United States Geological Survey

Natural Hazards Programs:
Lessons Learned for Reducing Risk

The USGS provides maps, reports, and information to help others meet their needs to manage, develop, and protect America's water, energy, mineral, and land resources. We help find natural resources needed to build tomorrow, and supply scientific understanding needed to help minimize or mitigate the effects of natural hazards and environmental damage caused by human activities. The results of our efforts touch the daily lives of almost every American.

The U.S. Geological Survey (USGS) provides maps, reports, information, technical assistance, and training to individuals, organizations, and communities to deepen understanding, increase public awareness, and decrease losses from earthquakes, volcanic eruptions, landslides, hydrologic hazards, and droughts in the United States and abroad. The results of these ongoing efforts help to make the United States and the world safer from the socioeconomic impacts of recurring natural hazards.

In a typical year, the Earth generates about:

- 12 million earthquakes, about 100 of which are extremely damaging and disruptive to society
- 100,000 thunderstorms
- 10,000 floods
- Hundreds of landslides and tornadoes
- Scores of hurricanes, wildfires, volcanic eruptions, droughts, and tsunamis

At present, the average economic toll from natural hazards in the United States reaches $52 billion per year—$1 billion per week—about one-third of the worldwide toll. The average annual death toll is about 150,000 worldwide but is only about 200 in the United States.

The USGS produces maps, reports, and information about natural hazards through six types of activities on national, regional, urban, and local scales. When requested, these activities are performed internationally. These activities encompass:

- Establishment and operation of monitoring networks consisting of more than 25,000 land- water-, and satellite-based sensors to locate and characterize geologic and hydrologic hazards in time and space and to warn the public.
- Compilation of data bases and development of geographic information systems on earthquakes, volcanoes, landslides, and hydrologic hazards
- Basic and applied research to determine "where," "how big," "how often," "how bad," and "how to cope"
- Risk assessment (for example, hazard, exposure, vulnerability assessments)
- Transfer of technology to end users responsible for managing risk (that is, mitigation, preparedness, emergency response, recovery measures)
- Postdisaster investigations to learn the lessons of each disaster

The United States at Risk

Natural hazards do not observe political or geographic boundaries. The building stock, infrastructure, and national resources in every State and territory that are at risk include the following:

- Tens of millions of single- and multiple-family dwellings, including manufactured housing
- More than 5 million miles of roads and highways, railroads, and transit systems

All 30,000 local jurisdictions of the Nation, large and small, urban and rural, have buildings and infrastructure at risk from natural hazards.

- More than 5 million miles of underground pipelines associated with oil, gas, water, and electrical utilities
- Hundreds of thousands of Federal, State, and private-sector buildings
- Hundreds of thousands of schools, colleges, and universities
- Hundreds of thousands of factories and manufacturing facilities
- Hundreds of thousands of small businesses and shopping centers
- Hundreds of thousands of bridges
- Tens of thousands of civic centers and places of public assembly
- Tens of thousands of hospitals and health-care facilities
- Tens of thousands of monuments, historic buildings, and museums
- Thousands of ports and harbors
- Thousands of conventional powerplants
- Thousands of military bases
- Thousands of airports
- Hundreds of dams
- Hundreds of national forests and parks
- Capitols of the States and the territories
- The White House and the Capitol

Recurring Natural Hazards

The States and the U.S. territories are affected every year by recurring natural hazards. Earthquakes, although they happen infrequently in comparison with floods and hurricanes, are dangerous because of their unpredictability. Damaging earthquakes occur most frequently in California and Alaska, but some of the largest have struck in the Eastern United States. Earthquakes cause the greatest damage to communities located near the energy source because of strong ground shaking and permanent ground failure (for example, liquefaction, surface-fault rupture, landslides). Secondary losses caused by fire, flooding from dam failure or tsunamis, and aftershocks can be as

To reduce the risk from recurring natural hazards, the USGS integrates scientific knowledge on hazards with planning and engineering data on location, exposure, and vulnerability to foster prevention, mitigation, and prepare local jurisdictions.

great as the primary losses from the main shock.

Floods happen more frequently than any other natural hazard. The States and the territories have communities that are at risk from flooding that occurs annually and in every season of the year primarily as riverine and flash floods caused by thunderstorms, rapid melting of ice and snow, storm surges, and tsunami flood waves. Until the Mississippi River flood of 1993, which caused an estimated $15 billion to $20 billion in damage, floods generally caused annual losses of about $4 billion. Flash floods cause greater loss of life than riverine floods because the technology to forecast them is not fully developed, but riverine floods in the more than 6 million miles of the Nation's river systems cause the highest economic losses. Storm surges generated by hurricanes in late summer and autumn have inundated thousands of miles of the coastlines of the Gulf of Mexico and the Atlantic Ocean. Urbanization, deforestation, wildfires, and other human and natural actions that alter natural drainage patterns keep increasing the vulnerability of communities to flooding.

Volcanic eruptions are restricted to Hawaii and the Western United States. Of the world's 500 active volcanoes, the United States has 52 that have erupted explosively in the past 200 years. Of these volcanoes, 44 are located in Alaska, with 30 being in the 1,000-mile-long Aleutian Island chain. Nineteen volcanoes are monitored continuously by observatories in Hawaii and Alaska. Nonexplosive eruptions have occurred annually for many years in Hawaii. Explosive eruptions have occurred in Alaska, Washington, Oregon, California, Nevada, Utah, Wyoming, Arizona, and New Mexico; the last ones were Mount Saint Helens, Washington, in 1980, Mount Redoubt, Alaska, in 1989; and Mount Spurr, Alaska, in 1992. In an explosive volcanic eruption, the great destruction is near the volcano, but lahars (mud flows generated by melting of snow and ice), ash fall, lava and pyroclastic flows, and lateral blasts can adversely affect urban areas and the safety of aircraft great distances from the volcano.

Landslides, which cause average annual losses of $2 billion, are generated as a result of either excessive precipitation or earthquake ground shaking. They have affected industry and community development in every State and territory. California, Alaska, Washington, Utah, Kentucky, Tennessee, Ohio, West Virginia, Puerto Rico, and American Samoa have the most extensive and frequent problems.

Wildfires occur annually throughout the Nation along wilderness/urban interfaces. One effect is to increase the susceptibility to landslides and erosion.

Although hurricanes occur annually, they are seasonal and more restricted geographically than floods. About a dozen hurricanes strike the Gulf and the Atlantic Coasts in late summer and autumn each year and cause significant beach erosion, flooding, and wind damage to buildings and infrastructure. The most recent notable hurricane, Andrew, caused $30 billion in losses in Florida and Louisiana.

Recent Disasters

Earthquakes in Kobe, Japan, and Northridge, California

Under Public Law 101–614, the USGS organizes and conducts scientific and technical studies after damaging United States and foreign earthquakes. Two recent notable earthquakes were in Kobe, Japan, on January 17, 1995, and in Northridge, California, on January 17, 1994. The magnitude 6.9 Kobe earthquake is considered by scientists to be a model of what is likely to happen in future earthquakes centered in the East Bay of the San Francisco Bay region. It caused an estimated $200 billion in damage; destroyed port facilities, infrastructure, and more than 200,000 dwellings and buildings; and left more than 5,000 people dead and 350,000 homeless. The magnitude 6.7 Northridge earthquake caused an estimated $30 billion to $40 billion in damage, but killed only 59 people. It adversely affected 3.5 million people as a result of damage to housing units, welded steel-frame buildings, freeway structures, schools, hospitals, and underground utilities. Lessons learned from both earthquakes are being incorporated into improved prevention, mitigation, and preparedness measures by local jurisdictions and the private sector.

Mississippi River Flood, 1993

The Mississippi River flood of 1993 caused an estimated $15 billion to $20 billion in damage and 48 deaths. The 1993 flood did not have the highest known peak discharges in some locations, but flood peaks at 45 USGS stream-gaging stations exceeded a recurrence level of 100 years and peaks at 56 other stations exceeded the previous maximum known discharge. Swollen by as much as 30 inches of rainfall in a 3-month period, flooding streams inundated more than 17,000 square miles and more than 20 million acres of farmland in nine States of the Mississippi River Basin. The Basin covers more than 1.25 million square miles, collects water from more than 40 percent of the contiguous United States, and normally dumps 100 trillion gallons of water into the Gulf of Mexico. A clearinghouse was established to facilitate use of the extensive and unique data base now available through the efforts of the interagency Scientific Assessment and Strategy Team. These data will be used by Federal and State agencies and local jurisdictions to develop and implement loss-reduction measures to avert future flood disasters.

As part of the ongoing studies of the Mississippi River Basin and other basins, the USGS measures streamflow at about 7,000 continuous-record gaging stations

and about 3,000 partial-record gaging stations. About 1,000 Federal, State, and local cooperating agencies provide financial or other support, including sister agencies of the U.S. Department of the Interior—the Bureau of Indian Affairs, the Bureau of Land Management, the U.S. Fish and Wildlife Service, the National Park Service, and the Bureau of Reclamation.

Volcanic Eruptions and Aircraft Safety

Volcanic eruptions have been recognized as a major threat to aviation safety since the eruption of Mount St. Helens in 1980. In 1989, a jumbo jet temporarily lost power in all four engines as a result of intake of volcanic ash vented during the eruptions of Mount Redoubt in Alaska. The USGS, in cooperation with the Alaska Volcano Observatory, the Cascades Volcano Observatory, and the Hawaiian Volcano Observatory, has intensified monitoring of some of the 65 active or potentially active volcanoes in the Pacific Northwest and Hawaii to provide near realtime warnings to commercial airlines flying polar routes threatened by ash clouds.

In 1991, the USGS provided technical assistance as part of its volcano crisis assistance program to the Philippine Institute of Volcanology and Seismology to monitor Mount Pinatubo prior to its eruption. Personnel, aircraft, and other equipment at Clark Air Force Base were evacuated along with tens of thousands of the populace, thus saving lives and millions of dollars in property loss and preventing a disaster.

Southern California Wildfires

The USGS provides technical assistance every year to Federal and State agencies and local jurisdictions to assess risks associated with wild fires that occur most frequently in the West. After 24 large wildfires broke out in southern California in late October 1993, the USGS assisted Federal and State agencies and local jurisdictions to assess risks and to adopt realistic mitigation measures. Typically, these activities encompassed assessment of enhanced landslide susceptibility from either meteorological or seismological sources, monitoring of increased sediment load in streams, and remote sensing to construct detailed maps of the damage patterns and greenness maps showing relative dryness.

Landslides

The landslides that occurred in conjunction with the January and March 1995 flooding in northern California are typical of the ever-present landslide potential in every State and territory. The most notable large-volume landslide occurred near Thistle, Utah, in 1982, causing direct losses of $200 million. It severed two major transportation arteries and the main line of the Denver and Rio Grande Western Railroad; dammed the Spanish Fork River, which led to inundation of Thistle; and destroyed homes and businesses.

Conclusions

USGS products are making it possible for every community in the Nation to adopt hazard-mitigation measures that are commensurate with the risk and to prevent the inevitable earthquakes, floods, volcanic eruptions, and landslides from becoming natural disasters. Hazard-prone countries throughout the world are also benefitting from technical assistance in times of crisis, training, and technology transfer.

—Walter W. Hays

For more information contact any of the following:

For earthquake, volcano, and landslide information

Chief, Office of Earthquakes, Volcanoes, and Engineering
U.S. Geological Survey
905 National Center
Reston, Virginia 22092
(703) 648-6714

For flood information

Chief, Office of Surface Water
U.S. Geological Survey
415 National Center
Reston, Virginia 22092
(703) 648-5305

For hurricane information

National Oceanographic and Atmospheric Administration.
National Weather Service
Industrial Meteorology Staff
1325 East-West Highway
Silver Spring, Maryland 20910
(301) 713-0258

For wildfire information

Director, Office of Hazards and Fire Programs Coordination
U.S. Department of the Interior
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(202) 208-7963

Additional earth science information can be found by accessing the USGS "Home Page" on the World Wide Web at "http://www.usgs.gov".

For more information on all USGS reports and products (including maps, images, and computerized data), call 1-800-USA-MAPS.

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