

Understanding Postfire Debris-Flow Hazards

Every year, wildfires burn hundreds of thousands of acres of steep terrain across the United States. Fire alters how water interacts with the landscape, making burned areas especially susceptible to debris flows. Debris flows are a particularly dangerous type of landslide composed of water, mud, rocks, and vegetation, which can travel very fast and very far. After a wildfire, even relatively modest rainstorms can trigger these flows.

Postfire debris flows often begin in steep burned watersheds and can move rapidly downstream, sometimes traveling far beyond the burned area into flat terrain.



Intense rainfall in January 2018 triggered damaging debris flows in the 2017 Thomas Fire burned area. Flows carried mud and boulders downstream, causing widespread damage and 23 fatalities. Photo: U.S. Geological Survey

When these flows reach developed areas, they may pose a threat to life and safety and can cause widespread damage to homes, roads, and infrastructure.

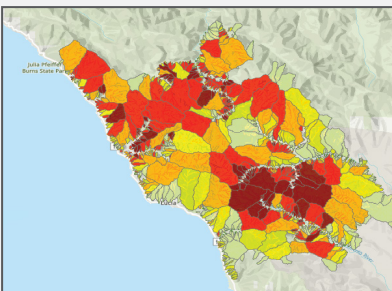
USGS Postfire Debris-Flow Hazard Assessments

For more than 25 years, the USGS and partner agencies have developed tools to rapidly assess postfire debris-flow hazards in steep, burned terrain across the western United States. Because damaging storms may occur soon after a fire is contained, the USGS completes hazard assessments as quickly as possible after the fire, often before the first major rainfall event. These assessments answer three key questions:

Key Hazard Assessment Questions

Where?

Shows which burned watersheds are most susceptible to debris flows during intense rainfall.



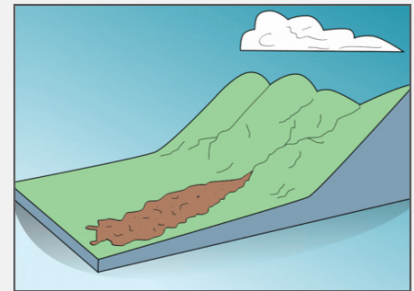
How Big?

Estimates the amount of material that may leave the burned watersheds.



How Far?

Shows potential debris-flow travel paths, known as runout in and beyond the burned area.



Rainfall and Debris-Flow Hazards

Short bursts of intense rainfall are the most common trigger of debris flows in burned watersheds. Rainfall intensity – how hard it rains – is a key factor in how big the flows will be and where they will travel. A 15-minute rainfall intensity describes how much rain falls over 15-minute time period. Rainfall intensity is usually reported as an hourly rate (millimeters or inches per hour).

Example Rainfall Intensity

1 inch per hour = 0.25 inches of rain falling in 15 minutes

25 millimeter per hour = 6.3 millimeters of rain falling 15 minutes

Higher rainfall intensities generally produce larger debris flows that will travel farther.

How hard it will rain over a burned area cannot be reliably predicted in advance. To account for this uncertainty, debris-flow hazard assessments are generated for several storm scenarios, each representing a different rainfall intensity. Each scenario produces hazard maps showing estimated likelihood, volume, and potential debris-flow travel paths, called runout. Rainfall amounts and intensity can also vary across the burned area. Some locations may receive little rain, while other locations may experience the intense rainfall needed to trigger debris flows.

Uncertainty in debris-flow size and travel

Just as rainfall conditions are uncertain, the size of debris flows and how far they may travel is also uncertain. To represent this uncertainty, hazard assessments estimate debris-flow travel paths using a range of *flow mobility conditions* and *flow sizes*.

Mobility describes how easily a debris flow travels. More mobile flows travel farther and faster than less mobile ones. Three mobilities are used – low, moderate, and high.

Debris-flow size is measured by the volume of material that may be carried in a debris flow. For each burned watershed three volumes are used – lower than expected, expected, and higher than expected.

For each rainfall scenario different debris-flow volume and mobility estimates are combined to create nine possible travel paths. Paths are grouped together to show a range of where debris flows may go if rainfall occurs.

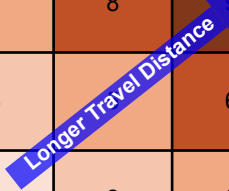
Debris-flow Travel Distance

For every rainfall scenario:

↓
3 Mobilities x 3 Sizes

	Less mobile	More mobile
Larger	7	8
	4	6
Smaller	1	3

9 Possible travel paths



Debris-flow hazard maps

Debris-flow hazard maps identify where debris flows may begin and where they could travel within and beyond the burned area, potentially affecting downstream channels, roads, and communities.

Because debris-flow hazard varies with rainfall intensity, maps are created for multiple storm scenarios. In general, stronger storms increase both debris-flow likelihood and potential travel path.

Debris-flow runout is only mapped for watersheds that have at least a 50% likelihood of debris flows.

These maps are rapid emergency products created after a fire but before rainfall occurs. They support emergency response, public safety, and postfire planning across an entire burned area, but are not intended to replace more detailed, site-specific studies.

Visual Guide to Debris-Flow Runout Maps

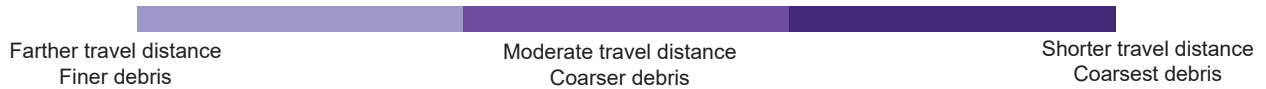
HOW LIKELY ARE DEBRIS FLOWS?

Burned watersheds are colored according to how likely debris flows are to occur.



WHERE MIGHT DEBRIS FLOWS TRAVEL?

Purple shows potential debris-flow runout paths, but not all shaded areas will be inundated during a storm.

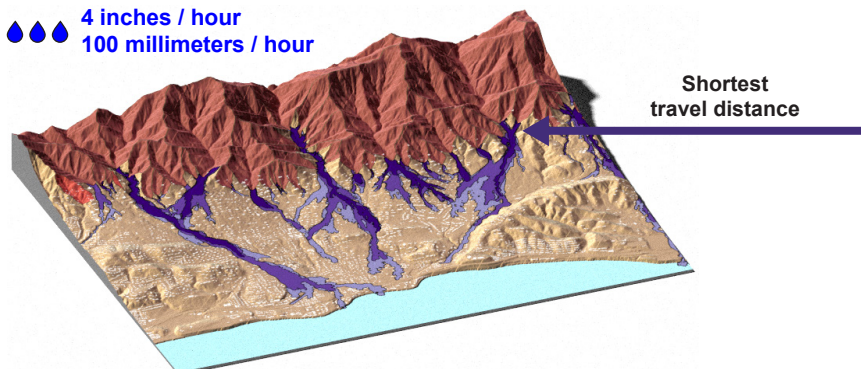
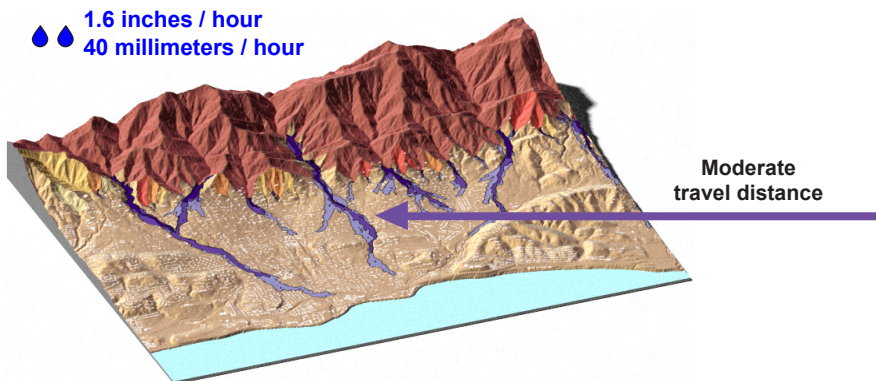
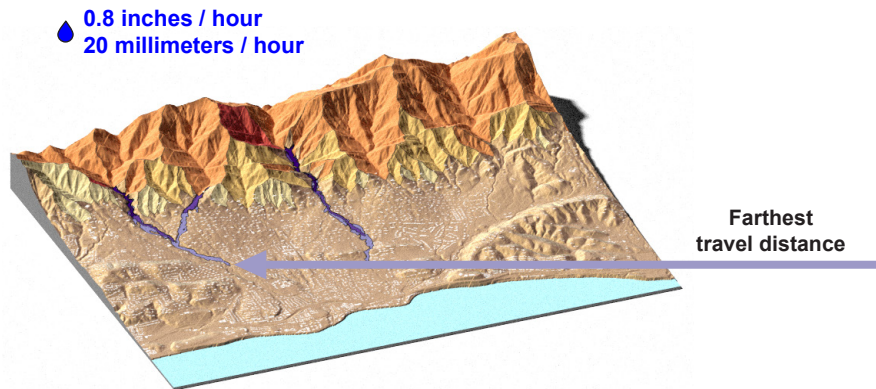


HAZARD MAPS

Maps of debris-flow likelihood and potential runout for several rainfall scenarios from the 2017 Thomas Fire.

RUNOUT AND STORM IMPACTS

Impacts from a storm shortly following the fire. Impacts are paired with runout paths, but are not specific to rainfall scenarios.



For each rainfall scenario, runout is only mapped for watersheds with a 50% or greater likelihood of debris flows.

Limitations of Hazard Maps

Hazard maps are based on simplified rainfall scenarios and identify areas where debris flows may start and travel, but do not predict the exact timing or location of these events. ***Intense rainfall in burned areas may also produce hazardous flash floods and sediment-laden flows that are not explicitly represented on debris-flow hazard maps.*** Important considerations when using these maps:

- Hazard zones show potential impact areas. Debris flows and flooding may occur outside of these areas.
- Maps are not intended for site-specific decisions. These maps are designed for use at scales no larger than 1:10,000 which means they are intended for neighborhood-level planning, *they are not intended for evaluating a specific home, individual parcels, or infrastructure.*
- Rainfall variability introduces uncertainty. Real storms vary in space and time, and intense rainfall may occur in only part of a burned area. Real storms may be more intense than those represented by hazard assessments, resulting in more severe hazards.
- These assessments represent conditions *soon after wildfire*; debris-flow hazard typically decreases as vegetation and soil conditions recover in the years following the fire.

Safety Tips

- If you live near debris-flow travel paths have an evacuation plan and leave before storms arrive. Know how to contact your local emergency response authorities.
- Listen to National Weather Service watches and warnings. They may issue alerts when forecasted rainfall could trigger debris flows. **DO NOT WAIT** for an alert or warning to take life-saving action.
- Be ready to move quickly. Sounds like cracking trees or knocking boulders may signal an approaching debris flow. The ground may shake like from a passing freight train.



- Watch for sudden changes in water flow or a shift from clear to muddy water – these may signal debris-flow activity upstream. A small flow of mud or debris may precede larger flows.
- If you hear or feel a debris flow it is likely already very close, and it may be too late to escape. Move to a second story or climb to a high point on the downslope side of the house.

More Information

POSTFIRE DEBRIS FLOW DASHBOARD



Explore interactive web maps and downloadable hazard assessment data for assessed wildfires across the United States.

USGS LANDSLIDE HAZARDS PROGRAM



Scan to learn more about postfire debris-flow science, including publications, data, and interactive story maps documenting hazards and impacts.