1/1000th of the rate found in the DFZ. For a 10 KT detonation, the Hot Zone could extend in a number of directions for 100s of miles, but will reach its full potential after one day.

Response actions in Hot Zones will NOT result in significant exposures of 100 rem and higher.

Caution should still be taken along the edges of the Hot Zone closest to the DFZ.



0.01R/h Boundary Changes with Time

Just like the DFZ, the Hot Zone will change with time.

This animation shows how the Hot Zone reaches its peak after about one day, than begins to recede.

- **Click –Animation begins**

This shows the first six hours after the detonation.

- **Click -24 hours appears**

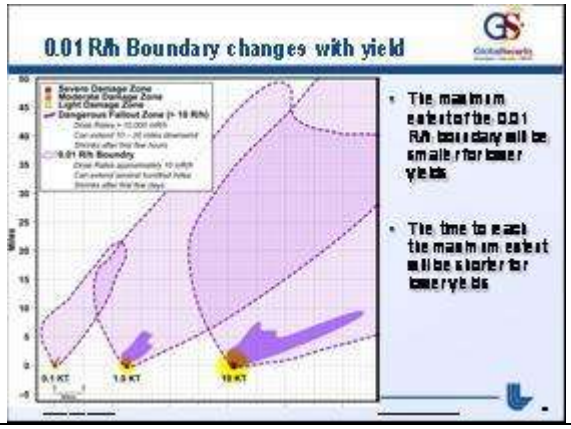
The Hot Zone is already shrinking in size.

- **Click -48 hours appears**

After 48 hours, the Hot Zone is greatly reduced.

Also Changes with Yield

This graphic illustrates the maximum extent for several different low-yield, ground level explosions. Note how smaller yields create much smaller Hot Zones. The timing will also be accelerated and the fallout will reach the maximum extent much quicker.

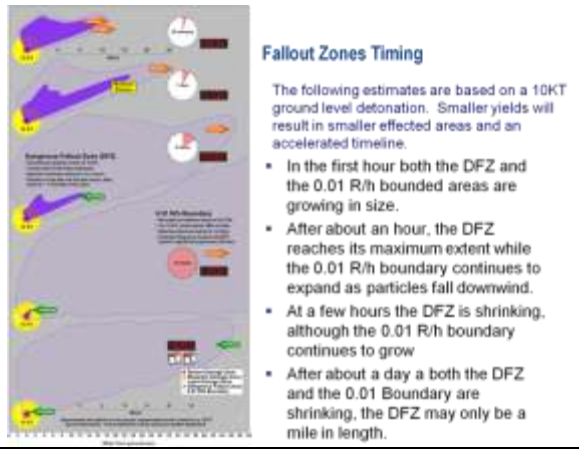


Fallout Zone Timing

The example list is just for a 10KT, lower yields will have accelerated timing.

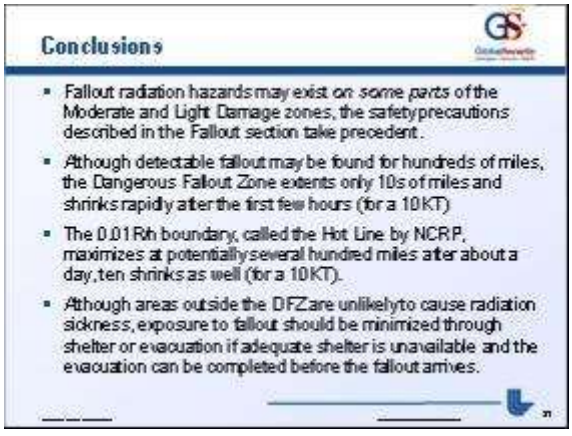
This example tracks both the DFZ and 0.01 R/h border with time

{review slide}



Conclusions

- Fallout radiation hazards may exist ***on some parts*** of the Moderate and Light Damage zones, the safety precautions described in the Fallout section take precedent.
- Although detectable fallout may be found for hundreds of miles, the Dangerous Fallout Zone extends only 10s of miles and shrinks rapidly after the first few hours (for a 10KT)
- The 0.01R/h boundary, called the Hot Line by NCRP, maximizes at potentially several hundred miles after about a day, and then shrinks as well (for a 10KT).
- Although areas outside the DFZ are unlikely to cause radiation sickness, exposure to fallout should be minimized through shelter or evacuation if adequate shelter is unavailable and the evacuation can be completed before the fallout arrives.



Check Your Understanding

1. What is Fallout?
2. How high will a 10kT fallout cloud rise in the atmospher
3. Is it true that if you don't see the radiation cloud, then it to be outside? Why or why not?
4. How much energy does fallout lose in the first hour?
5. Name the boundary dose rates of the 2 fallout zones.
6. Does Fallout radiation only appear in these zones?
7. About how far do the zones extend to?
8. When do they reach their maximum?

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