



Center for Biosecurity of UPMC

Rad Resilient City:

A Preparedness Checklist for Cities to Diminish Lives Lost from Radiation after a Nuclear Terrorist Attack





FALLOUT PREPAREDNESS CHECKLIST

- ❑ **ACTION 1:** Obtain broad community backing and understanding of nuclear incident preparedness to sustain the program over time.
- ❑ **ACTION 2:** Conduct an ongoing public education program to inform the public about the effects of a nuclear detonation and how they can protect themselves.
- ❑ **ACTION 3:** Enable building owners and operators—from individual householders to skyscraper managers—to assess shelter attributes and to teach others.
- ❑ **ACTION 4:** Strengthen the region’s ability to deliver actionable public warnings following a nuclear detonation through well-chosen technologies and organizational procedures.
- ❑ **ACTION 5:** Establish a rapid system for mapping and monitoring the dangerous fallout zone to specify which residents need to take what protective action.
- ❑ **ACTION 6:** Develop planning strategies and logistical capabilities to support a large-scale, phased evacuation.
- ❑ **ACTION 7:** Integrate, test, and conduct training on the above elements of a comprehensive fallout preparedness and public warning system.



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Lost from Radiation after a Nuclear Terrorist Attack

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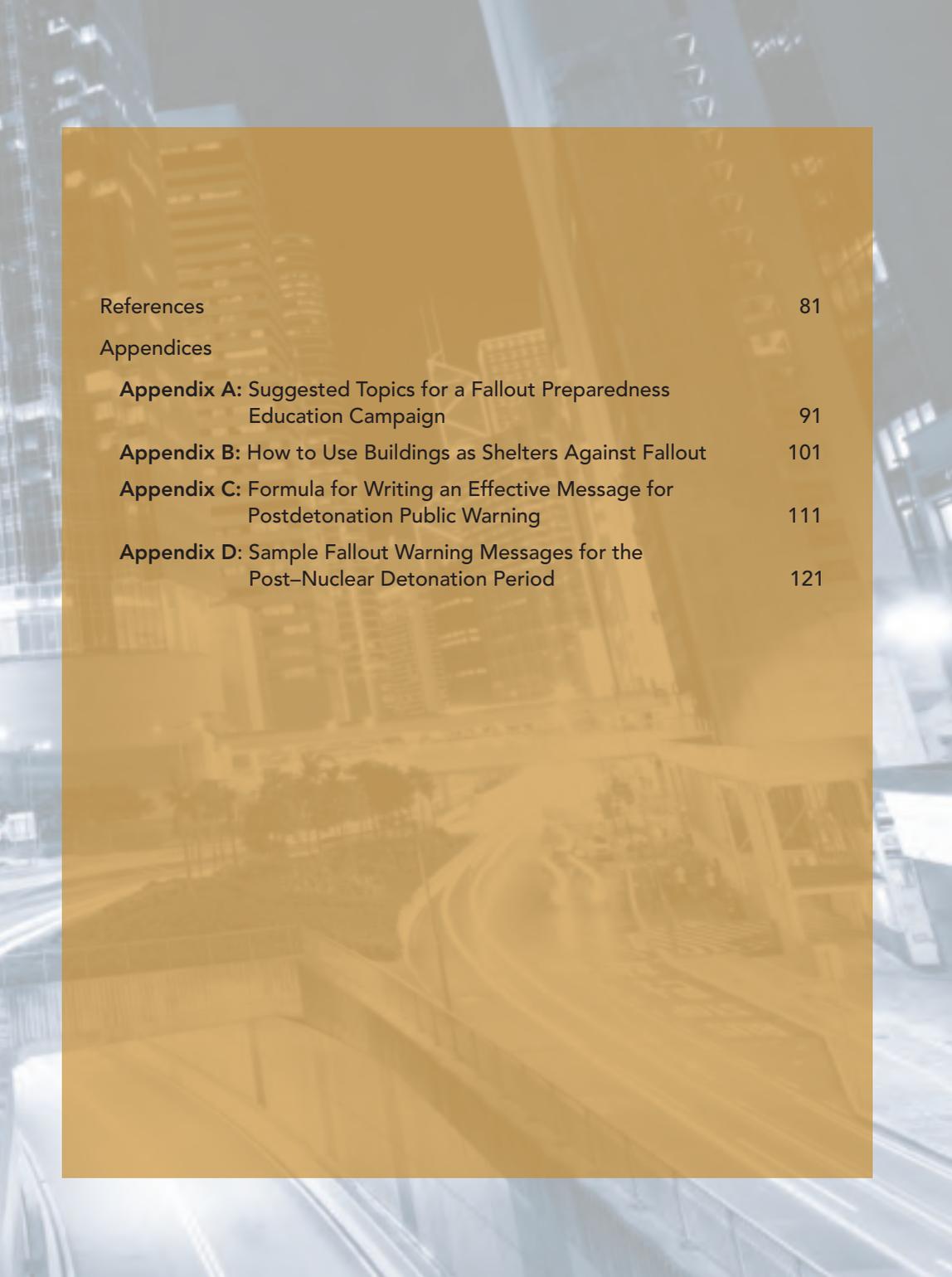
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Executive Summary

EXECUTIVE SUMMARY

The purpose of this document is to provide cities and their neighbors with a checklist of preparedness actions that could save tens of thousands of lives following a nuclear detonation through adequate protection against radioactive fallout. This *Fallout Preparedness Checklist* converts the latest federal guidance and technical reports into clear, actionable steps for communities to take to protect their residents. The checklist and supporting materials reflect the shared judgment of the Nuclear Resilience Expert Advisory Group, led by the Center for Biosecurity of UPMC in 2011. This interdisciplinary panel includes government decision makers, scientific experts, emergency responders, and leaders from business, volunteer, and community sectors.

Nuclear terrorism is a real and urgent threat, according to assessments by the U.S. and other governments and by independent nongovernment experts.^{1,3} Detonation of a crude nuclear bomb in a thriving city could kill tens of thousands of people, dislocate millions, and inflict immense economic and social damage.⁴ Even if prevention fails, U.S. cities need not be resigned to a worst-case toll of injuries and deaths. Casualties due to exposure to radioactive dust and debris—that is, “fallout”—could be minimized if the public immediately sought adequate shelter and awaited further information before evacuating.^{5,6} Federal modeling of a 10-kiloton groundburst in Los Angeles suggests that if everyone at risk of exposure to dangerous fallout quickly went into a shallow basement or an equally protective place, then 280,000 lives could be saved.⁷

Cold War memories and movies have shaped popular ideas about nuclear weapons and created a fatalistic outlook about nuclear terrorism that still persists. But the terrorist scenario of a low-yield explosion in a modern urban setting does not, by any means, approach the wholesale destruction

imagined in an all-out nuclear war. This document dismantles these and other misconceptions that may be held by communities and their leaders. Users learn that:

- Not all casualties due to a nuclear detonation are predetermined; those from exposure to fallout can be prevented.
- Quickly sheltering in the right place—not fleeing the area—is the safest thing to do after a nuclear attack.
- People can protect themselves immediately following a detonation and should not wait for emergency professionals to help them.

The *Fallout Preparedness Checklist* provides mayors, county executives, city administrators, emergency managers, public health and safety officers, business executives, heads of volunteer- and community-based groups, and other local opinion leaders with a unified vision and concrete implementation plan for fallout preparedness. Recognizing that implementation will take time, the checklist balances the practical and the “perfect,” and it puts actions in order of priority. A high-level summary of the checklist is below.

FALLOUT PREPAREDNESS CHECKLIST

- ❑ **ACTION 1: Obtain broad community backing for nuclear incident preparedness.** Fallout preparedness requires commitment across a community. There is no single entity that can deliver this public service. Sound emergency management structures and strategies are essential, but so too are efforts by businesses, schools, nonprofits, and average citizens. A coalition of diverse stakeholders can help overcome the political and popular resistance to planning for an unthinkable incident like a nuclear detonation.
- ❑ **ACTION 2: Conduct ongoing public education to inform members of the public about the effects of a nuclear detonation and how they can protect themselves.** In a “no notice” nuclear detonation, people need to be empowered beforehand with the knowledge that the most effective action they can take is to find adequate shelter immediately. Following a detonation, it will be difficult or impossible to issue fallout warnings in the areas that most need them due to destruction and disruption of the communication infrastructure.
- ❑ **ACTION 3: Enable building owners and operators—from individual householders to skyscraper managers—to assess shelter attributes and to teach others.** U.S. studies show that people spend almost 90% of their time in enclosed buildings. Homeowner associations, commercial building managers, public building operators, faith-based entities, and school facility administrators can adopt and promulgate shelter rating information so that occupants of all types learn which structures and which places within them provide the most safety.
- ❑ **ACTION 4: Hone the ability to deliver public warnings post-incident.** Assuming a degraded communication infrastructure in certain locales, jurisdictions need to devise creative ways to deliver fallout warnings (eg, blending radio broadcasts with text-based messaging) and to have pre-scripted, scientifically based public messages about protective actions. City leaders should not wait until after an incident to decide who should authorize the release of a fallout warning and what it should say. Time delays can result in preventable deaths.

- ❑ **ACTION 5: Establish a rapid system for mapping and monitoring the dangerous fallout zone.** Knowing the fallout “footprint” (from on-the-ground monitoring) can vastly improve guidance about which residents need to evacuate, how quickly, and which routes present the lowest possible exposure. It will be just as important to communicate to people for whom fallout is not a health risk. Unnecessary evacuation strains resources and infrastructure needed for people in high-risk areas.
- ❑ **ACTION 6: Develop capabilities to support a large-scale, phased evacuation.** At a certain point in time, some people will need to transition from their protective shelter to a place of greater safety. This complex task calls for advance planning. People still exposed to significant radiation levels and those suffering from life-threatening injuries will need to leave the area sooner than others, and their departure could be impeded by impassable roads and heavy demand.
- ❑ **ACTION 7: Integrate, test, and conduct training on the above elements of a comprehensive fallout preparedness and public warning system.** Unless people have a chance to train and to practice in routine—that is, nonemergency—time, they will be less likely to perform well when it really matters.

Successful adoption of the *Fallout Preparedness Checklist* can benefit communities by:

- Producing spillover effects for the management of other complex, regional disasters;
- Making a jurisdiction’s all-hazards framework more robust in addressing nuclear terrorism;
- Creating momentum to tackle other difficult nuclear response issues like the sheltering of mass displaced populations; and
- Saving tens of thousands of lives after an actual nuclear detonation.



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FEMA/Mark Wolfe



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RAD RESILIENT CITY:

A PREPAREDNESS CHECKLIST FOR CITIES TO
DIMINISH LIVES LOST FROM RADIATION
AFTER A NUCLEAR TERRORIST ATTACK

Two decades after the end of the Cold War, we face a cruel irony of history — the risk of a nuclear confrontation between nations has gone down, but the risk of nuclear attack has gone up.

— President Barack Obama,
Remarks at the Nuclear Security Summit,
April 13, 2010

WHAT IS THE PURPOSE OF THIS DOCUMENT?

This document provides cities and their neighbors with a checklist of preparedness actions that could save tens of thousands of lives or more following a nuclear detonation through adequate protection against radioactive fallout.

WHY IS A FALLOUT PREPAREDNESS CHECKLIST NEEDED?

If prevention of nuclear terrorism fails, then reducing exposure to radioactive dust and debris—that is, “fallout”—is *the* intervention that can save the most lives following a nuclear detonation. Nuclear terrorism is a real and urgent threat, according to assessments by the U.S. and other governments and by independent, nongovernment experts.¹⁻³ Detonation of a 10-kiloton nuclear device in a thriving urban center could kill tens of thousands of people, dislocate millions, and inflict significant economic and social damage.⁴

U.S. cities may face the possibility of a nuclear detonation, but they do not have to resign themselves to a worst case toll of injuries and deaths. Sickness and death resulting from exposure to fallout could be minimized if the public immediately sought adequate shelter and awaited further information before evacuating.^{5,6} Federal modeling of a 10-kiloton groundburst in Los Angeles suggests that if everyone at risk of exposure to dangerous fallout quickly went into an adequate shelter, like a shallow basement or the middle of a multi-story building, then 280,000 lives could be saved.⁷

Most Americans, however, are not familiar with correct safety measures against fallout. In fact, many Americans believe that nothing can be done to reduce the suffering inflicted by a nuclear attack. Moreover, cities have no checklist on how to prepare the emergency management infrastructure and the larger population for this radioactive hazard, despite hundreds of pages of useful guidance from the federal government and radiation professional organizations. Experts generally agree that the country is not well prepared to respond to a nuclear catastrophe.⁹⁻¹³

The *Fallout Preparedness Checklist* converts new federal guidance and technical reports into a community-based vision of fallout preparedness, and it provides clear, actionable steps for cities and their neighbors to follow in implementing that vision. Actions are prioritized so that cities and their neighbors know where to apply their resources first and foremost. Hardly a far-fetched activity, fallout preparedness hinges on a very familiar formula for disaster readiness: the ability to shelter in place. In the case of a nuclear detonation, sheltering could last 1 day, at a minimum, to avoid the highest levels of radiation. People may also find it necessary or be advised to stay sheltered for 2 to 3 days or more depending on the state of infrastructure and other logistics.

WHO IS THE INTENDED AUDIENCE?

Everyone who holds sway and authority in a city and its surrounding communities—mayors, county executives, city administrators, emergency managers, public health and safety officers, business executives, chiefs of volunteer- and community-based groups, heads of faith-based organizations, and other local opinion leaders—are encouraged to put the *Fallout Preparedness Checklist* into action in their hometowns. While high-threat, high-density urban areas have strong incentives to adopt this checklist, any community concerned with a comprehensive approach to disaster preparedness can benefit from the recommended course of action and the supporting materials.

WHAT KNOWLEDGE INFORMS THE CHECKLIST?

The *Fallout Preparedness Checklist* is the work of the Nuclear Resilience Expert Advisory Group.

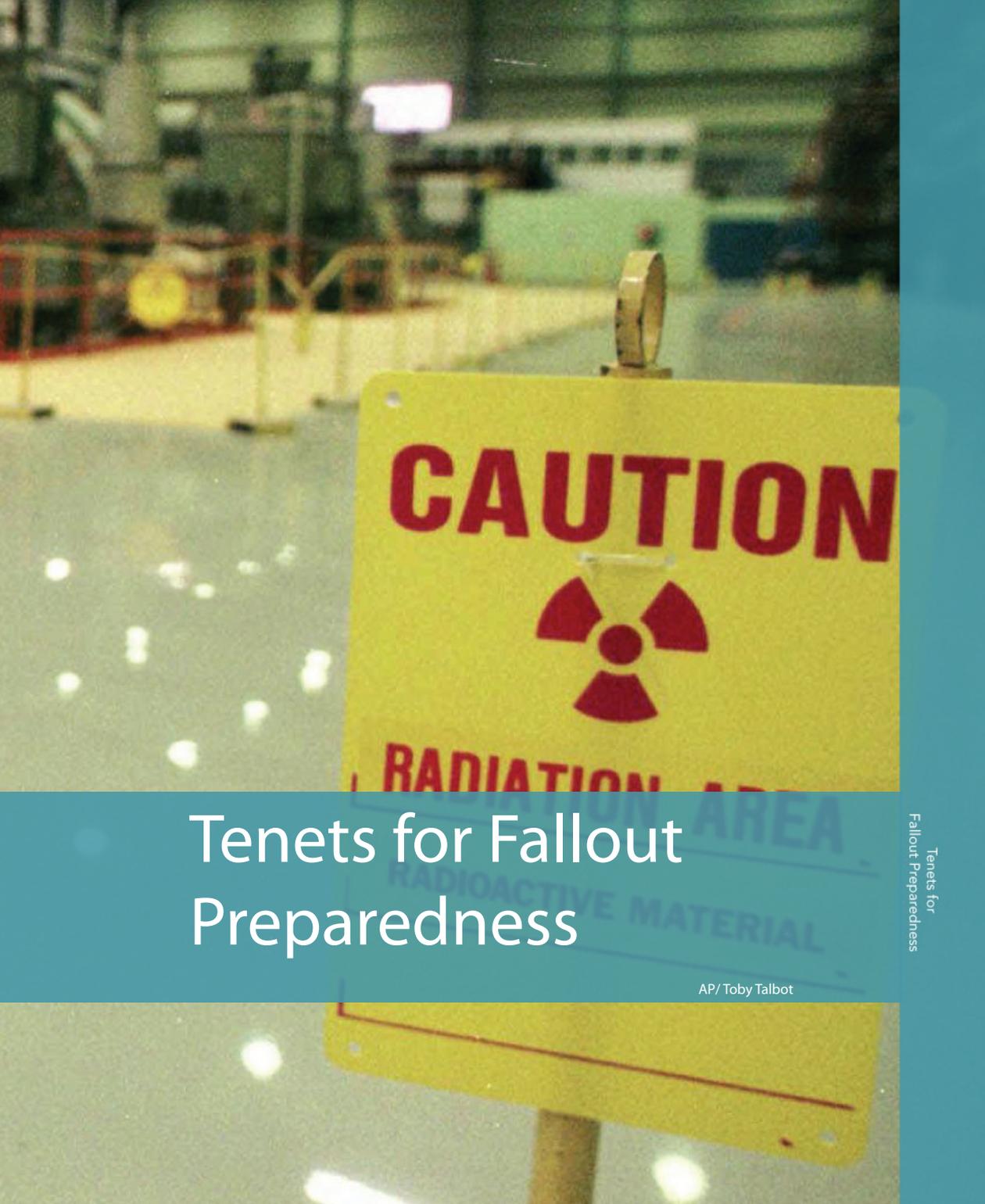
Led by the Center for Biosecurity of UPMC, this panel includes seasoned decision makers from local and federal government; practitioners in emergency management, public health and safety, radiation control, and law enforcement—all from high terrorism risk jurisdictions; leaders from the business, community, and volunteer sectors; and experts in health physics, disaster sociology and psychiatry, disaster management, risk communication, vulnerable populations, public education, public warning, and evacuation.

The checklist and supporting materials reflect the experience and professional judgment of the Expert Advisory Group, as well as evidence obtained by the review of relevant literature, including current federal guidance on nuclear incident response, technical committee reports from radiation professional organizations, research studies on community preparedness, and select local radiation emergency plans and protocols. National practitioner organizations in the fields of emergency management, public health, and radiation control reviewed and further improved the document.

The *Fallout Preparedness Checklist* is in keeping with federal recommendations. On issues in which federal guidance has not yet been provided or developed, the Expert Advisory Group provided its best judgment. These limited instances are noted in the document.

WHAT TENETS UNDERPIN THIS APPROACH TO FALLOUT PREPAREDNESS?

Much of what the public knows or imagines about nuclear detonations has been shaped in the context of Cold War science, military strategy, and movies such as *The Day After*. Many such notions, however, do not apply to nuclear terrorism involving a low-yield explosion in a modern urban setting. Ideas about what constitutes the best protective actions may similarly be based on false premises. The next section therefore provides a common baseline of understanding in advance of a community integrating fallout preparedness into its larger disaster agenda. It reviews relevant scientific details, operational considerations, and planning assertions that underpin the proposed checklist for fallout protection.



Tenets for Fallout Preparedness

AP/Toby Talbot

TENETS FOR THE FALLOUT PREPAREDNESS CHECKLIST

- **TENET 1:** In contrast to Cold War images of widespread destruction, terrorist-sponsored nuclear threats pose a more contained range of damage and a higher degree of survivability.
- **TENET 2:** Not all casualties due to a nuclear detonation are destined to happen; those that result from exposure to radioactive fallout can be prevented.
- **TENET 3:** Quickly going and staying inside the closest, most protective building—not fleeing the area—saves lives by minimizing exposure to fallout.
- **TENET 4:** Evacuation may further reduce radiation exposure (after initial sheltering), but it only makes sense when sufficient information and logistical capacity exist.
- **TENET 5:** An informed public capable of acting on its own can save more lives following a nuclear blast than can a limited number of emergency professionals.

TENET 1: In contrast to Cold War images of widespread devastation, terrorist-sponsored nuclear threats pose a more contained range of damage and a higher degree of survivability.

These guidelines are based on a 10-kiloton ground-level detonation, with no advance warning, as outlined in National Planning Scenario #1.¹⁴

Ten kilotons is considered the “approximate yield of a fully successful entry-level fission bomb made by a competent terrorist organization.”¹⁵ It is also the scale of the attack outlined in the first of 15 national planning scenarios developed by the Department of Homeland Security (DHS) to support national and local preparedness and to help identify what resources and abilities are needed to respond to a range of terrorist attacks and natural disasters. Many unknowns about an actual weapon, however, have implications for fallout preparedness and response. These include the nuclear yield of the weapon, the device’s location, its altitude above ground, weather conditions, and the time of detonation (ie, during the workday or at night). Such factors determine the potential impact and the populations at risk. The actions in the *Fallout Preparedness Checklist*, however, are sound and apply to the full range of nuclear detonation scenarios, not just the 10-kiloton context. Alternative scenarios, such as the situation in which a terrorist organization claims to have placed a nuclear device in a city, present additional challenges such as interdiction and are outside the scope of this document.

In terms of scale, an act of nuclear terrorism bears no resemblance to a Cold War nuclear attack on the United States.

A nuclear war scenario modeled in 1985 assumed 6,559 megatons (6,559,000-kilotons) of nuclear explosives aimed at targets throughout the U.S., and it projected only 93 million survivors, of whom approximately one-third would be injured.¹⁶ By comparison, a 10-kiloton groundburst would

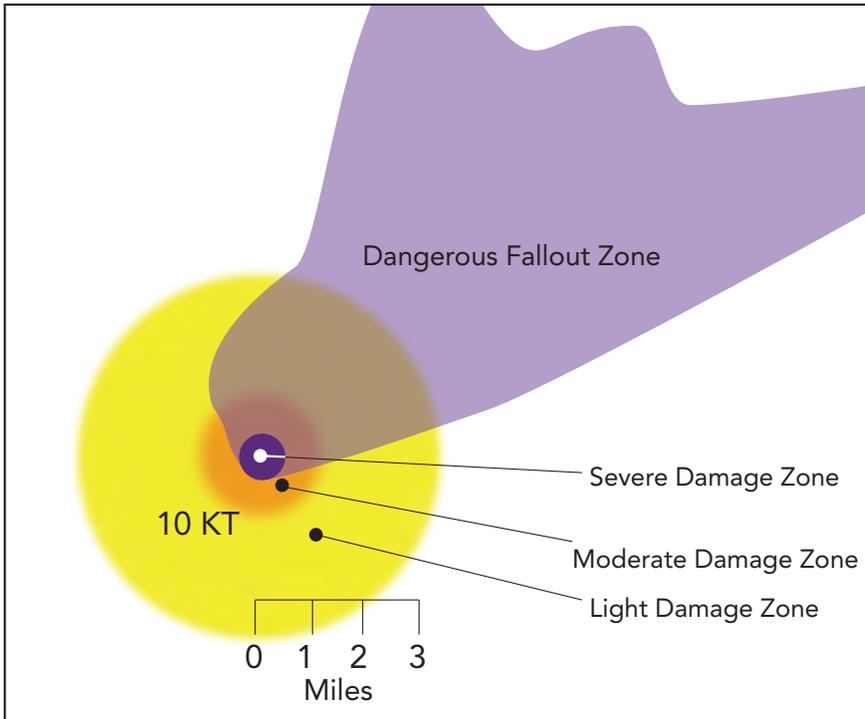
create an explosion 5,000 times greater than the Oklahoma City bomb.^{6,17} In other words, 10 kilotons is about two-thirds the estimated yield of the atomic bomb (approximately 14 kilotons)¹⁸ dropped on Hiroshima—a city that has recovered and is thriving once again.

A 10-kiloton nuclear detonation will cause severe damage at ground zero; the damage will then decrease over a distance of a few miles.

The initial explosion will produce a blast wave and an intense thermal pulse that will dissipate over a few miles resulting in severe damage within a radius of approximately one-half mile or 10 average city blocks (see Figure 1). Within this severe damage zone, nearly all buildings and structures will be reduced to rubble; few people will survive unless protected by robust buildings or stable underground structures. From 0.5 to 1 mile beyond the blast area, the moderate damage zone will include blown-out building interiors and destroyed lighter buildings.⁵ In this zone, many people will survive, although many will have significant injuries. A greater number of survivors are expected in the light damage zone, which may extend from 1 mile to beyond 3 miles from the blast area and will be characterized by broken glass and damaged roofs due to shock waves.

Most destruction in the damage zones will happen in seconds, leaving people little time to take protective actions. The nuclear detonation will also produce a flash of radiation, with intense light and heat. The immediate (or prompt) radiation generated during the detonation (which is distinguished from delayed outdoor radiation or fallout) could injure people who are outdoors up to a mile away. Fires and serious burns will affect buildings and people up to a mile from the explosion. “Flash blindness” (usually temporary blindness, lasting from several seconds to minutes) may also affect those people who observe the flash of intense light energy—perhaps as much as 10 miles from the explosion.⁵

Figure 1: Damage and Fallout Zones Modeled for 10-Kiloton Groundburst



Adapted from Knebel AR, Coleman CN, Cliffer KD, et al. Allocation of scarce resources after a nuclear detonation: setting the context. *Disaster Med Public Health Prep* 2011;5(Suppl 1):S20-S31.

TENET 2: Not all casualties due to a nuclear detonation are destined to happen; those that result from exposure to radioactive fallout can be prevented.

Fallout is made of highly radioactive particles mixed with dust and debris, and it can be spread quickly and widely by upper and lower air patterns.

The highly radioactive particles that make up fallout are generated when vaporized and irradiated earth and debris are drawn upward by the fireball's heat and combine with the radioactive fission products created by the detonation. This cloud rapidly rises to an altitude of 2-5 miles for a 10-kiloton detonation, where, under some weather conditions, it assumes a mushroom shape.¹⁹ As the cloud cools, highly radioactive particles coalesce and fall to earth, with the heaviest and most dangerous falling first. Fallout will likely be visible as ash, rain, or particles the size of sand, but it may be present even if it is not visible. The distribution of fallout is determined primarily by upper level and surface wind patterns, which often travel in different directions from each other. Because wind patterns are so variable, fallout deposition cannot be predicted ahead of time. Even in real time, fallout patterns are difficult to predict because of microclimates, urban canyon effects, and other complications. Hence, actual measurements on the ground should augment plume models.

Fallout poses its greatest health effect in the hours immediately following the detonation, during which time high levels of penetrating radiation can lead to death.

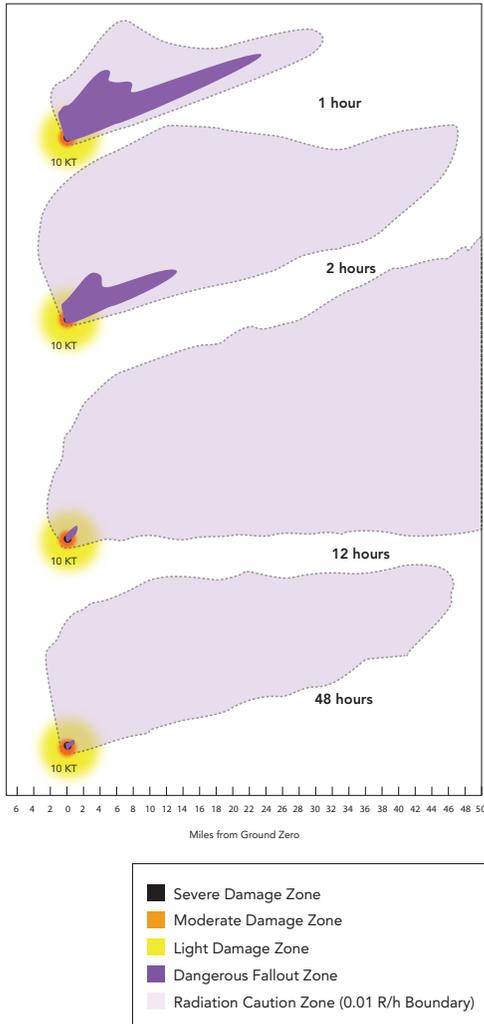
The health hazard associated with fallout comes primarily from the human body's exposure to penetrating radiation (similar to x-rays) discharged from fallout that has settled on the ground and building roofs. Exposure to high levels of radiation over a short period of time can cause acute radiation syndrome, in which people become very ill or die within minutes to months. The *Fallout Preparedness Checklist* focuses principally on the goal of saving

the most lives in the immediate aftermath of a detonation by reducing the chances that people will develop acute radiation syndrome. This can be achieved if people take prompt protective actions against fallout exposure (Tenets 3 and 4). Outside the scope of the *Fallout Preparedness Checklist* is the delayed health effect that comes from exposure to lower doses of radiation over time, namely, an increased chance of developing cancer later in life. This delayed health effect is of secondary concern in the nuclear detonation context. In contrast, planning around nuclear accidents—usually slowly evolving events—focuses primarily on the goal of cancer avoidance by limiting individuals’ level of exposure to radiation to “as low as reasonably achievable.”

The strength of radiation drops sharply over time and distance from the nuclear detonation.

Radiation levels from fallout particles drop off rapidly with the passage of time, with more than half (55%) of the potential exposure occurring in the first hour and 80% occurring within the first day. The most dangerous concentrations of fallout particles (ie, potentially fatal to those outdoors) could extend 10 to 20 miles downwind from ground zero.⁵ This area is called the dangerous fallout zone (DFZ) (see Figure 1). Larger radioactive particles will settle out within 1-2 hours of the nuclear detonation, leaving behind the DFZ footprint.⁵ Most people in the DFZ will experience some level of exposure to fallout,⁷ but a series of decisions regarding shelter and evacuation may vastly reduce their chances of becoming sick or dying from high radiation levels. Outside the DFZ, fallout with lower levels of radiation will be spread up to hundreds of miles away. Radiation levels in this area, known as the radiation caution zone, are not high enough to cause immediate health problems. Nonetheless, protective actions such as sheltering/evacuation, controls on food consumption, and water advisories are warranted to prevent accumulated exposure to radiation that could result in a greater chance of cancer over a lifetime. Figure 2 illustrates how the radiation zones shrink dramatically over time.

Figure 2: Time Sequenced Size of Dangerous Fallout Zone and Radiation Caution Zone (0.01 R/h Boundary) for the 10 KT Groundburst Scenario



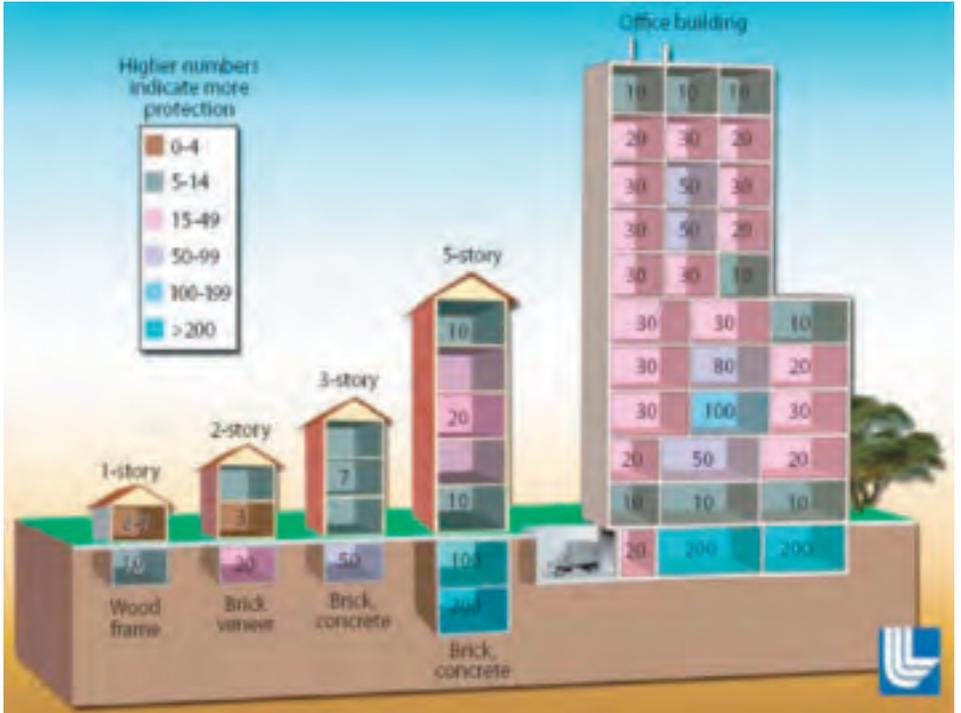
Adapted from: National Security Staff Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats. Planning guidance for response to a nuclear detonation. 2d edition. 2010. <http://www.remm.nlm.gov/PlanningGuidanceNuclearDetonation.pdf>.

TENET 3: Quickly going and staying inside the closest, most protective building—not fleeing the area—saves lives by minimizing exposure to fallout.

Sheltering in common urban structures such as large office buildings or underground garages significantly reduces radiation exposure.^{6,20,21}

A building’s “protective factor” (PF)—that is, the level of protection from radiation—is a measure of the structural materials and the distance between people and radioactive fallout.⁵ The greater the protective factor, the better the shelter (see Figure 3). Dense materials such as brick, cement, and earth provide better protection than wood, drywall, and thin sheet metal. Areas within a building, such as restrooms and stairwell cores, which are distant from deposited radioactive fallout, provide better protection than those close to roofs, windows, and exterior walls. Multistory brick or concrete structures, cores of large office buildings, multistory shopping malls, and basements, tunnels, subways, and other underground areas are examples of good shelters. Many good shelters will also have ventilation systems that should be shut down or segmented to prevent the introduction of radioactive fallout in the building. Examples of poor shelters include outdoor areas, cars and other vehicles, mobile homes, single-story wood-frame houses, strip malls, and other single-story light structures.²² For more detail on protective factors, see Appendix B, “How to Use Buildings as Shelters Against Fallout.”

Figure 3: Sample Protection Factors for a Variety of Building Types and Locations



Buddemeier BR, Dillon MB. Key Response Planning Factors for the Aftermath of Nuclear Terrorism. Livermore, CA: Lawrence Livermore National Laboratory LLNL-TR-410067; August 2009.

Fallout takes time to travel downwind and sink to the ground; this provides a short period of time for most people to go into buildings that will protect them.

Computer modeling of a 10-kiloton detonation in Washington, DC, using actual weather conditions from May 23, 2005, illustrates the timeframe for potential fallout.⁶ In this scenario, the detonation occurs 1.6 miles upwind from the Capitol. In the simulation, it takes roughly 6 minutes for fallout to arrive at the Capitol, with most of it arriving in approximately 10 minutes. Fallout arrives at the beltway (which is 10 miles out) at 34 minutes. Survivors should seek the very best possible shelter *before* fallout arrives. As modeled above, fallout may arrive in several miles of the detonation within 10 minutes, and the window of time for finding a good shelter increases in distance from ground zero.⁶ This time lag may permit people on the street and in cars or other poor shelters to find a nearby shelter with adequate or better protection. However, people may be unable to judge exactly when and where fallout will arrive; those in the most hazardous areas may be caught unawares. Therefore, everyone should seek the best shelter available *immediately* following a detonation. Moreover, people should not assume that they can outrun fallout. Safely evacuating out 10 to 20 miles from ground zero—the anticipated outer perimeter of the DFZ—before fallout arrives may not be feasible.

Any sheltering, even in a poor shelter, can save a majority of lives among people caught in the DFZ.

State-of-the-art modeling using the city of Los Angeles demonstrates the importance of promptly seeking shelter after a nuclear detonation.⁷ For people in the dangerous fallout zone, being outside for the first 24 hours would expose approximately 280,000 individuals to enough radiation to sicken or kill them. If everyone in the DFZ were to go inside a poor shelter (ie, one with a PF=3 such as a car or small house), then 160,000 would avoid

significant radiation exposure. If all went into a just adequate shelter (ie, one with a PF=10 such as a shallow basement), then 240,000 would escape significant exposure and 40,000 would avoid death but would be very sick. If everyone sheltered in the core of an office building or an underground basement (PF=50 or greater), then no one would be exposed to significant or deadly levels of radiation.

TENET 4: Evacuation may further reduce radiation exposure (after initial sheltering), but it only makes sense when sufficient information and logistical capacity exist.

Just how long a person in the dangerous fallout zone should stay sheltered before evacuating cannot be predicted in advance.⁶

The best time for an individual to leave the safety of a shelter will depend on several factors: the quality of the shelter, the levels of radiation around that shelter, and the feasibility of moving to greater safety quickly.⁶ Precise knowledge of radiation levels and speedy routes to safety, however, will not be available in the early, chaotic hours following a nuclear detonation. Communities implementing a fallout preparedness program nonetheless need a framework with which to educate people in advance about the best course of action to minimize fallout exposure and to save lives. Recognizing that a complicated algorithm does not serve a majority of people in the DFZ, the Expert Advisory Group proposes the following rule of thumb for the sequence of recommended protective actions:

- **1 Minute → Shelter:** Immediately after a detonation—by minute one, for ease of planning and public communication, the best course of action is to take shelter quickly in a solid structure with the highest protective factor as possible. In some instances, this may have to be a poor shelter. The most extreme radiation levels are present in the first hour following a detonation; being inside a protective shelter at this time is essential to saving one's life.
- **1 Hour → Upgrade:** At hour one postdetonation, people who were forced to locate in a poor shelter should relocate quickly to a building with a higher protective factor and resume sheltering.²³ Exposure during the brief time spent outdoors seeking a better shelter is an investment in a lower radiation dose overall. For those in an adequate shelter, however, staying put is more important.

- **1 Day → Prepare to evacuate:** By day one postdetonation (24 hours), potential exposure to radiation will have dropped off by 80%. Those sheltering should be prepared to evacuate according to guidance from authorities who will have mapped the DFZ to determine the safest routes for evacuation. Until information on safe evacuation routes is available, people should stay sheltered. In some instances, this may be 2-3 days or more.

Choices about when and who to evacuate will be very complex and context dependent.

Decisions about who to evacuate, and in what order, should be driven by the hazards faced by survivors and logistical considerations.⁵ The anticipated impact of a nuclear detonation is immense—in terms of geographic area and potential evacuees—and it could exceed available infrastructure and resources (eg, transportation, hospitals). It may be necessary to relocate in phases according to available assets and accommodations, both in the area being evacuated and in the receiving locations.²⁴ High-priority candidates for early evacuation are people who are located in poor quality shelters in the highest dose regions of the DFZ; who require critical medical attention or who are threatened by building collapse or fire; or who face special circumstances or vulnerabilities, such as children and the elderly.⁵ Uninjured people in adequate shelters are not priorities for early evacuation, nor are individuals in minimally protective shelters outside the DFZ (unless other threats to survival exist).⁵ People located in good shelters (ie, large buildings or underground) should be considered candidates for late-phase evacuation (days after a detonation).²² A phased evacuation is a complex undertaking, with the strong possibility for disorganization. Nonetheless, survivors and their families will expect that response professionals and evacuation planners employ a rational approach.

Mass evacuation should be delayed until fallout hazard zones and unobstructed routes are clearly known.

No evacuation should be attempted until basic information is available regarding fallout distribution and radiation dose rates. In general, it is best to assume radioactive material is present and dangerous until measurements show otherwise. Basing evacuation routes on erroneous data about high dose rate regions in the dangerous fallout zone could eliminate the very benefits of evacuation.²³ The principal goal is to minimize the time that evacuees spend unsheltered when leaving the DFZ. To develop timely and safe evacuation routes, planners will also need to consider infrastructure status (eg, whether roads are passable and bridges are intact). Officials should not underestimate the time it may take to conduct a mass evacuation under postdetonation conditions. In comparison, estimated times for evacuating many major urban areas in the Atlantic and Gulf Coast regions, in advance of a hurricane and with no damage to infrastructure, exceed 30 hours; in some cases, evacuation time can exceed 48 hours.²⁵

TENET 5: An informed public capable of acting on its own can save more lives following a nuclear blast than can a limited number of emergency professionals.

Due to the scale and severity of the incident, there will likely be long delays in assistance from emergency professionals.

Rather than wait for assistance or guidance from authorities, members of the public must be poised to act promptly on their own following a nuclear detonation. Specifically, they should be ready to get themselves and others into an adequate shelter, potentially staying there for a period of several days. Given both the scale of destruction by a nuclear device and the amount of resources needed, it will also take time for authorities to characterize the situation and mobilize a response. Prior to executing the response, emergency professionals will also need to seek adequate shelter for at least an hour, if not more, postdetonation, just like the public.⁶ As discussed below, the infrastructure for transmitting and receiving fallout warning messages may be inoperable for several days in the most vulnerable areas, requiring survivors to act independently. Sheltering for an extended period of time is the principal protective action against fallout exposure. Therefore, being personally prepared, being able to identify shelter, having a family disaster plan, and keeping essential supplies (eg, food, water, a battery/crank powered radio, flashlight, first aid kit, medications, extra clothes) matters a great deal. Having a family reunification plan will also be important once evacuations begin.

The closer to ground zero, the more likely officials cannot communicate quickly with survivors; thus, people will need to know how to protect themselves in advance.

Following a nuclear detonation, it will be difficult or impossible to issue fallout warning messages in the areas that most need them, because communications may be severely impaired. Within the damage zones, there will be little, if any, ability to send or receive information.⁵ Telephone poles, utility lines, fiber-optic

cables, cell towers, and other equipment will be knocked out; restoration of communication capabilities could take days. Moreover, the detonation's electromagnetic pulse (EMP)—a transient electromagnetic field that produces a rapid high-voltage surge—may destroy or severely disrupt surviving electronics around ground zero.* Experts generally anticipate the worst EMP effects of a 10-kiloton groundburst to be confined within a 2- to 5-mile radius of the detonation site.⁵ However, cascading effects along transmission lines could lead to outages of electricity, phone, and internet extending up to hundreds of miles.⁵ Enormous demand for telephone and internet services will further complicate communication on surviving equipment. Overall, the operability of communications systems following a nuclear detonation is unpredictable: Which systems will be affected over what distances and for how long? As a general rule of thumb, planners might assume that the ability to communicate with survivors will increase the farther the distance from ground zero and the longer the time frame from the explosion.

Pre-incident education that uses average citizens as spokespersons may help promote greater personal preparedness and understanding of fallout protective behaviors.

The potential lack of an intact infrastructure for delivering public warnings in the time and places that protective guidance is most needed following a detonation makes it necessary to convey the value of personal preparedness to the public. Social and behavioral science experts suggest that the strongest motivator of public preparedness for disasters, including terrorism, is when average people share what they have done to prepare with others who have done much less.²⁶ Coworkers, neighbors, friends, and family who talk

* Not all equipment within the EMP-affected area will fail, however. Electronics are more likely to fail the closer they are to ground zero, the larger their effective receptor antenna, and the more sensitive they are to EMP effects.²⁷ Cell phones and handheld radios have relatively small antennas and will probably still function if they are not plugged in at the time of the EMP. If equipment does not work initially, turning it off and then back on, removing and then replacing the battery, or rebooting may restore function. In general, protective actions used to protect equipment from lightning strikes, such as shielding, may "harden" electronics.

about and/or demonstrate what they have done to prepare may be the most powerful preparedness spokespersons of all. A second top motivator is knowledge of what preparedness actions to take, how to take them, and why these actions are beneficial²⁶—in this case, preparation for extended sheltering can prevent illness and death due to radiation. Preparedness education that focuses on abstract science lessons and disaster consequences is less likely to motivate the desired behavior. The third key motivator to preparedness is receiving repetitive and consistent information over multiple channels (eg, social media, newspaper, flyers, TV), so that people can hear the message above everyday background noise.



Checklist

AP/ Rhonda Birndorf



HOW CAN CONCERNED CITIES AND REGIONAL PARTNERS BEST PREPARE FOR RADIOACTIVE FALLOUT?

The *Fallout Preparedness Checklist* is a tool for designing and implementing a fallout preparedness program for cities and their regional partners. Coupled with each action is a set of implementation tasks. Because implementation will take time and jurisdictions have limited resources, the checklist attempts to balance the practical and the “perfect.” The order in which the actions are presented reflects the Expert Advisory Group’s judgment about what activities should be tackled first. This appraisal includes a measure of which steps are prerequisites for others and which exhibit a high degree of complexity and expense.

FALLOUT PREPAREDNESS CHECKLIST

- ACTION 1:** Obtain broad community backing and understanding of nuclear incident preparedness to sustain the program over time.
- ACTION 2:** Conduct an ongoing public education program to inform the public about the effects of a nuclear detonation and how they can protect themselves.
- ACTION 3:** Enable building owners and operators—from individual householders to skyscraper managers—to assess shelter attributes and to teach others.
- ACTION 4:** Strengthen the region’s ability to deliver actionable public warnings following a nuclear detonation through well-chosen technologies and organizational procedures.
- ACTION 5:** Establish a rapid system for mapping and monitoring the dangerous fallout zone to specify which residents need to take what protective action.
- ACTION 6:** Develop planning strategies and logistical capabilities to support a large-scale, phased evacuation.
- ACTION 7:** Integrate, test, and conduct training on the above elements of a comprehensive fallout preparedness and public warning system.

ACTION 1

Obtain broad community backing and understanding of nuclear incident preparedness to sustain the program over time.

- ❑ Task 1.1—Cultivate leadership behind the goal of community preparedness for fallout.
- ❑ Task 1.2—Build a fallout preparedness coalition that reflects the entire community and that can maintain support for the issue.
- ❑ Task 1.3—Incorporate radiation professionals and organizations into emergency planning and volunteer registries.
- ❑ Task 1.4—Recruit community-serving nonprofits and faith-based organizations to participate in emergency planning and to be conduits for reaching vulnerable and underrepresented populations.
- ❑ Task 1.5—Define the problem in local terms by mapping a nuclear detonation's effects against the region's unique terrain and inhabitants.

ACTION 1: Obtain broad community backing and understanding of nuclear incident preparedness to sustain the program over time.

Fallout preparedness is a broad community concern. There is no single entity that can deliver this public service. Sound emergency management structures and strategies are essential, as is expertise in radiological control, but so too are efforts by business, schools, nonprofits, faith-based organizations, and average citizens.

- ❑ **Task 1.1**—*Cultivate leadership behind the goal of community preparedness for fallout.*

Mobilizing a community to confront a potential nuclear detonation will require a political catalyst—whether the jurisdiction’s chief executive, an issue champion with the expertise and organizational legitimacy to promote readiness, or a disaster planning body that can marshal a broad base in support of nuclear preparedness.²⁵ Such leadership is necessary to overcome both active and passive resistance to advance planning for a nuclear emergency. In general, people tend to discount preparedness because disasters are infrequent and because they believe that such tragedies happen to *other* people. Some individuals fatalistically assume that little can be done to limit losses, while others reject emergency planning out of fear that more immediate community concerns such as crime and education will receive less attention and resources. The prospect of preparing for a nuclear detonation will likely exacerbate such attitudes. A further complication may be that some authorities wrongly assume that raising the issue of nuclear terrorism will panic people. Past experience, however, has taught us that leaders often underestimate the public’s ability to handle difficult issues.

- ❑ **Task 1.2**—*Build a fallout preparedness coalition that reflects the entire community and that can maintain support for the issue.*

The most realistic and complete emergency plans are developed when diverse government departments and agencies work alongside representatives of the

entire community, including leaders from business, public utilities, education, and community- and faith-based groups.²⁸ Inclusion of all community stakeholders in emergency planning conveys the reality that everyone shares in the responsibility for public safety, especially in this case when personal preparedness and protective actions can save many lives. Moreover, inclusive planning strengthens the public motivation for people to undertake planning for themselves and their organizations.²⁸ A partnership approach to emergency management helps to generate resources (eg, ideas, skills, funding, and momentum), advance public understanding and buy-in, and diminish agency turf battles as people coalesce around a common goal—all conditions necessary for successful nuclear response planning.²⁹ Local and regional news media will be essential participants in the fallout preparedness coalition, as they can report on the life-saving benefits of nuclear incident preparedness and on initiatives to educate residents on key protective actions. Existing coalition groups such as citizen corps councils, local voluntary organizations active in disaster, and local emergency planning committees can facilitate needed partnerships with the community. Communities can integrate fallout preparedness into strong, pre-existing coalitions capturing the momentum and commitment that already exists around other hazards and disasters.

❑ **Task 1.3**—*Incorporate radiation professionals and organizations into emergency planning and volunteer registries.*

Radiation professionals from both private and public sectors should be fully integrated into nuclear emergency planning. Depending on the jurisdiction, radiation control programs may reside within a public health or emergency management agency or be free standing. Few localities have their own radiation control programs, and most must rely on a state agency (New York City and Los Angeles are exceptions). Volunteer radiation experts from industry, healthcare settings, and research universities are natural allies in carrying out pre-incident public education. Following a detonation, they

can relay trusted public warnings and perform population monitoring and other assistance at community reception centers (CRCs), shelters, hospitals, and other locations where potentially contaminated people may converge.³⁰ Jurisdictions should establish relationships in advance with local, state, and/or regional chapters of radiation professional organizations (eg, Health Physics Society, American Association of Physicists in Medicine, Society of Nuclear Medicine, American Society for Radiation Oncology, National Registry of Radiation Protection Technologists, American Nuclear Society, Conference of Radiation Control Directors [CRCPD]). Planners are encouraged to consult CRCPD guidance (2011) on recruiting, credentialing, training, exercising, and deploying such volunteers.³⁰ Some jurisdictions are already incorporating volunteer radiation professionals into preexisting volunteer programs like the Medical Reserve Corps (MRC).

□ **Task 1.4**—*Recruit community-serving nonprofits and faith-based organizations to participate in emergency planning and to be conduits for reaching vulnerable and underrepresented populations.*

People with disabilities and others not traditionally included in emergency preparedness planning—including the hearing- and vision-impaired, elderly people, non-English speakers, ethnic minorities, and communities distrustful of government—are more likely to suffer the impacts of a nuclear detonation because they are not well-positioned to receive, trust, and act on meaningful protective guidance. Agencies and nonprofits serving these groups, however, can provide insights for emergency planning and help promote the dissemination and uptake of critical safety information by their clients. Emergency planners can also benefit from consulting community-serving nonprofits about conditions that might inhibit or facilitate people’s movement to safety, especially among disadvantaged, disabled, or distrusting groups. Community-serving nonprofits and faith-based organizations should also ensure their own continuity of operation by incorporating into their existing emergency plans procedures for reducing the exposure of employees and clients (when on the premises) to fallout.

- **Task 1.5**—*Define the problem in local terms by mapping a nuclear detonation’s effects against the region’s unique terrain and inhabitants.*

Knowledge of the physical effects of a nuclear explosion as well as attributes of the people and properties in harm’s way can facilitate local planning for fallout protection. Local emergency professionals should take advantage of the state-of-the-art modeling and analysis developed at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Sandia National Laboratories, and Applied Research Associates and/or work with their local universities to prepare regional maps that chart the basic anatomy of a nuclear detonation and a range of fallout predictions.^{6,31} At a minimum, jurisdictions can overlay local and regional maps against projections devised for other cities. At the request of Congress, the DHS Office of Health Affairs has already coordinated efforts to model the effects of 0.1-, 1.0-, and 10-kiloton nuclear yields in New York City, Washington, DC, Chicago, Houston, San Francisco, and Los Angeles. (For illustrative maps using Washington, DC, and Los Angeles, see Buddemeier & Dillon 2009.⁶) Actual fallout patterns will depend on the real-time conditions of weather, weapon yield and location, and other variables that are hard to predict. Nonetheless, visual representations can raise awareness of the risk environment and set planning expectations—both among emergency professionals and the larger population.

ACTION 2

Conduct an ongoing public education program to inform the public about the effects of a nuclear detonation and how they can protect themselves.

- ❑ Task 2.1—Designate a lead agency to coordinate the public education program across stakeholder agencies within the city and with neighboring jurisdictions.
- ❑ Task 2.2—Focus messages on how people can protect against fallout exposure; using nontechnical language, explain how these actions could save their lives.
- ❑ Task 2.3—Disseminate information frequently using multiple modalities (eg, TV, pamphlets, radio, social media) and multiple sources.
- ❑ Task 2.4—Encourage people who have already prepared for fallout to share what they have done with those who are less prepared or who have taken no actions.
- ❑ Task 2.5—Periodically evaluate progress toward preparedness outcomes and make revisions to improve the public education program over time.

ACTION 2: Conduct an ongoing public education program to inform the public about the effects of a nuclear detonation and how people can protect themselves.

Because a nuclear detonation may be a “no notice” incident and will severely disrupt communications, educating people before an incident on how to protect themselves from fallout is essential. The best strategy to maximize lives saved following a nuclear detonation is for cities and their neighboring communities to implement a coordinated and sustained public education program on fallout preparedness. Pre-incident public education will play a critical role in priming the public to seek shelter rapidly after a nuclear detonation. At its best, a well-executed campaign will also motivate people to take actions beforehand, such as purchasing a hand-crank radio and scouting out familiar buildings that afford the highest protection factors. The following steps rely on empirically based “best principles” for designing a pre-incident public education. Appendix A, “Preliminary Topics for a Fallout Preparedness Education Campaign,” outlines key topics that a region may wish to incorporate into its own public education efforts. Resource-constrained jurisdictions may wish to weave fallout preparedness information into an already-existing, credible mass education program for disasters.

- **Task 2.1**—*Designate a lead agency to coordinate the public education program across stakeholder agencies within the city and with neighboring jurisdictions.*

To maximize lifesaving, adjacent jurisdictional plans for pre-incident public education should be coordinated. Science has demonstrated that to be effective, messages should be consistent and delivered by multiple information sources or organizations.^{26,32,33} The process works best if a single agency is designated as the lead and if stakeholder organizations and jurisdictions commit to a coordinated, long-term strategy. An important task will be to work together to craft key fallout protection messages for use

by all members, rather than each group producing a unique message. An example of an inconsistent message would be one group advising residents to stay inside a building for a minimum of 4 hours following a nuclear detonation, while a different organization recommends a threshold of 8 hours. Coordinated messaging is vital in the case of a large city: a person who works in an urban center but who lives in the suburbs needs to hear the same message and to have it reinforced. At best, conflicting information is confusing and, at worst, can undermine the public's confidence in the efficacy of sheltering and the competence of the organizations issuing messages.

- ❑ **Task 2.2**—*Focus messages on how people can protect against fallout exposure; using nontechnical language, explain how these actions could save their lives.*

While often used in public education campaigns, scare tactics and probability estimates are not effective motivators of preparedness. Instead, people respond to knowledge about what to do, how to do it, and why it will help them.^{26,32,33} Rather than focus on the likelihood of nuclear terrorism and the horror of radiation injuries, fallout preparedness messages should inform people how to minimize radiation exposure (take shelter), how to do it (know which buildings are best and set aside enough supplies), and why it is important (you can save your life). Educational messages about minimizing fallout exposure can also be linked to other “all-hazard” messages—namely, those about sheltering—and to “teachable moments” where interest in radiation is piqued, such as the March 2011 nuclear power plant emergency in Japan.

Familiar, all-hazard preparedness recommendations—have a family disaster plan including ideas for postdisaster reunification; store a supply of food, water, and essential medications; and have a crank or battery-powered radio—all support the goal of extended sheltering in the context of a nuclear detonation and a potentially degraded communication infrastructure. For disaster preparedness in general, emergency professionals recommend that

if individuals have not yet set aside any emergency supplies, they should begin with a 3-days' supply and work up to 1 week and then 2 weeks, once they have adopted a preparedness lifestyle. Larger stockpiles will provide people with more flexibility for unpredictable events and conditions. While people may not need to shelter for more than 1 day to avoid exposure to high radiation levels following a nuclear detonation, damage to critical infrastructure could interrupt access to food and water for several days, maybe more.*

□ **Task 2.3**—*Disseminate information frequently using multiple modalities (eg, TV, pamphlets, radio, social media) and multiple sources.*

Sustained repetition of public education messages is necessary to break through the background noise of everyday life.^{26,32-34} Also, people vary in what information sources they trust and in how they receive their information. Materials should be translated into multiple languages and the technological needs of those with visual and hearing disabilities addressed. Planning should include the development of resources such as websites for people who may seek more information and the identification of technical experts who are good communicators. Recent evidence indicates that most people trust the local weatherman over other spokespersons. Interweaving informational, social, and physical cues can help reinforce messages about fallout preparedness. For instance, fallout shelter signage serves as a visible reminder of the most important way to protect oneself from fallout. School safety officers could have a parent-teacher association (PTA) group learn about fallout protection, enlist them in the posting of signs at schools, and then work together to identify what is needed to shelter their children safely from fallout.

* For more detailed instructions on gathering supplies to support sheltering-in-place, individuals and families are encouraged to consult the Ready.gov and American Red Cross websites on basic emergency provisions. Businesses, schools, and organizations are similarly encouraged to adopt the Red Cross Ready Rating Program (<http://readyrating.org/>) to evaluate and improve institutional preparedness, which includes acquiring and maintaining adequate emergency supplies.

- ❑ **Task 2.4**—*Encourage people who have already prepared for fallout to share what they have done with those who are less prepared or who have taken no actions.*

The most effective spokespersons for preparedness are people who have already taken action.^{26,32,33} Thus, the primary targets of a public education campaign on fallout should be those people in the community who typically prepare for other hazards. These individuals can then lead by example, talking about and demonstrating ways to protect oneself from fallout. Drawing on their own in-depth knowledge of the community and its subgroups, these preparedness champions can develop innovative ways to teach others about what they have done to prepare for fallout and why. Training curricula for existing volunteer networks (eg, MRC, Community Emergency Response Teams [CERTs], and Neighborhood Watch Program [NWP]) should be updated with radiation basics and fallout protection guidance. In addition, these volunteers can be trained to deliver a vetted localized nuclear readiness presentation to groups and organizations throughout the community. After an incident, MRC, CERTs, NWP, and other volunteers can also perform key support roles such as reading pre-scripted messages as part of “rumor control” hotlines (Task 4.4) or greeting people who arrive for monitoring and decontamination at community reception centers (Task 6.8).³⁵

- ❑ **Task 2.5**—*Periodically evaluate progress toward preparedness outcomes and make revisions to improve the public education program over time.*

As with any education initiative, progress toward the goal of preparedness should be assessed and the public education program restructured as needed.^{34,36} Jurisdictions are encouraged to perform a baseline assessment of the public’s knowledge about the effects of a nuclear detonation, the public’s awareness of protective measures, and individuals’ level of preparedness. This inquiry can also help officials to identify factors that could impede people from taking protective actions and to collect information on trusted spokespersons and preferred means of receiving messages for various

population segments (eg, Spanish radio station, internet, TDD for the hearing impaired). Later, survey questions can be repeated to test the effectiveness of the education program. Assessments may also rely on focus groups or organization/community exercises. Program effectiveness should be based on actual preparedness outcomes, such as an increase in knowledge of which types of buildings offer the greatest protection, rather than measurement of the number of times a particular training was given or the number of flyers distributed.

ACTION 3

Enable all building owners and operators—from individual householders to skyscraper managers—to assess shelter attributes and to teach others.

- ❑ Task 3.1—Disseminate a shelter rating guide to commercial building managers, enabling tenants and their employees to learn about fallout protection in the workplace.
- ❑ Task 3.2—Rate public buildings in terms of their performance as fallout shelters and equip with signage that designates top safety spots.
- ❑ Task 3.3—Partner with schools to expand their emergency plans to include fallout protection and to communicate these plans to parents.
- ❑ Task 3.4—Distribute a shelter rating guide to homeowner and tenant associations to build neighborhood awareness about the protective factor of a home.

ACTION 3: Enable all building owners and operators—from individual householders to skyscraper managers—to assess shelter attributes and to teach others.

Given the central role of shelter in preventing fallout exposure, it is important that people become more aware of the protective attributes of the structures in which they and their families spend a majority of their days. A national study of human activity patterns in the U.S. suggests that people spend an average of 87% of their time in enclosed buildings and about 6% of their time in enclosed vehicles.³⁷ On average, a majority of people (90%) are found in their residences from about 11 PM to 5 AM; schools, public buildings, offices, factories, and malls or stores are frequented mostly between 7 AM and 5 PM.³⁷ Building owners and operators—across commercial and residential sectors, and privately and publicly owned properties—have the responsibility to be key educators in advancing the public’s familiarity with places that promise the most protection against radioactive fallout.

- **Task 3.1**—*Disseminate a shelter rating guide to commercial building managers, enabling tenants and their employees to learn about fallout protection in the workplace.*

The protective factor from radiation varies among building types and among different locations within buildings. Basements, the cores of large multistory buildings, and underground parking can generally reduce doses of radiation from fallout by a factor of 10 or more and are significantly better areas for shelter than the ground level and exterior rooms of buildings or areas near rooftops.⁶ By providing easily accessible and useful information on the best places to shelter (see Appendix B), proper sheltering can be incorporated into workplace disaster planning and reduce employee exposure to radiation. Some federal buildings, such as the Hubert Humphrey Building, which serves as the headquarters of the Department of Health and Human Services

(DHHS) in Washington, DC, have posted signage to designate shelter-in-place locations for their employees. Building safety managers should ensure that any sheltering locations predesignated for other hazards also provide adequate protection from radioactive fallout. Businesses and organizations, too, should also plan for the storage of emergency supplies.

- ❑ **Task 3.2**—*Rate public buildings in terms of their performance as fallout shelters and equip with signage that designates top safety spots.*

Designating large public buildings, such as a library, school, or post office, as a public shelter may be necessary in areas where other buildings do not provide sufficient protection (eg, neighborhoods with wood-frame houses or single-story buildings with no basements). Planners should evaluate neighborhood and commercial areas to determine which public shelter designations are needed in advance of a nuclear attack.⁵

- ❑ **Task 3.3**—*Partner with schools to expand their emergency plans to include fallout protection and to communicate these plans to parents.*

On any given day, more than 1 out of every 5 people in the U.S. is located in a K-12 school—as a student, a teacher, other staff member, or volunteer.³⁸ Emergency professionals should reach out to these centers of social life and convey the importance of incorporating fallout protection into standing emergency plans. Issues to address include determining building and interior locations that provide the best shelter, maintaining supplies to sustain residents for at least 24 hours, and communicating with parents and guardians about preparations. Following disasters, when parents have been asked what was important to them, they have replied that knowing about the safety and whereabouts of their children was their top priority.³⁸ Addressing people’s needs to know whether their loved ones are safe and how to reunite with them will be central to successful sheltering education. Parents and guardians will need solid information from administrators that adequate preparations are in place and that automatically retrieving children from school following a

nuclear detonation could endanger both the adults and their dependents by exposing them to outdoor radiation. Jurisdictions also need to develop and publicize their plans for family reunification following a nuclear detonation. Similarly, school plans must address how they will care for unaccompanied minors in the event that caretakers do not arrive.

- ❑ **Task 3.4**—*Distribute a shelter rating guide to homeowner and tenant associations to build neighborhood awareness about the protective factor of a home.*

Community associations connected with all housing types (eg, single-family units, mobile homes, condominiums, and apartments) can serve as conduits to equip heads of households and their families with information that permits them to judge the protective quality of their residence and, if need be, to identify an alternative sheltering location. Educational materials tailored to local residential building trends may prove beneficial given the differences in housing structures across U.S. regions. In the Northeast, more than one-third (38%) of all households live in apartments, a majority of which are located in buildings 7 stories or taller.³⁹ In the South and West, only 2 of every 10 single-family units have a basement (either full or partial), in contrast to 87% of such units in the Northeast and 76% in the Midwest.³⁹

ACTION 4

Strengthen the region's ability to deliver actionable public warnings following a nuclear detonation through well-chosen technologies and organizational procedures.

- ❑ Task 4.1—Develop pre-scripted, pre-vetted, and scientifically based fallout warning messages tailored to the specific needs of the community.
- ❑ Task 4.2—Address organizational issues related to effective warning dissemination (eg, who can “trigger” a public message and when).
- ❑ Task 4.3—Devise low-tech, redundant means for issuing public warning messages, assuming a degraded telecommunications infrastructure.
- ❑ Task 4.4—Plan to establish hotlines for an acute demand for health-related information; monitor for rumor control.
- ❑ Task 4.5—Monitor public peer-to-peer communications to enhance situational awareness postdetonation and to refine official warnings.

ACTION 4: Strengthen the region’s ability to deliver actionable public warnings following a nuclear detonation through well-chosen technologies and organizational procedures.

In the nuclear terrorist context, effective public communication is essential to saving lives, reducing injuries, relieving distress, and keeping fears in proportion to risk. Community preparedness for fallout must include advance preparations for the effective release of public warnings and guidance in an actual incident. In a nuclear detonation, the communications infrastructure normally used to disseminate official warnings will be degraded. Contingency plans must account for these material impacts and incorporate redundant means of disseminating key messages. Also, public communication strategies should be grounded in what is currently known about the social and psychological processes that people go through from the point of first hearing a warning to acting on the information.⁴⁰

- **Task 4.1**—*Develop pre-scripted, pre-vetted, and scientifically based fallout warning messages tailored to the specific needs of the community.*

Effective fallout warning messages about protective actions during the immediate response phase should be a jurisdiction’s top priority because of their life-saving potential (although a community’s information needs should be anticipated for all phases of the disaster). It is just as important to communicate to people who are *not* at risk of fallout exposure as it is to those who are. Unnecessary evacuation impedes logistics and strains resources necessary for those living in high-risk areas. Information gleaned from properly conducted education campaigns (see Action 2) and technical knowledge of the community should be used to tailor these warning messages for the unique circumstances for each area. The format of an effective generic warning message (one that maximizes the listener’s likelihood of taking appropriate actions) is summarized and then modeled in Appendix C, “Formula for Writing an Effective Message for Postdetonation

Public Warning.”⁴¹ Appendix D, “Sample Fallout Warning Messages for the Post–Nuclear Detonation Period,” includes fallout warning message templates developed by Los Angeles County.²² Communities are also encouraged to review key public messages crafted by a multidisciplinary group of technical experts and practitioners for the first 72 hours following a detonation.⁴² These messages are undergoing further refinement, so jurisdictions should watch for updates. FEMA is currently developing several short videos that can be disseminated after a nuclear detonation. Postdetonation messages should be consistent with the information delivered during pre-incident education.

❑ **Task 4.2**—*Address organizational issues related to effective warning dissemination (eg, who can “trigger” a public message and when).*

In the context of a nuclear detonation, providing rapid public warnings about protective behaviors is critical because the fallout hazard is greatest in the early minutes to hours following the explosion. Some jurisdictions lack written procedures on “who” is authorized and responsible for activating a public warning protocol.⁴³ Similarly, plans often fail to document criteria that should trigger the release of public warning messages.⁴³ These omissions can lead to costly delays in notifying the public. Therefore, written plans and procedures for a nuclear detonation should document the role(s) authorized to activate the public warning protocol as well as the criteria that will be used, and they should outline local/regional contingency plans in the event the local Emergency Operations Center (tasked with issuing messages) is nonfunctional. Triggering criteria, for example, could include the primary sources of data (eg, using local meteorological forecasts rather than awaiting federal mapping [see Action 5]). Just as criteria need to be established to trigger initial warning messages, jurisdictions should also determine what indicators will lead to a change in warning message content. For instance, a drop in radiation levels and removal of debris from the roadway may trigger the change from a sheltering message to an evacuation message for certain areas.

- **Task 4.3**—*Devise low-tech, redundant means for issuing public warning messages, assuming a degraded telecommunications infrastructure.*

EMP effects and the surge in information demand will severely strain surviving telecommunications infrastructure, throwing up barriers to the dissemination of public warning messages. Thus, plans should include lower-tech means to communicate warnings (eg, radio broadcasts, megaphones, 2-way radios, National Weather Service warning radios, amateur radios, loudspeakers, sirens, alarms, PA systems) to augment usual means. For example, the Indian Ocean tsunami and the Haiti earthquake highlighted the importance of radio broadcasts after extensive infrastructure damage and disruption. The use of cell phone texting—which may be available the farther one gets from ground zero—has also been found to be very effective in some disaster settings because it does not require very much bandwidth. Authorities should plan to use any and all communication means at their disposal following a detonation.

- **Task 4.4**—*Plan to establish hotlines for an acute demand for health-related information; monitor for rumor control.*

Plans should be in place for establishing emergency call-in banks that can deliver pre-scripted messages and dispel rumors. Some people may not be able to access these resources for some time, but many people outside affected areas will need reassurance that they are not in harm's way. Rumors are a normal indicator of people's urgent need to gather and confirm useful information during ambiguous situations, particularly those with a safety element, and they become intensified in the absence of meaningful, authoritative information.⁴⁴ Emergency professionals thus should review callers' concerns and monitor both "old" and "new" media (see Task 4.5) to act swiftly in correcting misinformation and in refining public messaging.

This is especially important with social media that can instantaneously propagate information. For example, in the aftermath of the 2004 tsunami, a tsunami warning was circulated in Indonesia, only to be revealed as an anonymous hoax.⁴⁵ More recently, a fake Short Message Service (SMS, also

known as text messaging), purporting to be from the BBC, warned that radiation from the Fukushima nuclear plant had leaked beyond Japan and that people should start taking precautions; reportedly this message frightened many in Asia.⁴⁶

❑ **Task 4.5**—*Monitor public peer-to-peer communications to enhance situational awareness postdetonation and to refine official warnings.*

In disasters, people no longer rely exclusively on official sources and traditional media to find useful, credible information. Some individuals are turning to community websites, social networking sites, personal blogs, public texting systems like Twitter, and photo and mapping sites to gather and disperse helpful information and to coordinate a broader response to disaster.⁴⁷ For example, some residents who wanted timely, local news during the 2007 California wildfires relied on the Twitter postings of 2 men who compiled reports from friends, monitored news broadcasts, and snapped firsthand photos of their surroundings. The men aggregated this information to provide rapid updates about evacuations, meeting points, and places to gather supplies.⁴⁸ The use of social media in a disaster, however, is an emergent phenomenon. Some disaster research suggests that while younger people may rely greatly on internet-based communication, older adults making decisions about evacuations typically do not—at least not yet. Planners should be aware of these new, citizen-generated flows of crisis communications, tap into them to enhance situational awareness postdetonation, monitor them to refine official warnings and messages, and take proactive measures to develop their own social media capabilities.

ACTION 5

Establish a rapid system for mapping and monitoring the dangerous fallout zone to specify which residents need to take what protective action.

- ❑ Task 5.1—Develop relationships in advance with federal partners; plan to integrate their contributions to fallout mapping and radiation measurements.
- ❑ Task 5.2—Conduct a regional inventory of monitoring staff, equipment, dosimeters, and personal protective equipment; plan for a surge in demand.
- ❑ Task 5.3—Develop plans for synthesizing diverse data scattered across the region to render an accurate picture of fallout distribution.
- ❑ Task 5.4—Plan for the prompt release of plume maps via broadcast media and social media to reassure the public and support decisions to seek adequate shelter.
- ❑ Task 5.5—Pre-position a network of automated radiation monitors to limit human exposure as well as human errors in readings.

ACTION 5: Establish a rapid system for mapping and monitoring the dangerous fallout zone to specify which residents need to take what protective action.

Rapidly determining the DFZ (an immediate health threat) and the wider area of contamination will be critical to guiding the public and responders on protective actions. Larger radioactive particles will settle out within 1-2 hours of the nuclear detonation, creating the DFZ footprint.⁵ Identification of the DFZ perimeter should occur within the first hours of the detonation to guide response planning and strategies for an informed, delayed evacuation.²² On-the-ground federal support may not be available for 24 to 72 hours or longer, so local jurisdictions should plan in advance to characterize fallout deposition and radiation levels on their own at the outset.⁵ Until detailed measurements are obtained, the DFZ can be conservatively defined as extending 20 miles downwind in a keyhole pattern⁶ (see Figure 1). This rough sketch can be refined once modeling of the fallout plume becomes available and actual dose readings from the ground are taken. (Some jurisdictions are prepared to do this on their own, while others will rely on a federal agency like the Department of Energy [DOE]) Knowing the actual fallout footprint and radiation dose levels can vastly improve guidance about where to locate response staging areas, which residents need to evacuate, how soon, which routes present the lowest possible dose, and when and where residents may eventually return.

- ❑ **Task 5.1**—*Develop relationships in advance with federal partners; plan to integrate their contributions to fallout mapping and radiation measurements.*

Before an incident occurs, local jurisdictions should contact federal partners with radiological assets and solicit their help in developing nuclear response plans. (See NCRP Report #165²² for a list of federal resources and activation times.) Ideally, jurisdictions (or their states) already have good working

relationships with regional all-hazard federal partners such as FEMA Regional Administrators (RAs), DHHS/Assistant Secretary for Preparedness and Response (ASPR) Regional Emergency Coordinators (RECs), and DOD Defense Coordinating Officer & Elements (DCO/E); such partners may be helpful in directing jurisdictions to relevant resources. Jurisdictions located in states with nuclear power plants can also reach out to state agencies that already partner with many of the key federal agencies involved in radiation events.

Nuclear response plans should include procedures for integrating federal resources and establishing a bidirectional flow of mapping and monitoring information. Fifteen minutes to an hour after a nuclear detonation, for instance, the Interagency Modeling and Atmospheric Assessment Center (IMAAC)—led by DHS and supported by DOE—will start to provide plume and fallout projections to federal, state, and local authorities, thus helping to guide radiation monitoring and to identify at-risk populations.⁵ IMAAC maps and predictions will be refined as local field data become available over time. Additional DOE assets—Radiological Assistance Program (RAP) teams and Federal Radiological Monitoring and Assessment Center (FRMAC) resources—will also start to arrive 24 to 72 hours after the blast and provide assistance with actual radiation measurements.

❑ **Task 5.2**—*Conduct a regional inventory of monitoring staff, equipment, dosimeters, and personal protective equipment; plan for a surge in demand.*

Following a nuclear detonation, radiation detection equipment and trained personnel will be in high demand over a broad geographic area. Thus, prior to an incident, jurisdictions throughout the region should assess numbers of trained staff, dosimeters, and radiation detection and monitoring equipment; coordinate the purchase of additional equipment (when feasible); standardize staff training programs; and standardize radiation exposure policies across the region.²² At-risk regions should be prepared to use radiation detectors with

high-dose rate capabilities. (For additional technical guidance on detection systems and calibration requirements, see American National Standards Institute [ANSI],* NCRP Commentary #19 [2005],⁴⁹ and Federal Planning Guidance for Response to Radiological and Nuclear Threats [2010].⁵) To overcome anticipated staffing deficits, at-risk jurisdictions should develop mutual aid agreements with neighboring urban centers and states for sharing radiation health personnel; develop just-in-time training for formal and volunteer responders; have protocols ready for incorporating federal personnel; and recruit and register radiological health professionals into existing volunteer programs (also see Task 1.3).

❑ **Task 5.3**—*Develop plans for synthesizing diverse data scattered across the region to render an accurate picture of fallout distribution.*

As noted above, key decisions such as if, when, and who to evacuate will rest on good understanding of the fallout footprint. Various inputs could help construct this broad operating picture: plume projections from federal or other sources; visual observations of the fallout cloud and its downwind drift; discernible fallout particulates that look like fine, sandy material near the detonation; and, most important, actual radiation measurements from the field.⁵ At-risk jurisdictions and neighboring communities should jointly plan to incorporate diverse data points into a fuller understanding of the dangerous fallout zone and to distribute information, maps, and displays to emergency operations centers throughout the region.²² A region could establish a network of “plume tracking groups”—that is, people who are practiced and exercised in compiling diverse plume data and in knowing where to seek information while working their way up to the best quality materials, likely to be available last. Information must be updated sequentially as more

* The American National Standards Institute is developing performance criteria for Personal Emergency Radiation Detectors (PERDs). There are two standards: (1) Alarming Electronic Personal Emergency Radiation Detectors (PERDs) for Exposure Control (ANSI N42.49A) are alarming electronic radiation measurement instruments used to manage exposure by alerting the emergency responders when they are exposed to photon radiation; (2) Nonalarming Personal Emergency Radiation Detectors (PERDs) for Exposure Control (ANSI N42.49B) are ionizing photon radiation-measuring detectors that provide a visual indication of the exposure to the user and are designed to be worn or carried on the body of the user.

radiation readings are obtained and because of the rapid drop-off in levels of radioactivity over time. Planning should also address how fallout data will be combined with infrastructure damage data to guide staged evacuations.

- ❑ **Task 5.4**—*Plan for the prompt release of plume maps via broadcast media and social media to reassure the public and support decisions to seek adequate shelter.*

Because images are powerful communicators, plume maps should be released without delay, to alert people to the presence—and, equally important, the absence—of a risk; to prevent possible exposure to fallout; and to avoid self-evacuation when it is unnecessary and when it may be harmful. Indeed, as part of pre-incident public education, it will be useful to show what a plume map looks like so people will be familiar with their meaning in an actual incident. Planners should also note that Doppler weather radar may be able to follow the fallout cloud; thus, it will be important for officials to work with television stations in advance to tap this resource as part of the region’s plume mapping endeavor and to train producers, meteorologists, and broadcast announcers in how to put out statements in the interest of the public’s health.

- ❑ **Task 5.5**—*Pre-position a network of automated radiation monitors to limit human exposure as well as human errors in readings.*

Because responders charged with mapping fallout may be exposed to significant levels of radiation, the fewer personnel deployed the better. It would thus be prudent—when economically and technically feasible—to pre-position a broadly distributed network of detection and monitoring equipment that could provide radiation readings automatically to supplement input from roving personnel. Owners of private buildings will be key allies to approach for hosting equipment in technically strategic locations. At this time, there are both technical and financial limits to a “pre-positioned” monitoring system. Such equipment is expensive, and the high levels of radiation anticipated with a nuclear detonation may saturate devices (ie, render them

useless). Nonetheless, some forms of automation are obtainable in the short term. For example, Los Angeles County uses a telemetry system, coupled with a GPS, to automate collection and display of readings on a map of the county to gather situational awareness. Previous nuclear response exercises revealed that responders would be unable to use radios to call in dose readings, as the radio system would be quickly overwhelmed, and that miscommunication was possible between a person giving a field reading and a person recording it on a map at the command center. Following a nuclear terrorism incident, Los Angeles County staff from public health, law enforcement, the fire department, and other cities within the county plan to drive around the county with meters and send measurements over cellular data bandwidth for central plotting and display.⁵⁰ A rough cost estimate for a telemetry system comprised of 10 instruments and supporting software is \$140,000.

ACTION 6

Develop planning strategies and logistical capabilities to support a large-scale, phased evacuation.

- ❑ Task 6.1—Form regional partnerships and execute mutual aid agreements in support of mass evacuation.
- ❑ Task 6.2—Map out buildings and neighborhoods according to how they will perform as fallout shelters.
- ❑ Task 6.3—Predesignate the criteria against which some groups will be selectively evacuated early.
- ❑ Task 6.4—Consider how preestablished evacuation routes and transportation options may have to be adapted to the nuclear detonation context.
- ❑ Task 6.5—Craft pre-incident public education materials that share evacuation plans.
- ❑ Task 6.6—Prepare scientifically based templates for postdetonation evacuation messaging.
- ❑ Task 6.7—Anticipate that a portion of residents will evacuate independent of government instruction.
- ❑ Task 6.8—Plan to establish monitoring and decontamination centers (ie, community reception centers) for people leaving affected areas and moving to host communities.

ACTION 6: Develop planning strategies and logistical capabilities to support a large-scale, phased evacuation.

Evacuation professionals in the post–nuclear detonation context face a powerful dilemma. They are responsible for helping to relocate people who might otherwise succumb to acute radiation syndrome (ie, people in the least protective of shelters in the most radiation-intense sections of the DFZ²³) or other life-threatening circumstances. Yet, these authorities must execute a large-scale, phased evacuation when the transportation and communication infrastructure is in disarray, when a potentially lethal and invisible hazard may be present, and when all survivors have the right to feel as if they deserve to leave first. Recognizing this complexity, this section outlines some preparedness steps that cities can take to improve the chances that, in an actual detonation, evacuation benefits those who most need it and adverse consequences are minimized. Carrying out a mass, phased evacuation in postdetonation conditions will be extremely challenging and contingent upon other capabilities such as rapid mapping of the DFZ. Preparing to execute this protective action is considered the most difficult implementation phase of the *Fallout Preparedness Checklist*. Comprehensive evacuation planning, according to federal policy, addresses the temporary resettlement of evacuees and the final return of evacuees to their predisaster residences or alternative locations.⁵¹ Preparedness for these activities is essential but is outside the scope of this document.

- **Task 6.1**—*Form regional partnerships and execute mutual aid agreements in support of mass evacuation.*

Safe and proper evacuation of a large city requires regional support. Cities should form public health and emergency management partnerships with surrounding areas to address dilemmas posed by a nuclear detonation. Pre-incident, this collaboration can be used to coordinate region-wide response, assess vulnerabilities, conduct training and exercises, plan for

communication, and make modifications to existing mutual aid agreements if indicated. During and following a nuclear incident, the surrounding region can support evacuee movement, provide valuable reception sites to address evacuees with immediate health needs or chronic conditions, and facilitate state and federal assistance.⁵² Highly coordinated evacuations that include an effective command structure characterized by cooperation among all relevant agencies have been shown to be most effective.⁵³

- ❑ **Task 6.2**—*Map out buildings and neighborhoods according to how they will perform as fallout shelters.*

Rapid identification of people who could benefit from priority evacuation will be among the top response goals (see Tenet 4).⁵ Selection of priority evacuees can be expedited to save more lives by having already prepared jurisdiction maps to show neighborhoods and building clusters in terms of shelter quality.⁵ People in neighborhoods comprised largely of single-story, wood-frame houses, for instance, will be exposed to significantly more radiation than those who seek protection in the core of a large, multistory building. Prior knowledge of areas without adequate shelter options can also inform plans for designating public shelters in advance of a nuclear explosion (see Tenet 3).⁵ Planners should reach out to the private sector to access databases on area buildings, in addition to relying on data in the public domain. Similarly, emergency planners should identify clusters of children and disabled individuals (eg, nursing homes, hospitals, senior apartments) that may require additional assistance in evacuating.

- ❑ **Task 6.3**—*Pre-designate the criteria against which some groups will be selectively evacuated early.*

A difficult though vital preparation for a mass, phased evacuation is an agreed-upon framework among regional partners to guide the application of scarce resources in relocating people. Pre-established criteria about who will be evacuated first can help with tough choices in an actual postdetonation

scenario, assure that the most lives are saved, and diminish adverse effects associated with mass evacuation. Federal guidance identifies the following life-threatening conditions as warranting early selective evacuation: inadequate shelter in the context of acute radiation exposure, fires and unstable physical structures, critical medical needs, and lack of life-sustaining resources such as water (especially after 24 hours).⁵ In an actual event, logistical matters such as safe evacuation routes will need to be considered. Mass evacuation can be an extreme solution with many serious consequences. Potential adverse effects include psychological impacts, social distress, and income interruption.⁵⁴ Officials should therefore reserve its use for life-threatening circumstances or other exceptional circumstances where the benefits clearly outweigh risks.

□ **Task 6.4**—*Consider how preestablished evacuation routes and transportation options may have to be adapted to the nuclear detonation context.*

Predetermined evacuation routes and transportation options that assume an intact infrastructure and a nonradiological hazard, such as a hurricane, would need substantial revision in the context of a fallout plume and blast- and EMP-related damages (eg, debris-strewn roadways, overturned vehicles, no power for traffic signals, loss of public transportation). Comparing preestablished evacuation routes against different fallout plume projections and models of variously damaged infrastructure (eg, certain bridges are out) can provide planners with advance understanding of some of the challenges of moving large groups to safety following a nuclear attack.⁵ As part of a pre-incident public education campaign, explaining the uncertainties anticipated with a postdetonation evacuation may help reinforce the message that staying inside an adequate shelter and waiting for more information, rather than automatically leaving an area, is the more desirable protective action.

□ **Task 6.5**—*Craft pre-incident public education materials that share evacuation plans.*

Evacuations are more likely to be successful when officials have shared plans with the community in advance and explained alerting methods.⁵³

Pre-incident public education materials should convey when leaving a shelter is appropriate, what relocation plans exist, and how officials will communicate postdetonation. During a mass, phased evacuation, people in different locations will be asked to take different protective actions (“continue to shelter” versus “now evacuate”). Therefore, as part of pre-incident public education, planners should consider preparing diagrams, similar to those that would be used in an actual emergency, that represent different phases of an evacuation. Diagrams will be a critical communication tool in an actual warning scenario; introducing these images pre-incident can help familiarize residents with a phased evacuation process. While some people may not have access to such diagrams during the actual emergency, people in outlying regions where communications are still functioning will be prepared both to see and hear the message that they may be in areas that do NOT need to evacuate.

Some experts caution that raising the prospect of an informed evacuation in advance may confuse people about the principal importance of sheltering. In an actual incident, such confusion might predispose people to leave an area before there is sufficient information on safe evacuation routes or when evacuation is unwarranted because of low radiation levels. Public safety educators should strive to strike a balance between conveying the benefits of sheltering and adequately preparing residents for a phased evacuation. To balance potentially inconsistent messages about continuing to shelter and preparing to evacuate, public messages might be framed as, “Stay inside an adequate shelter until you receive additional information.”

□ **Task 6.6**—*Prepare scientifically based templates for postdetonation evacuation messaging.*

Preparing evacuation messages in advance can expedite their timely release in an incident and minimize radiation-related illness and death. Effective messaging (such as that modeled in Appendix C) helps ensure that only those who should evacuate do. An informed evacuation implies that a person understands both when to leave a shelter and in which direction he or she should go to minimize exposure to radioactive fallout and other hazards.⁵⁵ Evacuation messages should provide detailed evacuation instructions, including evacuation zones, plans, routes, and/or decontamination centers, as well as specific times and arrangements for certain neighborhoods.⁵⁶ Messages should also clearly state that certain areas do NOT need to evacuate and that unnecessarily leaving an area could jeopardize others by clogging evacuation routes. Evacuees should understand that they will need to evacuate from their place of shelter and that they may not have an opportunity to go home or reunite with their family first.

□ **Task 6.7**—*Anticipate that a portion of residents will evacuate independent of government instruction.*

Following a nuclear detonation, some people will attempt to escape real and perceived dangers independent of official recommendations and radiation data. Regional evacuation planning should prepare receiving communities for the challenges these self-evacuees may pose. Individuals who spontaneously evacuate a fallout area prior to receiving official instructions may have greater decontamination needs when compared to people who stay in adequate shelter before evacuating.⁵⁷ Any large-scale evacuation is also likely to have a high rate of shadow evacuation⁵⁸—that is, departure from areas not officially designated for relocation. After a nuclear detonation, the total evacuee population will likely include injured and noninjured individuals who have been relocated from at-risk fallout areas, plus a potentially large number of shadow evacuees. For example, New York City expects to have to evacuate 300,000

people for health reasons. Yet, receiving communities may also have to face many times that number of uninjured evacuees who still need food, shelter, and medical care for their chronic conditions.⁵⁸ Out of concern about possible radiation exposure, many spontaneous and shadow evacuees will likely self-report to hospitals in receiving communities.

❑ **Task 6.8**—*Plan to establish monitoring and decontamination centers (ie, community reception centers) for people leaving affected areas and moving to host communities.*

Given radiation's health effects as well as an ability to evoke fear sometimes out of proportion to risk, a nuclear detonation will produce high demand for monitoring of exposure to or contamination from radioactive materials. The Centers for Disease Control and Prevention (CDC), in collaboration with many other partners, has produced a guide for state and local public health planners on establishing a system for population monitoring, a core of which is the community reception center (CRC).³⁵ The purpose of the CRC—which may be co-located with other disaster resource sites such as alternative care treatment sites or shelters operated by the American Red Cross—is to assess people for exposure, contamination, and the need for decontamination or medical follow-up. CRCs will play a key role in protecting the public health of people from affected areas and alleviating the anxiety of communities taking in evacuees. Planners should note, however, that past evacuation experience indicates that when people evacuate, they often scatter to nearby friends and family; therefore, not all evacuees will report to a designated shelter or, in this case, a CRC.

ACTION 7

Integrate, test, and conduct training on the elements of a comprehensive fallout preparedness and public warning system.

- ❑ Task 7.1—Regularly conduct training programs for emergency personnel, volunteers, and key stakeholders in the community.
- ❑ Task 7.2—Exercise, test, and drill the elements of fallout preparedness and public warning systems and include the community in these exercises.
- ❑ Task 7.3—Routinely review, revise, and maintain current fallout protections plans.

ACTION 7: Integrate, test, and conduct training on the above elements of a comprehensive fallout preparedness and public warning system.

When effective, an integrated preparedness and public warning system enables populations to act swiftly and correctly on protective guidance, thus reducing casualties. Such a system incorporates technical, organizational, social, and human elements.³⁶ A continual process of advance planning, training, exercising, and evaluating are necessary to establish and strengthen linkages among all these elements.⁵⁹ As jurisdictions move forward through the phased implementation of fallout preparedness actions—from obtaining community support to planning an informed, phased evacuation—the information gathered through the process should be used to update existing plans across phases.

- ❑ **Task 7.1**—*Regularly conduct training programs for emergency personnel, volunteers, and key stakeholders in the community.*

Citizens, officials, and emergency personnel should be aware of fallout protection plans and what is expected of them under these plans.⁶⁰ For instance, citizens should be prepared to seek adequate shelter, and schools should have plans on the books to keep students safe from radiation. Regular training will ensure that current personnel as well as those new to the fallout hazard are familiar with priorities, goals, objectives, and best courses of action.²⁸ The training can also help to identify and address the concerns and information needs of emergency responders and others regarding a nuclear incident.^{61,62} Everyone—from individual citizens to emergency professionals to journalists (who will be key communicators with the public)—should know where they can get actionable information regarding the fallout plume and evacuation routes. In the case of radiation, a mapping and monitoring group should be trained to compile and produce plume information as soon as possible. These abilities will also need to be tested.

- ❑ **Task 7.2**—*Exercise, test, and drill the above elements of fallout preparedness and public warning systems and include the community in these exercises.*

Participation in preparedness exercises enhances perceptions of response knowledge and teamwork.²⁸ Exercises that involve the public serve to inform citizens about the radiation threat, increasing knowledge on what they should and should not do through a more “real” experience.⁶⁰ Tests that involve multiple agencies also allow these agencies to develop a history of interaction and cooperation that will facilitate their response in the highly complex scenario of a nuclear detonation.⁶⁰ Exercises should include emergency personnel as well as the private sector, schools, faith-based organizations, volunteers, and other community groups and should be integrated with ongoing pre-incident education programs regarding fallout protection.

Interagency coordination and roles should be among the first aspects of fallout protection tested so that officials have a clear understanding of who is in charge and who is authorized to release messages to the public. A public warning exercise with prepared messages should also be undertaken in early phases of fallout protection planning in order to understand the warning distribution system and how messages will be conveyed in situations such as large-scale blackouts and EMP damage. All exercises should include an after-action report that captures information and lessons learned from the exercise and includes remedial action processes as necessary.²⁸

- ❑ **Task 7.3**—*Routinely review, revise, and maintain current fallout protection plans.*

Fallout protection plans should be considered “living documents” to be revised and changed as new information from exercises, from events, and on capabilities emerge.²⁸ Exercises may indicate that some goals, objectives, decisions, actions, and timing outlined in existing fallout plans need to be reevaluated; operational failures or weaknesses may be identified and need to be addressed in subsequent plans. After exercising the plan, role reassignments

and procedural changes may become necessary. Changes in community make-up and resources will also alter plans. As a jurisdiction improves its radiation monitoring abilities, for instance, this may lead planners to reevaluate which information sources have priority for triggering warning messages. Planners should be aware of lessons and practices from other communities that are improving their fallout preparedness plans.



Phased Implementation



WHERE SHOULD A JURISDICTION BEGIN WHEN IMPLEMENTING THE CHECKLIST?

Actions outlined in the *Fallout Preparedness Checklist* can be grouped into 4 implementation phases with the following high-level objectives (Figure 4). Action 7, with a focus on integrating and testing the overall preparedness system, undergirds all phases.

- **PHASE 1:** Obtain broad-based community support for nuclear incident preparedness [Action 1].
- **PHASE 2:** Cultivate an informed population capable of acting on its own, principally to seek adequate shelter and stay there until it is safe to move [Actions 2-3].
- **PHASE 3:** Develop the ability to issue public warnings post-incident on protective actions that are geographically specific [Actions 4-5].
- **PHASE 4:** Build up the capacity to execute a mass, phased evacuation—from pre-educating the public on the process to planning CRCs [Action 6].

PHASED IMPLEMENTATION

The first 2 phases call for relatively low-cost, straightforward, if challenging, tasks: building a broad community base in support of nuclear preparedness; interweaving fallout preparedness messages into an already credible mass education campaign on disasters; enabling existing volunteers and preparedness champions to seed grassroots conversations about fallout and to model preparedness behavior; and distributing a tool to aid building owners and operators when assessing shelter quality and teaching others. The reward for these education and outreach interventions is immense: knowledgeable residents who can act independently to save the most lives following a nuclear detonation. Phases 3 and 4 will provide additional challenges for jurisdictions given the high degree of organizational complexity and the need to integrate technological systems. Nonetheless, these phases constitute more comprehensive preparedness that can save additional lives.

Figure 4: Phased Implementation of Fallout Resilience Checklist

PHASE 1: Broad Community Support

ACTION 1.0—Obtain broad community backing for nuclear incident preparedness.

- 1.1. Generate leadership to overcome apathy or resistance to preparedness.
- 1.2. Build a fallout preparedness coalition that reflects the entire community.

- 1.3. Incorporate private and public radiation professionals into emergency planning.
- 1.4. Recruit community-serving nonprofits to teach vulnerable, marginalized groups.
- 1.5. Map a nuclear detonation's effects against the region's terrain and inhabitants.

PHASE 2: Educated and Prepared Population

ACTION 2.0—Conduct an ongoing public education program.

- 2.1. Designate a lead agency to coordinate the program across agencies and region.
- 2.2. Use nontechnical language to deliver messages on protective actions.
- 2.3. Disseminate information using multiple modalities and multiple sources.
- 2.4. Develop a neighborhood or social network-driven training and education program.
- 2.5. Periodically assess progress toward preparedness outcomes.

ACTION 3.0—Enable building owners and operators to assess shelters and teach others.

- 3.1. Disseminate a shelter rating guide to commercial building managers.
- 3.2. Rate public buildings in terms of their performance as fallout shelters.
- 3.3. Partner with schools to expand their emergency plans to include fallout protection.
- 3.4. Distribute shelter rating guide to homeowner and tenant associations.

PHASE 3: Means to Issue Geographically Specific Warnings

ACTION 4.0—Strengthen the ability to deliver actionable public warnings post-incident.

- 4.1. Develop pre-scripted, pre-vetted, and scientifically based fallout warning messages.
- 4.2. Address organizational issues related to effective warning dissemination.
- 4.3. Devise low-tech, redundant means for issuing public warnings.
- 4.4. Plan to establish hotlines for an acute demand for health-related information.
- 4.5. Monitor peer-to-peer communications to enhance situational awareness.

ACTION 5.0—Establish a rapid system for mapping the dangerous fallout zone.

- 5.1. Develop prior relationships with federal partners.
- 5.2. Conduct a regional inventory of monitoring staff and equipment.
- 5.3. Develop plans for synthesizing diverse data scattered across the region.
- 5.4. Plan for the prompt release of plume maps via broadcast media and social media.
- 5.5. Pre-position a network of automated radiation monitors.

PHASE 4: Ability to Execute a Mass, Phased Evacuation

ACTION 6.0—Plan for a large-scale, phased evacuation.

- 6.1. Form regional partnerships and execute mutual aid agreements.
- 6.2. Map out buildings and neighborhoods according to shelter quality.
- 6.3. Predesignate the criteria against which areas will be prioritized for evacuation.
- 6.4. Consider how pre-established evacuation routes may have to be adapted.

- 6.5. Craft pre-incident education materials that share evacuation plans.
- 6.6. Prepare scientifically based templates for evacuation messaging.
- 6.7. Anticipate a portion of residents who evacuate independent of instruction.
- 6.8. Plan to establish monitoring and decontamination centers.

ACTION 7.0: Integrate, test, and conduct training in all elements of a comprehensive fallout preparedness system.



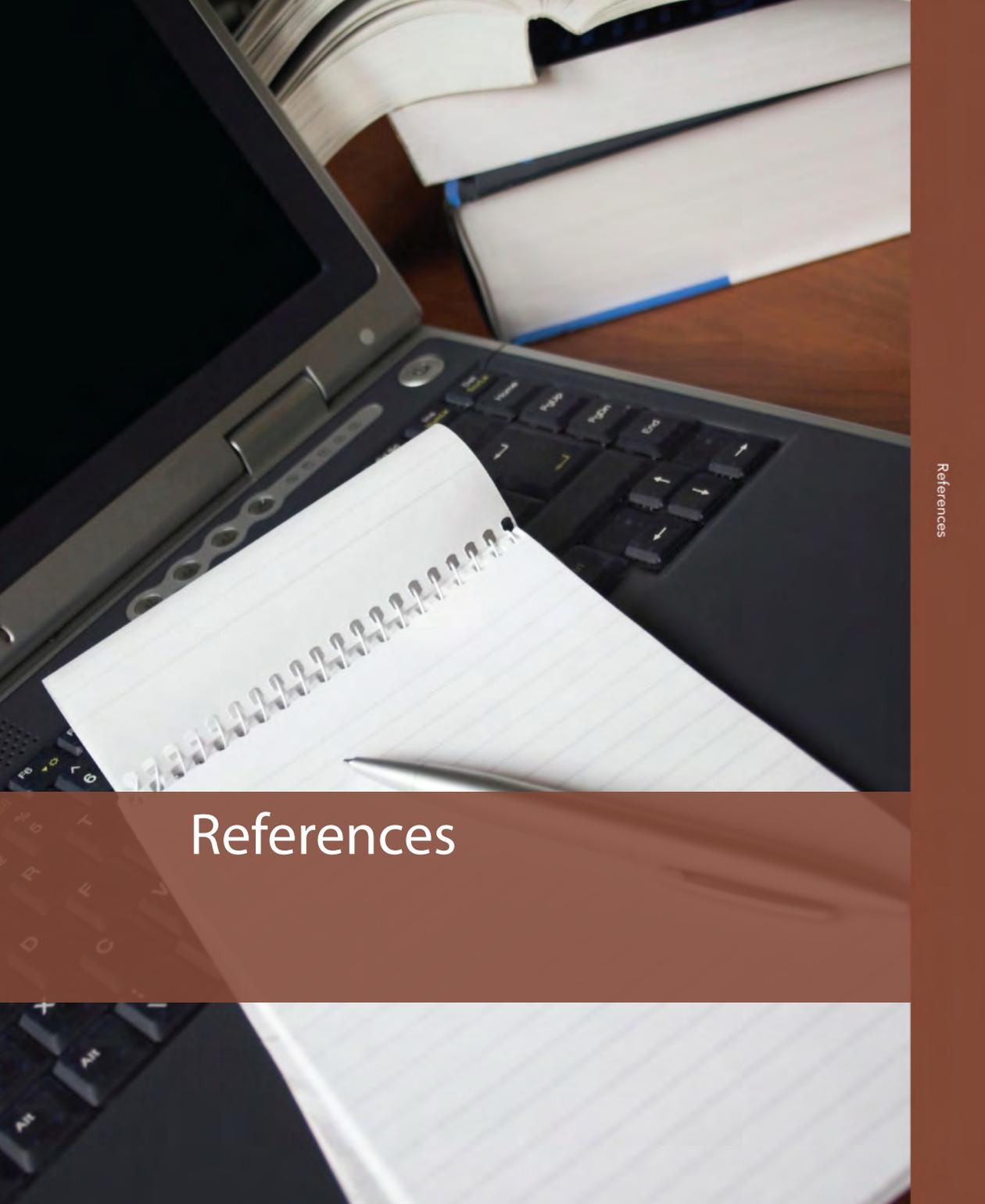


Benefits



HOW DOES A JURISDICTION BENEFIT FROM ADOPTING THE PREPAREDNESS CHECKLIST?

Successful adoption of the *Fallout Preparedness Checklist* can produce significant gains for communities. The collaborations essential for nuclear terrorism readiness can have spillover effects for other complex disaster management matters. A program for fallout preparedness—where the ability to shelter for at least 1 to 3 days is central—builds on elements of an all-hazards framework and extends that framework so that it truly becomes comprehensive in the ability to address nuclear terrorism. Moreover, steady implementation of the checklist can create momentum for cities and their neighboring areas to tackle other difficult nuclear response and recovery issues like the surge in demand for medical services, search and rescue capabilities, and the sheltering of mass, displaced populations. Lastly, and most important, after an actual nuclear detonation, having implemented this checklist could save tens of thousands of lives.



References

REFERENCES

1. Bunn M, Morozov Y, Mowatt-Larsen R, et al. *The U.S.-Russia Joint Threat Assessment of Nuclear Terrorism*. Cambridge, MA: Report for Belfer Center for Science and International Affairs, Harvard Kennedy School, Institute for U.S. and Canadian Studies; June 6, 2011. <http://belfercenter.ksg.harvard.edu/files/Joint-Threat-Assessment%20ENG%2027%20May%202011.pdf>. Accessed July 19, 2011.
2. The White House. *National Security Strategy*. May 2010. http://www.whitehouse.gov/sites/default/files/rss_viewer/national_security_strategy.pdf. Accessed March 15, 2011.
3. Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism. *The Clock Is Ticking: A Progress Report on America's Preparedness to Prevent Weapons of Mass Destruction Proliferation and Terrorism*. October 21, 2009. <http://www.preventwmd.com/static/docs/report/WMDRpt10-20Final.pdf>. Accessed March 23, 2011.
4. Meade C, Molander RC. *Considering the Effects of a Catastrophic Terrorist Attack*. Santa Monica, CA: RAND Center for Terrorism Risk Management Policy; 2006. http://www.rand.org/pubs/technical_reports/2006/RAND_TR391.pdf. Accessed March 28, 2011.
5. National Security Staff Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats. *Planning Guidance for Response to a Nuclear Detonation*. 2d ed; 2010. <http://www.remm.nlm.gov/PlanningGuidanceNuclearDetonation.pdf>. Accessed August 5, 2011.
6. Buddemeier BR, Dillon MB. *Key Response Planning Factors for the Aftermath of Nuclear Terrorism*. 2009. Lawrence Livermore National Laboratory. Document prepared for the U.S. Department of Energy. http://www.hps.org/hsc/documents/IND_ResponsePlanning_LLNL-TR-410067web.pdf. Accessed August 5, 2011.

7. Buddemeier B, Wood-Zika A, Doshi P. Training Document: Shelter and Evacuation Strategies (LA). Department of Homeland Security. June 25, 2010.
8. Obama B. Speech at the Nuclear Security Summit; April 13, 2010; Washington, DC. http://www.cfr.org/publication/21889/obamas_speech_at_the_nuclear_security_summit_april_2010.html. Accessed June 28, 2010.
9. Commission on the Prevention of WMD Proliferation and Terrorism. *World at Risk: The Report of the Commission on the Prevention of WMD Proliferation and Terrorism*. December 2008. <http://www.preventwmd.gov/report/>. Accessed August 5, 2011.
10. Bunn M. *Securing the Bomb 2008*. Cambridge, MA, and Washington, DC: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative; November 2008. http://www.nti.org/e_research/Securing_the_bomb08.pdf. Accessed August 5, 2011.
11. Statement for the Record of Charles E. Allen, Under Secretary for Intelligence and Analysis, U.S. Department of Homeland Security before the Senate Committee on Homeland Security and Governmental Affairs, Hearing on Nuclear Terrorism: Assessing the Threat to the Homeland, April 2, 2008. http://hsgac.senate.gov/public/_files/040208Allen.pdf. Accessed August 5, 2011.
12. Carter AB, May MM, Perry WJ. The day after: action following a nuclear blast in a U.S. city. *Washington Quarterly* 2007;20(4):19-32.
13. National Center for Disaster Preparedness, Columbia University Mailman School of Public Health. *Day Three: Regional Resiliency and Health Challenges in the Aftermath of Nuclear Terrorism*. 2010.
14. The White House Homeland Security Council. *National Planning Scenarios: Executive Summaries—Created for Use in National, Federal, State, and Local Homeland Security Preparedness Activities*. April 2005. <http://cees.tamui.edu/covertheborder/TOOLS/NationalPlanningSen.pdf>. Accessed August 5, 2011.

15. Carter AB, May MM, Perry WJ. *The Day After: Actions in the 24 hours Following a Nuclear Blast in a Major American City*. Workshop Report. http://belfercenter.ksg.harvard.edu/files/dayafterworkshopreport_may2007.pdf. Accessed August 5, 2011.
16. Orient JM, Lucas KA, Abrams HL. Medical resources after nuclear war. *JAMA* 1984; 253(10):1389-1390.
17. Oklahoma Department of Civil Emergency Management. *After Action Report Alfred P. Murrah Federal Building Bombing*. <http://www.ok.gov/OEM/documents/Bombing%20After%20Action%20Report.pdf>. Accessed March 29, 2011.
18. Lapp RE. Nuclear weapons: past and present. *Science and Public Affairs: Bulletin of the Atomic Scientists* 1970;26(6):103-106.
19. Glasstone S, Dolan PJ. *The Effects of Nuclear Weapons*. 3rd ed. Washington, DC: United States Department of Defense and the Energy Research and Development Administration; 1977.
20. Ferlic KP. *Fallout: Its Characteristics and Management*. Armed Forces Radiobiology Research Institute Technical Report AFRRRI TR83-5. Bethesda, MD; December 1983. <http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA140111>. Accessed August 6, 2011.
21. The Nature of Radioactive Fallout and Its Effects on Man. Hearings before the Special Subcommittee of Radiation of the Joint Committee on Atomic Energy. Congress of the United States. Eighty-fifth Congress. May 27-29 and June 3, 1957.
22. National Council on Radiation Protection and Measurements (NCRP). *Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers*. NCRP report no. 165. Bethesda, MD: NCRP; 2010.
23. Brandt L, Yoshimura AS. *Analysis of Sheltering and Evacuation Strategies for an Urban Nuclear Detonation Scenario*. SAND2009-3299. Sandia National Laboratories; May 2009.

24. Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents. Federal Emergency Management Agency. Department of Homeland Security. *Fed Regist* 2008;73(149):45029-45048.
25. Lindell MK, Perry RW. Planning and preparedness. In: Waugh WL, Tierney K, eds., *Emergency Management: Principles and Practice for Local Government*. 2d ed. Washington, DC: ICMA Press; 2007:113-141.
26. Wood MM, Mileti DS, Kano M, Kelley MM, Regan R, Bourque LB. Communicating actionable risk for terrorism and other hazards. *International Journal of Risk Analysis*. In press.
27. Knebel AR, Coleman CN, Cliffer KD, et al. Allocation of scarce resources after a nuclear detonation: setting the context. *Disaster Med Public Health Prep* 2011; 5:S20-S31.
28. Federal Emergency Management Agency (FEMA). *Developing and Maintaining Emergency Operations Plans: Comprehensive Preparedness Guide (CPG) 101, Version 2.0*. Washington, DC; November 2010. http://www.fema.gov/pdf/about/divisions/npd/CPG_101_V2.pdf. Accessed May 31, 2011.
29. Patton A. Collaborative emergency management. In: Waugh WL, Tierney K, eds., *Emergency Management: Principles and Practice for Local Government*. 2d ed. Washington, DC: ICMA Press; 2007:71-85.
30. McBurney RE. *A Plan for Incorporating Local Volunteer Radiation Professionals into Existing Health Volunteer Programs to Assist in Population Monitoring*. Frankfort, KY: Conference of Radiation Control Program Directors; March 2011.
31. Buddemeier B. Reducing the consequences of a nuclear detonation: recent research. *The Bridge* 2010;40(2):28-38. <http://www.nae.edu/Publications/Bridge/19804/19920.aspx>. Accessed March 30, 2011.

32. Mileti DS, Wood MM, Kano M, Kelley MM, LB Bourque LB. Motivating public preparedness. *International Association of Emergency Managers Bulletin* 2011;28(4): 9,12.
33. Mileti DS, Bourque LB, Wood MM, Kano M. Motivating public mitigation and preparedness for earthquakes and other hazards (invited paper). *Journal of Hazard Mitigation and Risk Assessment* Spring 2011:25-31.
34. Mileti DS, Kuligowski ED. Evidence-Based Guidance for Public Risk Communication and Education. START Research Brief. September 2006. http://www.start.umd.edu/start/publications/research_briefs/20060926_mileti.pdf. Accessed June 20, 2011.
35. Radiation Studies Branch, Division of Environmental Hazards and Health Effects, National Center for Environmental Health, Centers for Disease Control and Prevention. *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners*. August 2007. <http://www.bt.cdc.gov/radiation/pdf/population-monitoring-guide.pdf>. Accessed March 29, 2011.
36. National Research Council. *Tsunami Warning and Preparedness: An Assessment of the U.S. Tsunami Program and the Nation's Preparedness Efforts*. Washington, DC: National Academies Press; 2010.
37. Klepeis NE, Nelson WC, Ott WR, et al. The National Human Activity Pattern Survey (NHAPS): A Resource for Assessing Exposure to Environmental Pollutants. <http://eetd.lbl.gov/IE/pdf/LBNL-47713.pdf>. Accessed 16 May 2011.
38. Stein BD. The Role of Schools in Meeting Communities' Needs during Bioterrorism. The Public as an Asset, Not a Problem: A Summit on Leadership during Bioterrorism. Washington, DC; February 3-4, 2003. http://www.upmc-biosecurity.org/website/events/2003_public-as-asset/stein/stein_trans.html. Accessed April 1, 2011.

39. U.S. Department of Commerce; U.S. Department of Housing and Urban Development. American Housing Brief from the American Housing Survey: 1995. July 1997. <http://www.census.gov/prod/2/const/ahb/ahb-9501.pdf>. Accessed May 20, 2011.
40. Mileti DS, Sorensen JH. *Communication of Emergency Public Warnings: a Social Science Perspective and State-of-the-art Assessment*. Oak Ridge National Laboratory. ORNL-6609. August 1990.
41. Committee on Public Response to Alerts and Warnings on Mobile Devices: Current Knowledge and Research Gaps; National Research Council. *Public Response to Alerts and Warnings on Mobile Devices: Summary of a Workshop on Current Knowledge and Research Gaps*. Washington, DC: National Academies Press; 2011. <http://www.nap.edu/catalog/13076.html>. Accessed August 5, 2011.
42. Domestic Resilience Group, IND Response Sub-IPC, Nuclear Detonation Response Communications Working Group. *Nuclear Detonation Preparedness: Communicating in the Immediate Aftermath*. Approved for Interim Use, Department of Homeland Security, September 2010. <http://www.remm.nlm.gov/NuclearDetonationPreparedness.pdf>. Accessed August 8, 2011.
43. Bean H, Mileti D. RCPGP warning system integration research project; Los Angeles /National Capitol Region/New York—Final Report. National Consortium for the Study of Terrorism and Responses to Terrorism (START). November 2010.
44. Turner RH. Rumor as intensified information seeking: earthquake rumors in China and the United States. In: Dynes RR, Tierney, KJ, eds. *Disasters, Collective Behavior and Social Organization*. Newark, DE: University of Delaware Press; 1994:244-256.

45. Nelson A, Sigal I, Zambrano D. *Media, Information Systems and Communities: Lessons from Haiti, Communicating with Disaster Affected Communities*. John S. and James L. Knight Foundation; 2011. http://reliefweb.int/sites/reliefweb.int/files/resources/F156DD1E2F9D2D0085257815005DD82F-Full_Report.pdf. Accessed August 6, 2011.
46. 'Radiation' text message is fake. BBC News Technology March 15, 2011. <http://www.bbc.co.uk/news/technology-12745128>. Accessed April 1, 2011.
47. Palen L, Anderson KM, Mark G, et al. A vision for technology-mediated support for public participation & assistance in mass emergencies & disasters. Presented at: Association of Computing Machinery and British Computing Society's 2010 Conference on Visions of Computer Science; April 14-16, 2010; University of Edinburgh. http://www.bcs.org/upload/pdf/ewic_vs10_s4paper2.pdf. Accessed August 6, 2011.
48. Poulson K. First hand reports from California wildfires pour through Twitter. *Wired* 23 October 2007.
49. National Council on Radiation Protection and Measurements. *NCRP Commentary No. 19: Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism*. Bethesda, MD: NCRP; December 31, 2005.
50. Kaufman K. Presentation at Preparing to Save Lives and Recover after a Nuclear Detonation: Implications for U.S. Policy; conference convened by the Center for Biosecurity of UPMC. Washington, DC; April 29, 2010. Video recording available at http://www.upmc-biosecurity.org/website/events/2010_nuke/agenda.html. Accessed August 5, 2011.
51. Lindsay BR. *Federal Evacuation Policy: Issues for Congress*. Washington, DC: Congressional Research Service; April 29, 2010. <http://www.fas.org/sgp/crs/homesecc/RL34745.pdf>. Accessed August 5, 2011.

52. *Rural Preparedness Planning Guide: Planning for Population Surge Following Urban Disasters*. Western New York Public Health Alliance. <http://www.norc.org/NR/rdonlyres/227B10FB-44B4-41D9-B214-6F5DD26ABA6D/0/RuralPreparednessGuide2008.pdf>. Accessed August 5, 2011.
53. *Identification and Analysis of Factors Affecting Emergency Evacuations*. NUREG/CR-6864. Sandia National Laboratories. Prepared for U.S. Nuclear Regulatory Commission. January 2005. http://www.nei.org/filefolder/nrc_emergency_evacuation_study.pdf. Accessed August 6, 2011.
54. *Strategic Planning Guide for the Evacuation of a Highly Urbanized Environment*. Office of Critical Infrastructure Protection and Emergency Preparedness. Government of Canada; 2002. <http://orise.orau.gov/CSEPP/documents/planning/evacuation-documents/guidance-documents/canada-evacurban.pdf>. Accessed August 6, 2011.
55. *Regional Health and Public Health Preparedness for Nuclear Terrorism: Optimizing Survival in a Low Probability/High Consequence Disaster*. Columbia University Mailman School of Public Health. The Center for Public Health Preparedness; 2010. <http://www.ncdp.mailman.columbia.edu/files/Nuclear%20Event-Whitepaper.pdf>. Accessed August 6, 2011.
56. Nuclear Incident Communication Planning—Final Report. Homeland Security Institute. 15 March 2009.
57. Wein LM, Choi Y, Denuit S. Analyzing evacuation versus shelter-in-place strategies after a terrorist nuclear detonation. *Risk Anal* 2010;30(9):1315-1327. <http://onlinelibrary.wiley.com/doi/10.1111/j.1539-6924.2010.01430.x/abstract>. Accessed August 5, 2011.
58. Benjamin GC, McGeary M, McCutchen SR, eds. *Assessing Medical Preparedness to Respond to a Terrorist Nuclear Event: Workshop Report*. Washington, DC: National Academies Press; 2009. http://www.nap.edu/catalog.php?record_id=12578. Accessed August 5, 2011.

59. Perry RW, Lindell MK. Preparedness for emergency response: guidelines for the emergency planning process. *Disasters* 2003;27(4):336-350.
60. Perry RW. Disaster exercise outcomes for professional emergency personnel and citizen volunteers. *Journal of Contingency Crisis Management* 2004;12(2):64-74.
61. Becker SM, Middleton S. Improving hospital preparedness for radiological terrorism: perspectives from emergency department physicians and nurses. *Disaster Med Public Health Prep* 2008;2(3):174-184.
62. Becker SM. Risk communication and radiological/nuclear terrorism: perceptions, concerns and information needs of first responders, health department personnel, and healthcare providers. In: Johnson RH, ed. *Radiation Risk Communication: Issues and Solutions*. Madison, WI: Medical Physics Publishing; 2010:271-280.

ING PRINCIPLES

PLANNING PRINCIPLES

REBUILD



- Infrastructure projects must restoring confidence, enhance and withstanding future
- Recovery must be an engine with a high-priority given improving opportunities
- Public policies must promote healthy communities
- Housing must be insured

IMPROVE

- Recovery

Fallout Preparedness Education

FEMA/Marvin Nauman

APPENDIX A

SUGGESTED TOPICS FOR
A FALLOUT PREPAREDNESS
EDUCATION CAMPAIGN

Introduction

This appendix provides information on topics that communities may wish to address when designing their own public education campaigns around fallout preparedness. Professional associations, the federal government, and others have also provided guidance on information the public would need to prepare and respond to a nuclear detonation.¹³ These resources can help to inform a fallout preparedness campaign tailored to a specific community.

How will I know that a nuclear detonation has occurred?

It is important to recognize the cues or physical signs of a nuclear detonation promptly on your own, because damaged or disrupted communication lines may make it impossible for authorities to warn you to protect yourself. Detonation of a 10-kiloton nuclear weapon will cause a brilliant flash of light. At a distance of 1 mile from ground zero, the flash would be as bright as 1,000 midday suns. A mushroom-shaped cloud rising miles into the air may also indicate a nuclear detonation, but the weather can interfere with the cloud shape being formed or being seen. The mushroom cloud may not be seen at night. Conventional explosives can also produce a mushroom cloud, which could be confused with a nuclear incident, especially for smaller bombs. Sudden disruption of electronic equipment may also signal the explosion of a nuclear device, as might the sudden appearance of burn victims distant from the explosion.

What is fallout?

Fallout is created when soil and debris combine with radioactive material from the nuclear explosion as they are drawn miles upward into the air by the heat of the blast. As this cloud cools, the mixture of radioactive materials falls onto the ground and roofs where it looks like sand or dust.

How can fallout hurt me?

Some types of radioactivity work like x-rays in that their energy (penetrating radiation) can pass through solid objects. Fallout that has settled on the ground and building roofs can release this penetrating radiation, and it can then damage cells and tissues in the human body. Exposure to high levels of radiation over a short period of time causes people to become very ill or to die, within minutes to months. This injury is known as acute radiation syndrome (ARS). After a nuclear explosion, people can avoid ARS by immediately finding a safe place to shelter. Another health effect—having

a higher chance of developing cancer later in life—comes from long-term exposure to low doses of radiation. Your first concern following a nuclear detonation is avoiding ARS. After the crisis period is over, officials will provide you with additional information on how to lower the chances of developing cancer over time.

How can I avoid dangerous amounts of fallout radiation?

The single most important thing to do is to immediately go inside a sound and stable building before fallout arrives, picking a shelter that provides the most protection as possible. The goal is to put as much dense, solid material and distance as possible between you and the radioactive dust. Some types of buildings protect people better than others. Dense materials such as brick, cement, and earth stop radiation better than wood, drywall, and thin sheet metal. Similarly, areas within a building, such as restrooms and stairwell cores, which are farther away from where the fallout has settled, protect better than those close to roofs, windows, and exterior walls. Multistory brick or concrete structures, cores of large office buildings, multistory shopping malls, and basements, tunnels, subways, and other underground areas are examples of good shelters. Poor shelters include outdoor areas, cars and other vehicles, mobile homes, single-story wood-frame houses, strip malls, and other single-story light structures.

How long do I need to stay in my shelter before it's safe to come out?

In general, to reduce total radiation exposure, the longer you can wait in safety, the lower the amount of radiation you will receive. Everyone needs to be inside a shelter during the first hour following the detonation, when the levels of radiation are at their most dangerous. Then:

- If you are in a poor shelter and there's a better one nearby, wait at least 1 hour before moving. Potential radiation exposure decreases by 55% in the first hour following a detonation. If you move to a different shelter, minimize the time outside.
- If you are in a good shelter, stay inside a minimum of 1 day and then wait for instructions from authorities about when to come out. In the first day following a nuclear detonation, potential radiation exposure decreases by 80%.

It may take officials a day or more to determine where there are dangerous levels of fallout as well as which roads are passable. Once they know this, officials can inform people when and where it's safe to leave their shelters. Officials will help move people whose lives are most in danger first; others will be asked to wait their turn and keep the roads clear. Evacuating early may endanger your life and others' lives. This means that you may be sheltering for several days. TV, phone, and internet access may be difficult due to power outages or high demand. Therefore, turning on a battery-powered or hand-crank radio may be the best option for finding out what is happening and learning about what you should do next.

Should I go get my children from school after a nuclear detonation?

No. It's safest for your children immediately to go deep inside their school and stay there to avoid fallout radiation. You put both your children's and your own safety at risk by being outdoors or in cars during the time when radiation levels are at their highest. Your kids need you healthy. Take time now to find out the school's plans for a nuclear detonation. Where will they keep the children? Do they have enough food and water for several days? Do they have an alternative site chosen for moving students? How will you be reunited with your children? Making sure that the school has a good plan to keep your children safe should reduce some of the pressure you may feel to pick them up from school immediately following a nuclear detonation. Having a family

emergency plan on how you will stay in touch and reunite can also provide some peace of mind while you wait until it's safe.

What should I do if I get radioactive dust on me? What about dust on my pet?

Radioactive dust that settles on clothing, skin, and hair is known as external contamination. Some very easy steps can help remove radioactive dust that may be on you or your clothes or on your pets. Simply removing the outer layer of clothing can eliminate the vast majority of fallout;⁴ more dust, however, is taken off when removing a winter coat and boots than when taking off shorts and a t-shirt. Place the removed clothing in a plastic bag and leave outdoors. When possible, take a shower and use soap and water to eliminate any remaining radioactive material. If it is not possible to shower, use a wet cloth to wipe off skin not covered by clothing, especially hands and faces to prevent accidental ingestion of radioactive materials. Pets that have been outdoors following the detonation can also be washed to remove fallout.

What can I do to help others? Can I open my doors to people covered in fallout dust?

In the event of a nuclear detonation, you can help people in a variety of ways, whether you are in the dangerous fallout zone, in nearby affected areas, or in other parts of the country. It is safe to take in others using precautions to limit the spread of radioactive dust as described above. Letting others into your building could save their lives and not endanger yours. If you are in a community adjacent to an affected area, you can temporarily house evacuees or help organize reception shelters. People who live in major cities outside the stricken region can begin to make plans to accept longer-term evacuees and to provide support to people and their families who come for medical treatment.

What about breathing in fallout? Should I wear a mask?

Actually, inhaling fallout is not a major source of radiation exposure. During the first 24 hours, when fallout radiation levels are highest, the particles settling to the ground tend to be big enough that the nose filters them out, preventing them from going into the lungs.⁵ Once fallout has settled on the ground, you are much more likely to get it on lower parts of your body while walking through it. Generally, the dust won't be kicked up high enough to breathe in. That said, if you have a mask or want to cover your face with a cloth, it is a sensible thing to do. However, make sure the mask is definitely free of radioactive dust, otherwise you are increasing your chance of breathing in fallout.

Is it safe to eat and drink after a nuclear explosion, or will I get radiation inside me?

You can avoid ingesting fallout by consuming only things that were protected from fallout dust (eg, food that is wrapped or inside of containers or refrigerators) and/or that can be washed off. Also, make sure that your hands and face are clean of fallout dust so that you don't accidentally get it in what you are eating and drinking. Once the immediate crisis is over, officials will identify the places where food and water contain too high a level of radiation, and they will prevent people from eating and drinking items from these areas.

What are the 3 most important things I can do now to be prepared for a nuclear detonation?

1. Have a family emergency plan and kit.
 - Knowing what steps your loved ones plan to take after a nuclear detonation and how you will find one another after 24 to 72 hours reduces worry. In turn, this increases the likelihood that you will all stay inside buildings rather than exposing yourselves to radiation while trying to find one another.

- Set aside emergency supplies of medications, food, and water in your home and workplace. Emergency professionals recommend that if you have not yet set aside anything, begin with a 3-days' supply and work your way up to 1 week and then 2 weeks as you adopt a preparedness lifestyle. Larger stockpiles provide you more flexibility for unpredictable events. For more details on gathering supplies to support sheltering-in-place, consult the Ready.gov and American Red Cross websites.
2. Determine which buildings give the best fallout protection near and en route to where you live, work, or attend school.
 3. Buy a hand-crank or battery-powered radio to get information in the event other means don't work.

Appendix A References

1. Just-in-Time: Nuclear Detonation—10 Rules for the Public and Citizen Responders. Homeland Security Committee of the Health Physics Society. http://www.hps.org/hsc/documents/publicEmergency_Card_121509v2_3--4up.pdf. Accessed August 5, 2011.
2. National Council on Radiation Protection and Measurements (NCRP). *Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers*. NCRP report no. 165. Bethesda, MD: NCRP; 2010.
3. Domestic Resilience Group, IND Response Sub-IPC, Nuclear Detonation Response Communications Working Group. *Nuclear Detonation Preparedness: Communicating in the Immediate Aftermath*. Approved for Interim Use, Department of Homeland Security, September 2010. <http://www.remm.nlm.gov/NuclearDetonationPreparedness.pdf>.
4. Ferlic KP. *Fallout: Its Characteristics and Management*. Armed Forces Radiobiology Research Institute Technical Report AFRRRI TR83-5. Bethesda, MD; December 1983. <http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA140111>. Accessed August 6, 2011.
5. Glasstone S, Dolan PJ. *The Effects of Nuclear Weapons*, 3rd ed. Washington, DC: U.S. Department of Defense and the Energy Research and Development Administration; 1977.



Use of Buildings as Shelters



APPENDIX B

HOW TO USE BUILDINGS AS
SHELTERS AGAINST FALLOUT

Introduction

Quickly going inside and staying inside the nearest and most protective building in order to minimize exposure to radioactive fallout is the most critical lifesaving action for the public after a nuclear detonation.^{1,2} This appendix of frequently asked questions (FAQ) is a tool to aid building owners, operators, and occupants in judging a structure's ability to minimize fallout exposure and in identifying the best areas within a building to shelter. This FAQ is useful to commercial building owners and operators, apartment complex managers, safety officers for businesses and schools, neighborhood associations, individual homeowners, and apartment dwellers. The principal goals of this FAQ are to raise people's general awareness of the protective qualities of the spaces around them and to encourage individuals who oversee large properties to serve as key community resources and educators on fallout protection.

How does a building protect people from radiation?

Radiation from dangerous fallout can be blocked by dense material such as earth, cement, and concrete, and it can be reduced by increasing a person's distance from deposited fallout.² The more dense the material that separates people from radioactive fallout, the more protected they are from radiation. Dense materials such as brick, cement, and earth provide better protection than wood, drywall, and thin sheet metal. Similarly, the further a person is away from where fallout has settled on and around buildings, the more protected s/he is. A large concrete and steel building is doubly protective, for example, because its dense materials block radiation well, and because people can move to the core of the building, creating greater distance from the radioactive fallout outside.

Materials that provide best (1) to least (5) protection from radioactive fallout:³

1. Lead
2. Steel
3. Concrete
4. Earth
5. Wood

Is it more important to know where to shelter at home or at the workplace?

A nuclear detonation could occur at any time. It is important for people to know where the best places are around them to take immediate shelter—both during the day and at night. People are encouraged to be aware of their surroundings, creating a mental map of sheltering spaces around them—whether they are at home, at work, in a mall, or on the road. Individuals who hold authority over large properties are encouraged to assist tenants in identifying areas to shelter (see below).

What buildings offer the best protection? What places within buildings offer the best protection?

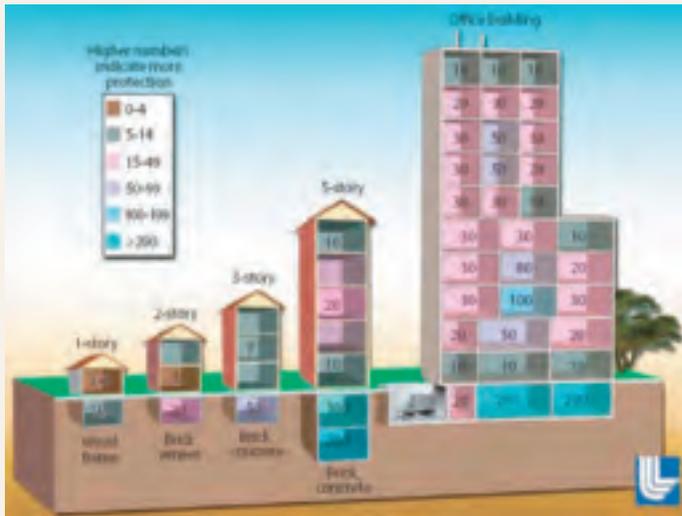
Both the density of building materials and the distance from fallout affect how much a building can protect occupants from radiation. The best areas to shelter are deep inside buildings made of dense material, far away from fallout that has settled outside. Areas within a building, such as restrooms and stairwell cores, which are distant from deposited radioactive fallout, provide better protection than those close to roofs, windows, and exterior walls. Multistory brick or concrete structures, cores of large office buildings, multistory shopping malls, basements, tunnels, subways, and other underground areas are examples of good shelters. Poor shelters have little material to block radiation and provide little distance from fallout that has settled on rooftops and the ground outside. Poor shelters include outdoor areas, cars and other vehicles, mobile homes, single-story wood-frame houses, strip malls, and other single-story light structures.⁴

What do scientists mean when they refer to “protection factor” (PF?)

The protection factor for radiation is similar in concept to the sun protection factor (SPF) values used in sunscreens.⁴ That is, the higher a shelter’s protection factor, the greater the ability of that shelter to minimize exposure

to radioactive fallout. Scientists assign PF values to buildings based on information about how radiation reduces in intensity as it moves through walls, floors, and over distance. This information was originally derived from mathematical and computer calculations on radiation penetration as well as small-scale models and full-scale experiments with radioactive material.⁵ Some of the research used to calculate PF was completed during the Cold War, but more advanced mathematical modeling has recently improved guidance on shelters, including information in the image below:

Figure 3: Sample Protection Factors for a Variety of Building Types and Locations¹



Shelters with a higher PF are made of more dense material and place people farther away from radiation sources, reducing the radiation exposure of those inside. To understand how PF corresponds to the reduction in radiation exposure, first assume that a person outside in the dangerous fallout zone for an hour immediately after the detonation would receive a potentially lethal dose of 500 rem (a “rem” is a unit of measurement for radiation). In contrast, a person in a nearby shelter with a protection factor of 10 would receive just 1/10 of the radiation, or 50 rem, in the same amount of time. The PF represents the fraction of radiation received by people sheltering, compared to full exposure outside the shelter.

Does a building have to be airtight to keep out fallout?

No. Federal guidance has stated that buildings do not have to be airtight to protect against fallout and that broken windows will not greatly reduce the protection offered by a shelter.¹ Nonetheless, building owners, managers, maintenance engineers, safety officers, building emergency coordinators, and others can take steps to “harden” buildings to prevent airborne hazards such as fallout from entering buildings. The county of Los Angeles has developed a checklist that may help prevent dangerous fallout from entering buildings.⁶ The prompt shutdown and isolation of air movement in large buildings could protect building occupants from fallout introduced through the ventilation system. Additionally, high-quality filters, properly maintained, could remove significant amounts of airborne fallout, especially the largest and most dangerous particles.⁴ Managers assessing the need to harden a building should have an understanding of critical systems, such as ventilation systems, and how they may move contamination through the building. Additionally, an engineering analysis of the ventilation system may need to be performed. In the case of individual householders, Los Angeles County has recommended that occupants close the doors and windows and turn off fans that bring in air from the outside.⁴ In-room fans that only recirculate air can still be used,

as can heating or air-conditioning systems that do not bring in air from the outside.

What supplies does someone need to be able to shelter-in-place?

Fallout preparedness hinges on a very familiar formula for disaster readiness: the ability to shelter-in-place. For effective sheltering, people should equip their emergency kit at home and at work with adequate food, water, and medications; a battery-powered or hand-crank radio; and other supplies. Emergency professionals recommend that if you have not yet set aside anything, begin with a 3-days' supply and work your way up to 1 week and then 2 weeks as you adopt a preparedness lifestyle. Larger stockpiles provide you more flexibility across unpredictable events. For more detailed instructions on gathering supplies to support sheltering-in-place, individuals and families are encouraged to consult the Ready.gov and American Red Cross websites on basic emergency provisions. Businesses, schools, and organizations are similarly encouraged to adopt the Red Cross Ready Rating Program (<http://readyrating.org/>) to evaluate and improve institutional preparedness, which includes acquiring and maintaining adequate emergency supplies.

What steps can building managers and safety officers take to help protect tenants and employees?

People who oversee large properties can help raise the awareness of occupants about how and where a building or building complex can best protect them in the event of a nuclear detonation. Building managers can bring this FAQ to the attention of their tenants (whether businesses, organizations, or individual residents). Moreover, building managers can work with the safety officers of tenant organizations to determine the best areas for occupants to shelter, combining an understanding of the protection factor of building materials with knowledge of building codes and structures

as well as ventilation systems. Tenant organizations can educate employees about sheltering, designate sheltering locations within buildings, post signs, and incorporate this information into disaster plans. Operators of large buildings with a high protection factor should also consider how to facilitate the availability of shelter to members of the public seeking refuge following a detonation.

Appendix B References

1. Buddemeier BR, Dillon MB. *Key Response Planning Factors for the Aftermath of Nuclear Terrorism*. LLNL TR 410067. Livermore, CA: Lawrence Livermore National Laboratory; August 2009.
2. National Security Staff Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats. *Planning Guidance for Response to a Nuclear Detonation*. 2d edition; 2010. <http://www.remm.nlm.gov/PlanningGuidanceNuclearDetonation.pdf>. Accessed August 5, 2011.
3. Ferlic KP. *Fallout: Its Characteristics and Management*. Armed Forces Radiobiology Research Institute Technical Report AFRR I TR83-5. Bethesda, MD; December 1983. <http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA140111>. Accessed August 6, 2011.
4. National Council on Radiation Protection and Measurements (NCRP). *Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers*. NCRP report no. 165. Bethesda, MD: NCRP; 2010.
5. What the planner needs to know about fallout. In: *Department of Defense. DCPA Attack Environment Manual*. June 1973. <http://training.fema.gov/EMLweb/edu/docs/HistoricalInterest/DCPA%20-%20June%201973%20-%20DCPA%20Attack%20Environment%20Manual%20-%20Chapter%206.pdf>. Accessed June 21, 2011.
6. *Building Assessment Checklist: Protection against Airborne Hazards*. County of Los Angeles Public Health. August 2006.



Writing an Effective Public Warning Message



APPENDIX C

FORMULA FOR WRITING AN
EFFECTIVE MESSAGE FOR POST
DETONATION PUBLIC WARNING

Introduction

Planning for an incident of nuclear terrorism should include the development of pre-scripted, pre-vetted, and scientifically based warning messages for fallout. This appendix summarizes the essential principles of an effective public warning message, drawing on an extensive evidence base about what actually motivates people to execute protective actions.¹⁴ A sample public warning message—one that provides initial guidance on immediate sheltering in the aftermath of a nuclear detonation—demonstrates these principles in practice. In actuality, jurisdictions will need to develop a series of time-sensitive public warning messages about protective guidance, as represented in Appendix D (“Provisional Fallout Warning Messages for the Post-Nuclear Detonation Period”). Until more comprehensive resources emerge, pre-scripted fallout protective guidance messages can adopt the form modeled in Appendix C and draw content from Appendix D, in consultation with the jurisdiction’s own radiation control and public health experts.

Components of an Effective Public Warning Message

Message Source

The warning message should specify who is issuing it. Since no one source is credible for everyone, a mixed group of agencies, officials, and advisors should be identified as the source of messages. Pre-incident coordination can facilitate alignment of messaging before and after an event.

Message Content

Four major elements should be addressed in the message's content:

1. The words should describe exactly what action people should take.
2. The message should tell people when to start taking the action and by when they should have completed it.
3. The message should specify who should and who should not take the recommended action. It should also provide the reasons why or why not.
4. Finally, the message should make clear what the consequences are of the hazard and how taking the protective action will decrease losses.

Message Style

The way in which the message is worded and spoken influences its ability to prompt action. There are 5 elements that contribute to a message's effectiveness:

1. **Clarity.** Simply worded messages work best. This is especially challenging for a nuclear detonation, which is technically complex and difficult to explain. Nevertheless, word choice can be guided by work that has been done previously for nuclear power plant preparedness and, more recently, on message testing for nuclear terrorism.
2. **Specificity.** Be as concrete as possible in telling what you want the audience to do, using local landmarks, etc.

3. **Certainty.** Messages should sound authoritative and confident.
4. **Accuracy.** Misinformation and misunderstandings can create confusion and quickly erode public confidence.
5. **Consistency.** Messages need to be internally consistent and stable over time. If circumstances change and advice differs, this should be noted and explained.

EXAMPLE PUBLIC NUCLEAR DETONATION MESSAGE**

(Shelter-in-place for 1 hour protective action recommendation)

This is a “MANDATORY SHELTER IN PLACE ORDER” from the Los Diablos County Sheriff’s Department, Fire Authority, and Department of Public Health. A nuclear bomb exploded at 1:05 p.m. this afternoon in downtown Los Diablos. Radioactive fallout is in the air and blowing in the wind. After consulting with the State Office of Emergency Management, the Department of Homeland Security, and the U.S. Environmental Protection Agency we issue this “MANDATORY SHELTER IN PLACE ORDER” for the following people in Los Diablos County.

If YOU’RE IN the area of Los Diablos defined by I-10 on the south, I-210 on the north, downtown Los Diablos on the west, and the Los Diablos county line on the east:

- **IMMEDIATELY GO INSIDE** a building or house. If you’re already in one **STAY THERE**.
- **SHUT ALL WINDOWS** and **TURN OFF ALL VENTILATION SYSTEMS** to reduce the amount of radioactive fallout that gets into the structure you’re in.
- If the structure you’re in has a basement, **GO THERE**. If it has multiple floors, **GO TO A MIDDLE FLOOR**. If you’re in a single story structure, **STAY THERE**.
- Then **GO TO THE CENTER-MOST PART OF THE FLOOR** you’re on to get as far away from outside walls and windows as possible.
- These locations will reduce your exposure to radiation that may seep into the building through the walls, windows, and roof.
- **STAY TUNED** to this station for important new information and instructions. New information will be issued **WITHIN THE NEXT HOUR**.

Take shelter inside a building or house now. **DO NOT DELAY**. This is a **MANDATORY SHELTER IN PLACE ORDER**. Take shelter **NOW**.

If you **AREN’T IN** the area of Los Diablos defined by I-10 on the south, I-210 on the north, downtown Los Diablos on the west, and the Los Diablos county line on the east there’s no reason for you to take any protective actions at this time. But please:

- **STAY OUT OF THE DESCRIBED AREA** because going there will expose you to fallout.
- **STAY OFF THE ROADS** since unnecessary traffic will delay emergency response.
- **STAY TUNED TO THIS STATION** for more information, which will be issued within the next hour.

If you have **CHILDREN IN SCHOOL** in the affected area:

- **DO NOT GO TO GET THEM.** Traveling to a school in the affected area will increase your exposure to radiation. Children in schools in the affected area **ARE BEING SHELTERED** and they **WILL NOT BE ALLOWED TO LEAVE.**
- We will provide you information about how to reunite with your children later.

There's **HIGH RISK** of exposure to severe levels of radiation in the described area from the nuclear explosion that occurred at 1:05 p.m. in downtown Los Diablos:

- Radioactive fallout may be invisible. It's in the air now and blowing in the wind.
- Exposure to fallout can cause severe illness and even death.
- The best way to reduce your exposure to the fallout and protect your health is to **SHELTER IN PLACE.** Do it **NOW.** Do not delay. Once inside, do not go outside.

If **YOU'RE IN** the area of Los Diablos defined by I-10 on the south, I-210 on the north, downtown Los Diablos on the west, and the Los Diablos county line on the east:

- **IMMEDIATELY GO INSIDE** a building or house. If you're already in one **STAY THERE.**
- **SHUT ALL WINDOWS** and **TURN OFF ALL VENTILATION SYSTEMS** to reduce the amount of radioactive fallout that gets into the structure you're in.

- If the structure you're in has a basement, **GO THERE**. If it has multiple floors, **GO TO A MIDDLE FLOOR**. If you're in a single story structure, **STAY THERE**.
- Then **GO TO THE CENTER-MOST PART OF THE FLOOR** you're on to get as far away from outside walls and windows as possible.
- These locations will reduce your exposure to radiation that may seep into the building through the walls, windows, and roof.

Take shelter inside a building or house now. **DO NOT DELAY**. This is a **MANDATORY SHELTER IN PLACE ORDER**. Take shelter **NOW**, stay there, and **STAY TUNED** to this station for important new information and instructions that will be issued **WITHIN THE NEXT HOUR**.

***Prepared by Dennis Mileti, Professor Emeritus of Sociology, University of Colorado at Boulder.*

Appendix C References

1. Mileti DS, Sorensen JH. *Communication of emergency public warnings: a social science perspective and state-of-the-art assessment*. Oak Ridge National Laboratory. ORNL-6609. August 1990.
2. Bean H, Mileti D. RCPGP warning system integration research project; Los Angeles / National Capitol Region / New York—Final Report. National Consortium for the Study of Terrorism and Responses to Terrorism (START). November 2010.
3. Committee on Public Response to Alerts and Warnings on Mobile Devices: Current Knowledge and Research Gaps; National Research Council. *Public Response to Alerts and Warnings on Mobile Devices: Summary of a Workshop on Current Knowledge and Research Gaps*. Washington, DC: National Academies Press; 2011. <http://www.nap.edu/catalog/13076.html>. Accessed August 5, 2011.
4. National Research Council. *Tsunami Warning and Preparedness: An Assessment of the U.S. Tsunami Program and the Nation's Preparedness Efforts*. Washington, DC: National Academies Press; 2010.

Next Operational Period

✓ Are there any additional goals or objectives that should be added for the next operational period?



Sample Post-Detonation Warnings

FEMA/Manuel Broussard



APPENDIX D

SAMPLE FALLOUT WARNING
MESSAGES FOR THE POST-
NUCLEAR DETONATION PERIOD

Introduction

One of the most important tasks for jurisdictions is to develop pre-scripted, pre-vetted, and scientifically based fallout warning messages tailored to their specific community. Below are a series of provisional public information statements developed by Los Angeles County and reproduced by the National Council on Radiation Protection and Measurements (NCRP).¹ Together with Appendix C, “Formula for Writing an Effective Public Warning Message,” the statements serve as a starting point for a community to develop its postdetonation fallout warning messages. Messages on fallout protective guidance can adopt the form modeled in Appendix C and draw content from Appendix D, with input from the jurisdiction’s radiation control and public health experts. Ideally, draft messages should be tested with small representative groups in a community to identify words or concepts that might be confusing and, in general, to get feedback on how warning messages might be made more effective for area residents.

IND: PUBLIC INFORMATION STATEMENT NO. 1

(Can be used immediately after the explosion, as soon as the fire department arrives and detects radiation and it appears to have been a nuclear terrorism incident.)

There has been an explosion at _____ *[site of detonation]*. Fire and police personnel are responding. Because of the size and extent of the explosion, and the presence of significant radiation levels, this may have been a nuclear explosion, releasing large quantity of radioactive material. People should stay away to facilitate response efforts and reduce the possibility of radiation exposure from this incident. If you are outside, go inside the nearest stable building. If you are inside building, you should stay inside. If the building has a basement, you should go to the lowest level. If the building does not have a basement, you should get as close as possible to the center of the building and go up two or three floors if it is a multistory building.

We request that people avoid using telephones, including cell phones, to ensure lines are available for emergency responders. We will provide a follow-up message on this issue in 1 h or sooner if additional information becomes available. This follow-up message is estimated to be issued not later than _____ *[e.g., give time as X:XX am/pm]*.

IND: PUBLIC INFORMATION STATEMENT NO. 2

(Can be used when additional information is available.)

There has been a nuclear explosion at _____ *[site of the detonation]*. The fire, police and health departments are assisting injured people. The highest levels of radionuclide contamination are near the explosion, and downwind from the explosion, going from the _____ *[north, south, east, west]* to the _____ *[north, south, east, west]*. People should stay away from this area to allow response efforts to take place, and to reduce the possibility of radiation exposure from the incident. If you are outside, you should go to the nearest stable building. The building may have windows that have been blown out, but if that appears to be the only damage and the building appears to be structurally sound, go inside the building if no other building is nearby that still has windows. If you are inside a building, you should stay inside. If the building has a basement, go to the lowest level. If the building does not have a basement, you should get as close as possible to the center of the building and go up two or three floors if it is a multistory building. You need to stay in this location unless advised differently by authorities.

The radiation levels are expected to significantly decrease over the next 24 to 48 h. You will be endangering yourself and others if you try to leave the building you are in. We understand how difficult this will be, but you will endanger your children's lives, as well as your own, if you try to retrieve your children from school. Schools have prepared for taking care of the children, and children are safest staying in their schools. We also understand your desire to return home, and to gather your family. But taking that action could endanger everyone's lives. Please stay where you are. We will provide further instructions on reuniting with your family as quickly as we can.

Even if you are not downwind and do not appear to have any structural damage in your location, stay indoors for your personal safety. You should close the doors and windows and turn off fans that bring in air from the outside. In-room fans that only recirculate air are OK to use. Air conditioning systems that do not bring in air from the outside may be operated.

To minimize your risk of radionuclide contamination, people who were near the _____ [*explosion site*], or outdoors since _____ [*time of the explosion*] in the potentially-contaminated area, are advised to change clothes and place the clothes you had been wearing in a plastic bag. Because most of the contamination will be on your clothes, removing your clothing reduces any contamination by ~80 to 90 %. Place the plastic bag in a garage or other remote location. If possible, take a shower with warm, not hot, water and gently wash your body and hair with ordinary soap and shampoo that does not contain a conditioner. Do not apply conditioner after you have washed your hair. You should stay indoors.

If we determine that you would be safer in another location, we will advise you where to go. You should not go to a hospital unless you were injured in the explosion, or have another medical emergency requiring immediate treatment, such as a heart attack.

You may drink or bathe in the water from your faucet. You may eat the food in your house. Do not eat food or water that has been outside.

We request that people avoid using telephones, including cell phones, to ensure lines are available for emergency responders. We also request that the media not fly over the scene so that airspace is available for emergency air responders, and to reduce air movement around the scene.

We will continue to respond and monitor the area to establish the extent of radionuclide contamination and structural damage to ensure the safety of members of the general public. We will provide an update in 1 h or sooner if additional information becomes available.

This follow-up message is estimated to be issued not later than _____ [*e.g., give time as X:XX am/pm*].

IND: PUBLIC INFORMATION STATEMENT NO. 3

(Can be delivered within a few hours of the incident.)

There has been a nuclear explosion at _____ *[site of detonation]*. The fire, police and health departments are implementing their emergency-response plans. People should stay away to facilitate response efforts, and to reduce their radiation exposure from this incident. We have determined that a radionuclide was carried _____ *[north, south, west or east; name neighborhoods, cities, towns, or other locations in addition to the compass direction, if possible]* of the explosion site by the wind. At this point, we do not know the extent to which the winds have carried the radioactive material, so we continue to advise people to stay indoors for their own, and others, safety. If you are located within _____ miles (_____ km) _____ of _____ *[explosion site]*, you should close the doors and windows and turn off fans that bring in air from the outside. In-room fans that only recirculate air are OK to use. Air conditioning systems that do not bring in air from the outside may be operated. This applies to a residential home, not an office building. If you were outside and saw the explosion and are not yet home, you may either continue home and shower there, or go to one of the following _____ *[name the evacuation center(s) and give address(es)]*. To minimize your risk of radionuclide contamination, people who were outdoors since _____ *[time of the explosion]* and within _____ miles *[north, south, east, west]* of the _____ *[location of the explosion]* should change clothes and place the clothes you were wearing in a plastic bag, which will likely reduce any contamination by ~80 to 90 % depending on the amount of the body covered by clothing. If possible, take a shower with warm, not hot, water and gently wash your body and hair with ordinary soap and shampoo. Children, if home, should also be given a shower or bath under supervision of a parent or other adult. Again, we recommend you stay indoors. If we determine that you would be safer in another location, we will advise you where to go. You should not go to a hospital unless you were injured in the explosion, or have a medical emergency requiring immediate treatment, such as a heart attack. Right now, the safest place for you is indoors.

You may drink or bathe in the water from your faucet. You may eat the food in your house. Food that was outdoors since _____ *[time]* today, within a few miles of _____ *[explosion site]* may need to be avoided.

We have received questions about using potassium iodide (KI) pills. KI will only reduce the radiation dose to one organ, the thyroid, and should be taken as soon as possible after being exposed, as the KI pills' effectiveness decreases rapidly. Begin taking KI within the first hour or two after the explosion, or as soon as you can. Continue taking KI until told it is OK to stop. The dose of KI varies according to size in children and age in adults, and also is different for pregnant women.

We request that people avoid using telephones, including cell phones, to ensure lines are available for emergency responders. We also request that the media not fly over the scene so that airspace is available for emergency air responders, and to reduce air movement around the scene.

We will continue to monitor the area to establish the extent of damage and radionuclide contamination to ensure the safety of members of the general public. We will provide a follow-up message on this issue in 1 h or sooner if additional information becomes available. This follow-up message is estimated to be issued not later than _____ [*e.g., give time as X:XX am/pm*].

IND: PUBLIC INFORMATION STATEMENT NO. 4

(Can be used when evacuation of designated areas is recommended.)

There was a nuclear explosion at _____ [*site of the detonation*]. The fire, police and health departments have activated emergency plans. Although the highest levels of radionuclide contamination are within about a mile radius from the explosion, radioactive material was carried by the wind in a _____ [*northern, southern, eastern, western*] direction from the site of the explosion. We are evacuating residents closer than _____ mile _____ [*north, south, east, west*] of the explosion site. That is, those within the area north of _____ [*street, avenue, etc.*], _____ south of _____ [*street, avenue, etc.*], east of _____ [*street, avenue, etc.*], and west of _____ [*street, avenue, etc.*]. These residents may report to _____ [*name the evacuation center(s) and give address(es)*], where staff will be onsite to determine if contamination is present, and provide additional decontamination if needed. **ONLY** the individuals within this designated area are advised to evacuate. If we determine that additional evacuations are advisable, you will be told where to go. As a precaution, if you are located within _____ miles _____ [*compass direction*] of the _____ [*explosion site*], you should continue to stay indoors, keep the doors and windows closed and turn off fans that bring in air from the outside. In-room fans that only recirculate air are OK to use. Air conditioning systems that do not bring in air from the outside may be operated.

You may drink or bathe in the water from your faucet. You may eat the food in your house. Food that was outdoors since _____ [*time*] yesterday may need to be avoided. We have received questions about using potassium iodide (KI) pills. KI will only reduce the radiation dose to one organ, the thyroid, and should be taken as soon as possible after the exposure, as KI pills' effectiveness decreases rapidly. Begin taking KI within the first hour or two after the explosion, or as soon as you can. Continue taking KI until told it is OK to stop. The dose of KI varies according to size in children and age in adults, and also is different for pregnant women.

We request people avoid using telephones, including cell phones, to ensure lines are available for emergency responders. We also request the media not fly over the scene so that airspace is available for emergency air responders, and to reduce air movement around the scene.

We will continue to monitor the area to establish the extent of radionuclide contamination to ensure safety of members of the general public. We will provide a follow-up message in 3 h or sooner if additional information becomes available. This follow-up message is estimated to be issued not later than _____ [*e.g., give time as X:XX am/pm*].

Appendix D Reference

1. National Council on Radiation Protection and Measurements (NCRP). *Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers*. NCRP report no. 165. Bethesda, MD: NCRP; 2010, pp. 128-129.

A nighttime photograph of a city skyline. In the center, a tall, illuminated skyscraper with a distinctive pointed top (the Transamerica Pyramid) stands out against the dark sky. To its left is another tall building with many lit windows. To its right is a modern glass skyscraper. In the foreground, a multi-lane highway with light trails from traffic runs across the frame. An elevated walkway or bridge with a glass railing and some greenery is visible above the highway. The overall scene is a vibrant urban night scene.

You may also find this document online:
www.radresilientcity.org



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