



## **DEFINITION**

Managing in-place natural materials, mine spoil (excavated over-burden), mine waste or overburden to reduce down-slope movement.

## **PURPOSE**

- Repair unstable slopes caused by slope failure, and reduce the likelihood of enlargement or renewed movement of slope surfaces;
- Protect life and property;
- Prevent excessive erosion and sedimentation;
- Improve water quality and landscape resource quality; and
- Create a condition conducive to establishing surface protection and beneficial land use.

This practice applies to areas where in-place material, mine spoil, waste, or overburden, or rock cut road banks are unstable, moving, or judged to have potential of moving down slope in a manner that will cause damage to life, property, or the environment. It does not apply to constructed embankment surfaces such as road fills, dams, dikes, levees and terraces.

## **PRACTICE INFORMATION**

Slope saturation by water is a primary cause of landslides. This effect can occur in the form of intense rainfall, snowmelt, changes in ground-water levels, and water level changes along earth dams and the banks of lakes, reservoirs, canals, and rivers.

Landsliding and flooding are closely allied because both are related to precipitation, runoff, and the saturation of ground by water. In addition, debris flows and mudflows usually occur in small, steep stream channels and often are mistaken for floods; in fact, these two events often occur simultaneously in the same area.

Landslides can cause flooding by forming landslide dams that block valleys and stream channels, allowing large amounts of water to back up. This causes backwater flooding and, if the dam fails, subsequent downstream flooding. Also, solid landslide debris can “bulk” or add volume and density to otherwise normal streamflow or cause channel blockages and diversions creating flood conditions or localized erosion. Landslides can also cause overtopping of reservoirs and/or reduced capacity of reservoirs to store water.

### **Landslide Mitigation – How to Reduce the Effects of Landslides**

Vulnerability to landslide hazards is a function of location, type of human activity, use, and frequency of landslide events. The effects of landslides on people and structures can be lessened by total avoidance of landslide hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. Local governments can reduce landslide effects through land-use policies and regulations. Individuals can reduce their exposure to hazards by educating themselves on the past hazard history of a site and by making inquiries to planning and engineering departments of local governments. They can also obtain the professional services of an engineering geologist, a geotechnical engineer, or a civil engineer, who can properly evaluate the hazard potential of a site, built or unbuilt.

The hazard from landslides can be reduced by avoiding construction on steep slopes and existing landslides, or by stabilizing the slopes. Stability increases when ground water is prevented from rising in the landslide mass by (1) covering the landslide with an impermeable membrane, (2) directing surface water away from the landslide, (3) draining ground water away from the landslide, and (4) minimizing surface irrigation. Slope stability is also increased when a retaining structure and/or the weight of a soil/rock berm are placed at the toe of the landslide or when mass is removed from the top of the slope.

## Signs of possible landslide problems:

- Structural deformation such as large foundation cracks, misaligned doors and windows, tilted floors, or sagging decks
- Large, open cracks in driveways, curbs, and roads
- Failing retaining walls
- Arc-shaped cracks in the ground

## ADDITIONAL ASSISTANCE

The U.S. Geological Survey Landslide Program has information, publications, and educational information on its Web site. Please see: <http://landslides.usgs.gov> or phone toll-free: 1-800-654-4966

Technical assistance is available through your local Field Service Center of the USDA Natural Resources Conservation Service (<http://www.ar.nrcs.usda.gov/>), and the Arkansas Geological Survey, (501) 296-1877 or online at <http://www.geology.ar.gov/home/index.htm>

For an assessment of the landslide risk to an individual property or homesite, obtain the services of a State-licensed geotechnical engineer or engineering geologist. These professionals can be found through the membership listings of two professional societies, the American Society of Civil Engineers (ASCE), <http://www.asce.org> and the Association of Engineering Geologists <http://www.aegweb.org>. Often, personnel in State or county planning or engineering departments can refer competent geotechnical engineers or engineering geologists.

For more information about the design and construction of debris-flow mitigation measures which may include debris basins, debris fences, deflection walls, or other protective works, consult your city or county engineer, local flood-control agency.

For photos of landslide types, visit: [http://landslides.usgs.gov/html\\_files/nlic/nlicmisc.html](http://landslides.usgs.gov/html_files/nlic/nlicmisc.html)

Two frequently referenced publications that describe the processes of landslides include:

Varnes, D.J., 1978, Slope movement types and processes, *in* Schuster, R.L., and Krizek, R.J., eds., Landslides—Analysis and control: National Research Council, Washington, D.C., Transportation Research Board, Special Report 176, p. 11–33.

Turner, Keith A., and Schuster, Robert L., 1996, Landslides—Investigation and mitigation: Transportation Research Board, National Research Council, National Academy Press.