HOW FAR DOES NUCLEAR FALLOUT TRAVEL?

The most dangerous fallout usually lands within tens of miles downwind of a ground-level explosion in the first few hours. Lower but still harmful levels can reach hundreds of miles, which is why federal guidance tells everyone within 50 miles to get inside until the direction is known.

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FEMA's planning guidance says the most dangerous fallout concentrations often occur within tens of miles downwind of ground zero and typically fall within the first few hours. The real pattern depends on the weapon, the height of the explosion, the ground below it, and above all the weather. This page explains each of those, using FEMA's guidance and the federal reference text it cites, *The Effects of Nuclear Weapons*.

WHAT FALLOUT IS

When a nuclear weapon explodes at or near the ground, the fireball pulls up thousands of tons of dirt and debris. Radioactive material from the explosion condenses onto those particles, and they fall back to earth as fallout. FEMA describes the particles as ranging from too small to see to as large as pebbles. Near the explosion, dangerous fallout comes down within minutes to hours and can be visible as fine, sandy material.

Do not rely on seeing it. FEMA warns that lethal radiation levels may be present in the first few hours even tens of miles from ground zero, including where fallout is not apparent, and that visible particles may not show up on rough or dirty surfaces.

The main hazard is the gamma radiation fallout gives off once it has landed, which FEMA notes can travel hundreds of feet through the air. Breathing it in is a much smaller concern by comparison. That is why walls, earth, and distance from roofs and outside surfaces protect you, as covered in the shelter-in-place guide.

GROUND BURSTS AND AIR BURSTS

Height matters a great deal. A weapon that explodes high in the air does not pull up much dirt, so the radioactive particles stay small and aloft and decay before they come down. FEMA uses Hiroshima

and Nagasaki as examples: air bursts without significant local fallout, although some people still suffered radiation sickness from the initial burst of radiation.

A ground-level or near-ground explosion is the case that produces heavy local fallout. Because the size and direction of fallout are uncertain at first, FEMA's guidance is to get inside either way.

HOW FAR FALLOUT TRAVELS

The Effects of Nuclear Weapons splits fallout into two kinds by when it lands (Glasstone and Dolan, section 9.03):

- **Early (local) fallout** reaches the ground in the first 24 hours. These are the larger particles, and they cause the immediate danger.
- **Delayed fallout** comes down after the first day. It is made of very fine, invisible particles spread thinly over a large part of the earth. Decay while it is still in the air greatly reduces its radiation, so most of it poses no immediate danger to health, though there may be a long-term hazard.

FEMA's guidance describes the danger from early fallout in two zones, measured by radiation levels on the ground (FEMA, section 1.6):

ZONE	HOW FAR IT CAN REACH	WHAT IT MEANS
Dangerous Radiation Zone	Potentially tens of miles downwind	Risk of acute radiation injury. Everyone inside it should shelter immediately.
Hot Zone	Hundreds of miles downwind	Not immediately dangerous, but sheltering, food limits, or water advisories may be needed to prevent longer-term health effects.

Both zones grow at first as fallout settles, then shrink as it decays. FEMA says the dangerous zone reaches its largest size after the first few hours and then shrinks, perhaps from tens of miles to a mile or two in just one day.

DO THIS

Until officials know where fallout is going, FEMA's guidance says everyone within 50 miles of a nuclear detonation should get inside, stay inside, and stay tuned. Check your distance from documented likely targets with the targets near me calculator.

HOW WIND AND WEATHER SHAPE FALLOUT

Fallout drifts downwind, but “downwind” is not one direction. FEMA notes that wind direction and speed change with altitude, which can cause fallout to be deposited in more than one direction. In one 1950s Nevada test, winds blowing different ways at three altitudes produced a fallout pattern with three separate lobes on the ground.

Rain and snow can also pull radioactive particles out of the air. FEMA warns that precipitation can create local hot spots that require protective actions a hundred miles or more downwind, in places that saw no blast damage, and that these hot spots are hard to predict. Cities add more complications: surrounding buildings can partly block the cloud’s airflow, so real patterns can differ from the simple cigar-shaped plumes that planning models output.

Because patterns vary this much, FEMA says widespread, ongoing radiation measurements are essential to confirm where the dangerous areas are. Officials will have those measurements and you will not, which is why “stay tuned” is one of the three steps. The evacuation routes guide covers how wind fits into planning a route ahead of time.

WHY FALLOUT LOSES STRENGTH SO FAST: THE 7-10 RULE

Most of the radioactive material in fallout is short-lived. FEMA states that fallout gives off over half of its energy in the first hour and then continues to decay rapidly.

The Effects of Nuclear Weapons gives a rule of thumb for how fast. For every sevenfold increase in time after the explosion, the dose rate decreases by a factor of ten (Glasstone and Dolan, section 9.15). Measured from one hour after the explosion:

TIME AFTER THE EXPLOSION	RADIATION LEVEL COMPARED WITH 1 HOUR
1 hour	Starting point
7 hours	One tenth
49 hours (about 2 days)	One hundredth
343 hours (about 2 weeks)	One thousandth

The same text notes that the level at one week is about one tenth of the level at one day. The rule is accurate to within about 25 percent up to about two weeks.

SOURCE

The 7-10 rule describes a fixed amount of fallout that has already landed. Glasstone and Dolan call it useful only for illustration and some planning purposes: fallout that is still coming down, or more than one explosion, changes the numbers, and real decisions depend on actual measurements. It explains why the first day matters. It is not a way to time your own exit.

WHAT DECAY MEANS FOR YOU

The rule turns into simple advice. FEMA calls sheltering during the first few hours (up to 24 hours) a critical protective measure. That is why Ready.gov says to stay in the most protective spot for the first 24 hours unless there is an immediate danger like fire or collapse, and notes that radiation levels decrease rapidly, becoming significantly less dangerous, during that first day. FEMA adds that the falling radiation enables safer evacuations once officials have found clear routes.

Delayed fallout is a different, slower problem. Glasstone and Dolan describe it as almost entirely a potential internal hazard from iodine, strontium, and cesium in food, especially milk. Officials handle this with food and water advisories. CDC's current advice is that sealed food and food that was already inside are safe, and that you should not eat food from your garden until officials say it is safe. The potassium iodide guide covers what FDA and CDC say about radioactive iodine.

NEXT STEPS

- Read what to do in the first 72 hours for the hour-by-hour actions.
- Pick your shelter spot using the shelter-in-place guide.
- Stock it from the fallout shelter kit list.

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COMPILED FROM THESE SOURCES

1. FEMA, Planning Guidance for Response to a Nuclear Detonation, Third Edition (2022)
2. Glasstone and Dolan, The Effects of Nuclear Weapons, 3rd ed. (DoD and ERDA, 1977), via DOE OSTI
3. Ready.gov, Radiation Emergencies (Nuclear Explosion)
4. CDC, Food, Drinking Water, and Medicine Safety in a Radiation Emergency

Every safety claim on this sheet links to its primary source.