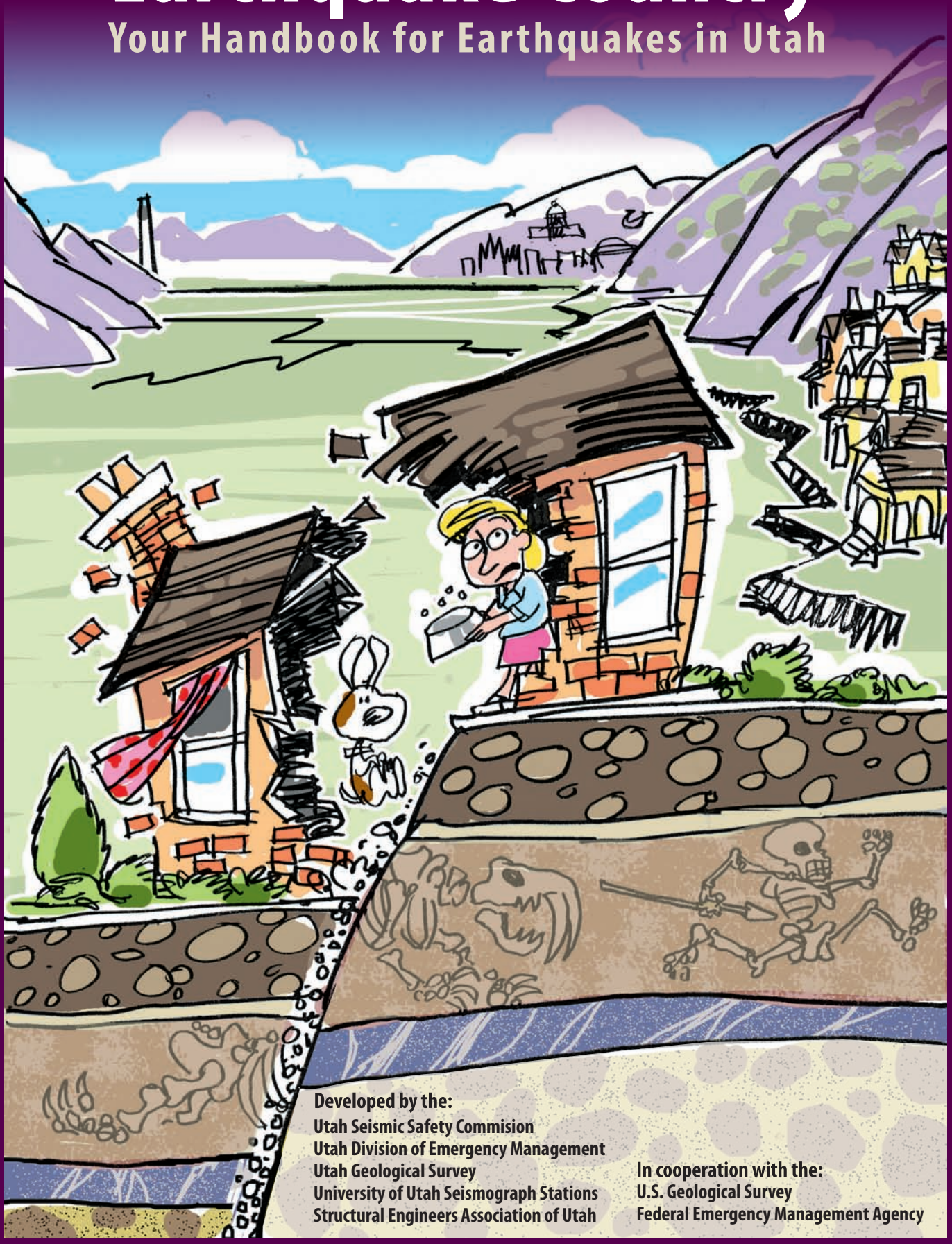
Putting Down Roots in Earthquake Country

Your Handbook for Earthquakes in Utah



Developed by the:

Utah Seismic Safety Commision
Utah Division of Emergency Management
Utah Geological Survey
University of Utah Seismograph Stations
Structural Engineers Association of Utah

In cooperation with the:

U.S. Geological Survey
Federal Emergency Management Agency

Utah Seismic Safety Commission, 2008
Salt Lake City, Utah

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Printed by the Utah Geological Survey, 2014
Third Printing

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Salt Lake City, Utah 84116
Phone (801) 537-3320, toll-free (888) UTAH MAP
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This report and any updates are available at:
http://geology.utah.gov/online/pdf/eq_handbook.pdf

Manuscript approved for publication, October, 2008

This document is adapted from California editions of "Putting Down Roots in Earthquake Country," originally written by Lucy Jones (U.S. Geological Survey [USGS]) with later revisions by Mark Benthien (Southern California Earthquake Center [SCEC]) and others, first published by SCEC in 1995 and updated yearly since 2004. The booklet was first adapted for the San Francisco Bay Region in 2005 by Mary Lou Zoback (USGS) and others, and published by the USGS. See http://www.earthquakecountry.info/roots/ for all versions.

Disclaimer: The suggestions and illustrations included in this document are intended to improve earthquake awareness and preparedness; however, they do not guarantee the safety of an individual or a structure. The writers, contributors, and sponsors of this handbook do not assume liability for any injury, death, property damage, or other effect of an earthquake.

Prepared by the Utah Seismic Safety Commission (USSC), Utah Geological Survey (UGS), Utah Division of Emergency Management (UDEM), University of Utah Seismograph Stations (UUSS), and Structural Engineers Association of Utah (SEAU), in cooperation with the U.S. Geological Survey (USGS) and Federal Emergency Management Agency (FEMA).

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Utah is "Earthquake Country"

This handbook provides information about the threat posed by earthquakes in Utah, particularly along the Wasatch Front, and explains how you can prepare for, survive, and recover from these inevitable events. If you live or work in Utah, you need to know why you should be concerned about earthquakes, what you can expect during and after an earthquake, and what you need to do beforehand to be safe and protect your property.

Much has been learned about the earthquake threat and vulnerability in Utah:

We know earthquakes occur here

Utah has experienced sixteen earthquakes greater than magnitude 5.5 since pioneer settlement in 1847, and geologic studies of Utah's faults indicate a long history of repeated large earthquakes of magnitude 6.5 and greater prior to settlement. Utah is not on a boundary between tectonic plates where most of the world's earthquakes occur, but rather is in the western part of the North American plate. However, earthquakes in Utah are indirectly caused by interactions with the Pacific plate along the plate margin on the west coast of the United States. Also, many small earthquakes in east-central Utah are induced by underground coal mining.

We know where earthquakes are likely to occur and what they can do

Large, damaging earthquakes in Utah are most likely to occur in a belt that extends north-south through the center of the state (page 4), essentially following Interstate Highway 15, where there are many active faults capable of producing earthquakes. Moderate to large earthquakes (generally magnitude 6 and greater) can kill and injure many people and cause substantial damage to buildings, roads, bridges, and utilities.

We know how to reduce losses in future large earthquakes

Most casualties and economic losses result from damage to poorly constructed, older buildings and their unrestrained contents. Improved building codes are now in force statewide, some older buildings have been strengthened, and steps are being taken to upgrade schools and other critical facilities. Some Utah residents have secured their homes to better withstand shaking, created emergency plans and disaster supply kits, and held home earthquake drills.

BUT we have not done enough to be prepared for the next large earthquake:

Few households have disaster plans

If an earthquake occurred right now, where would you go to be safe? If you are at work and your children are at school when the earthquake occurs, how will you get back together?

Few households have disaster supply kits

You will likely be on your own without vital services in the hours and days following an earthquake. Are you prepared with water, food, first aid supplies, and medications?

Few owners have taken steps to retrofit their older homes

Utah has many houses that predate modern earthquake building codes. Is your home bolted to its foundation? If you live in an older building, has it been retrofitted? Is your water heater strapped? Could unsecured furniture or objects fall and cause injury or damage?

Many earthquake-vulnerable homes and buildings exist in Utah, placing occupants at risk. The State of Utah reconstructed the State Capitol Building to preserve a historic building and to ensure public safety and continuity of government in the event of a large earthquake. (Photo courtesy of UGS, taken on September 24, 2006)

Don't be fooled!—Myth number 1

"WHAT EARTHQUAKE HAZARD?"

Many Utah residents discount the earthquake hazard based on the near absence of moderate to large earthquakes, particularly along the Wasatch Front, since pioneer settlement in 1847. Most people living in Utah today have not experienced a damaging earthquake in the state. They are unaware of the long time intervals between large earthquakes on faults in the Basin and Range Province (average time between large earthquakes measured in hundreds to many thousands of years, compared with tens to hundreds of years for parts of the San Andreas fault in California). Comparing the average recurrence interval with the amount of time since the last large earthquake indicates that the next large earthquake is becoming increasingly likely on certain parts of the Wasatch fault (see pages 6 and 7).

Utah and the Intermountain West are Seismically Active

Geologic evidence shows that movement on the Wasatch fault and other faults in Utah can cause earthquakes of magnitude 6.5 to 7.5, with potentially catastrophic effects. However, it can be difficult to use this knowledge to make us safer in our daily lives. Should we care only if we live along the Wasatch Front, or are other places in Utah also dangerous?

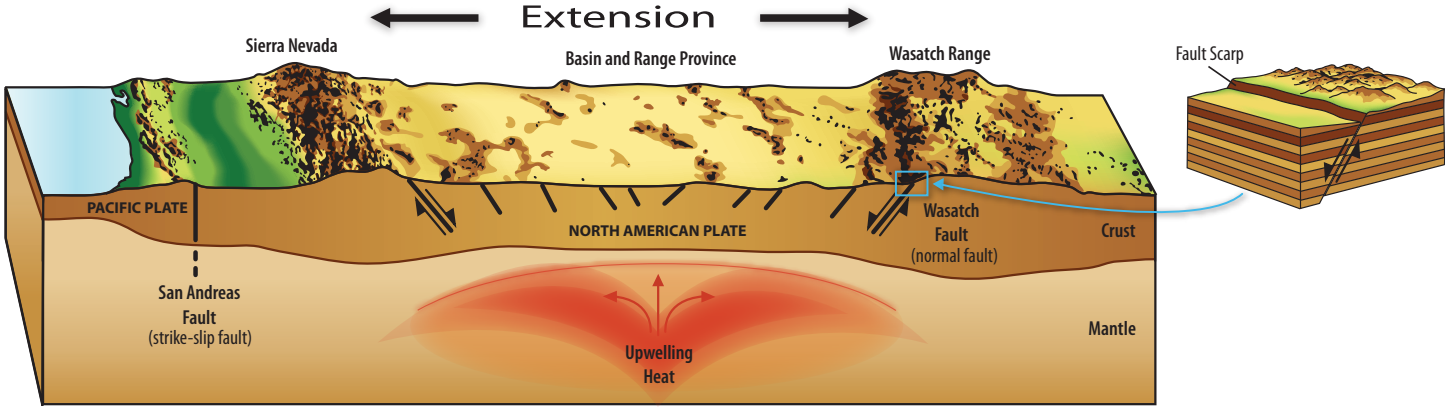
This section (pages 2-11) describes where earthquakes occur in Utah and explains how earthquakes will shake the ground and cause damage in other ways, such as liquefaction and landslides (pages 10 and 11). Technical terms used throughout this pamphlet are explained in the Glossary (page 33).

Stretching of the Crust Produces Movement on Faults

Most earthquakes occur on faults that form the boundaries of Earth's tectonic plates. Utah is not on a plate boundary, but many faults in the state can produce large earthquakes. Between Utah's Wasatch Range and California's Sierra Nevada, tectonic forces within the western part of the North American plate combine with high heat flow from the underlying mantle to literally stretch the crust in an east-west direction at the rate of about one-half inch per year. In response to this stretching, the rigid crust breaks and shifts along faults, and the fault movement produces earthquakes.

Intermountain Seismic Belt

Utah straddles the boundary between the extending Basin and Range Province to the west and the relatively more stable Rocky Mountains and Colorado Plateau to the east. This boundary coincides with an area of earthquake activity called the Intermountain Seismic Belt (ISB; page 3). Utah's longest and most active fault, the Wasatch fault, lies within the ISB. Unfortunately, the heavily populated Wasatch Front (Ogden – Salt Lake City – Provo urban corridor) and the rapidly growing St. George and Cedar City areas are also within the ISB, putting most of Utah's residents at risk.

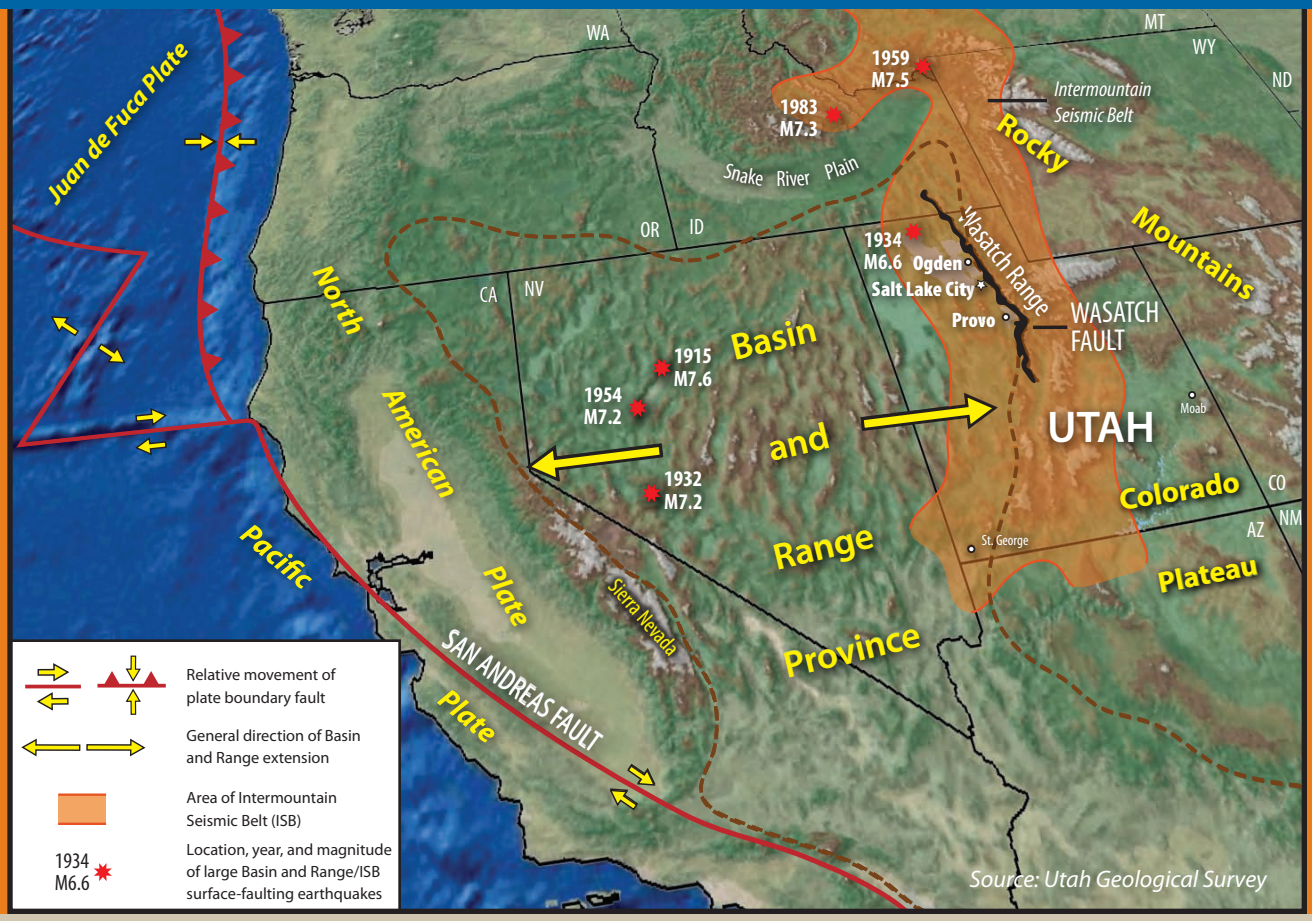


Source: Utah Geological Survey

Horizontal extension creates normal faults

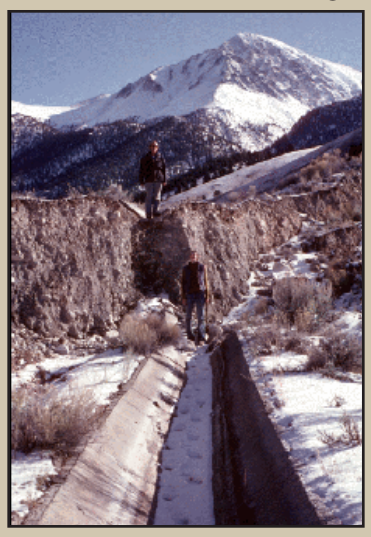
Stretching, or horizontal extension, of the crust produces a type of dipping (or inclined) fault called a "normal" fault. The movement of normal faults is characterized by the crust above the fault plane moving down relative to the crust below the fault plane. This up/down movement differs from movement on strike-slip faults like the San Andreas in California, where the crust on one side of the fault slides horizontally past the crust on the other side. Earthquakes in Utah can be generated by movement on a variety of different types of faults, but the faults that are considered capable of generating large surface-faulting earthquakes are mainly normal faults in and near the edge of the Basin and Range Province in western and central Utah.

For more information go to:
http://geology.utah.gov/online/pdf/pi-48.pdf
http://earthquake.usgs.gov/regional/imw/imw_bnr_faults/



Fault scarp formation

In a large normal-faulting earthquake the amount of vertical movement on the fault deep in Earth's crust is sufficient to rupture and offset the ground surface, producing a steep break or scarp. Geologic evidence shows that individual prehistoric earthquakes on the Wasatch fault produced scarps 6 to 12 feet high. Similar-sized scarps have formed during historical surface-faulting earthquakes in the region, such as the scarp shown below, which formed during the 1983 magnitude 7.3 Borah Peak earthquake in Idaho (surface faulting has broken and offset the concrete-lined ditch in which the people are standing). Over time, repeated movement on a normal fault eventually produces a mountain range on the uplifted crustal block (for example, the Wasatch Range) and a valley or basin on the downdropped block (for example, Salt Lake Valley). *(Photo courtesy of Walter Arabasz)*



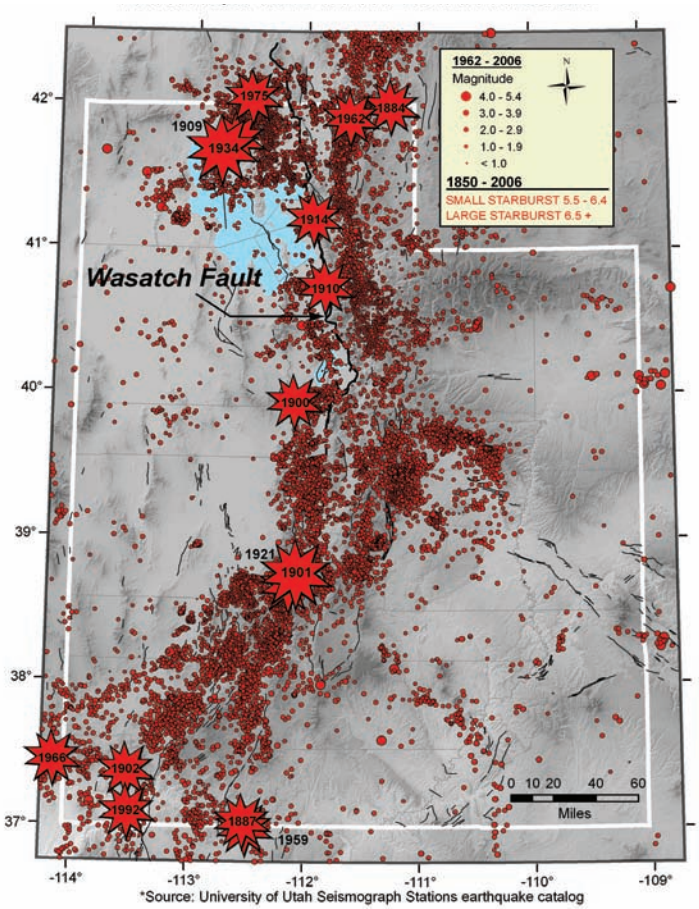
Surface faulting in Utah

In historical time, Utah has had only one earthquake large enough to form a fault scarp. The 1934 magnitude 6.6 Hansel Valley earthquake was near the threshold magnitude for earthquakes that cause surface rupture, and produced a small scarp in an unpopulated area north of Great Salt Lake. In Salt Lake City, 80 miles away, ground shaking from this earthquake was strong enough to cause adjacent 6- and 10-story buildings to sway and batter against each other and clock equipment to shake loose from the City and County Building's 12-story clock tower and crash down through the building. *(Photo courtesy of the F.J. Pack Collection, Special Collections Department, University of Utah Libraries)*

Most of Utah's Populated Area Lies Within an Active Earthquake Belt

Historical quakes of about magnitude (M) 5.5 and larger in the Utah region*		
1884	M 6	Bear Lake Valley
1887	M 5.5	Kanab
1900	M 5.5	Eureka
1901	M 6.5	Richfield
1902	M 6	Pine Valley
1909	M 6	Hansel Valley
1910	M5.5	Salt Lake City
1914	M 5.5	Ogden
1921	M 6	Elsinore (two events)
1934	M 6.6	Hansel Valley
1959	M 5.7	Utah-Arizona Border
1962	M 5.7	Richmond
1966	M 6.0	Utah-Nevada Border
1975	M 6.0	Utah-Idaho Border
1992	M 5.9	St. George
*sizes of shocks before 1934 are approximate		

Earthquakes in the Utah region



*Source: University of Utah Seismograph Stations earthquake catalog

Making a home in Utah's earthquake belt…

Distribution of settlements in Utah in 1877

Source: Atlas of Utah, Weber State College, 1981

What is UUSS?

The University of Utah Seismograph Stations (UUSS) is a research, educational, and public-service entity that operates a monitoring network of more than 200 regional and urban seismic stations in Utah and neighboring areas, including the Yellowstone National Park region. For more information about UUSS, recent earthquakes, and other earthquake information, see http://quake.utah.edu.

Threat 1 (time scale of hundreds to thousands of years):

Infrequent, large surface-faulting earthquakes (M 6.5 to 7.5) on mapped active faults, such as the Wasatch fault.

Threat 2 (time scale of tens of years):

More frequent, moderate-size (M 5 to 6.5) earthquakes that do not cause surface faulting. If they occur under an urban area, as happened in the 1962 Magna earthquake (see photo below), considerable damage can result.

Utah Faces a Dual Earthquake Threat

—and Earthquakes in Utah Are Not Just a Wasatch Front Problem

Large photo: Damage in Salt Lake City caused by the M 5.2 Magna earthquake of 1962. (Photo courtesy of Deseret News, Salt Lake City, Utah)

Smaller photos: Damage caused by the M 5.7 Richmond (Cache Valley) earthquake of 1962 (top) and the M 6 Elsinore, Utah, earthquakes of 1921 (bottom). (Photos courtesy of, respectively, Ariel D. Benson, Richmond, Utah, and the F. J. Pack Collection, Special Collections Department, University of Utah Libraries)

Earthquakes occur throughout Utah

- More than 36,000 earthquakes have occurred in the Utah region since 1962. The Wasatch Front is part of a regional Intermountain Seismic Belt (map on page 3).
- One-half of the 16 damaging earthquakes in Utah of magnitude 5.5 and larger since 1850 have occurred outside the Wasatch Front area in central and southwestern Utah.
- One of the largest historical earthquakes in Utah was a damaging shock of magnitude 6.5 near Richfield in 1901. The Sevier Valley area between Richfield and Marysvale has had eight earthquakes of magnitude 5 and larger.
- Thousands of mining-induced earthquakes (as large as magnitude 4.2), caused by underground coal mining, have occurred in Carbon, Emery, and eastern Sevier Counties.
- In the Uinta Basin, an earthquake of magnitude 4.5 in 1977 caused minor damage north of Duchesne. Earthquakes as large as magnitude 4.9 have been induced by oil and gas production and other activities in the Colorado-Utah border region.

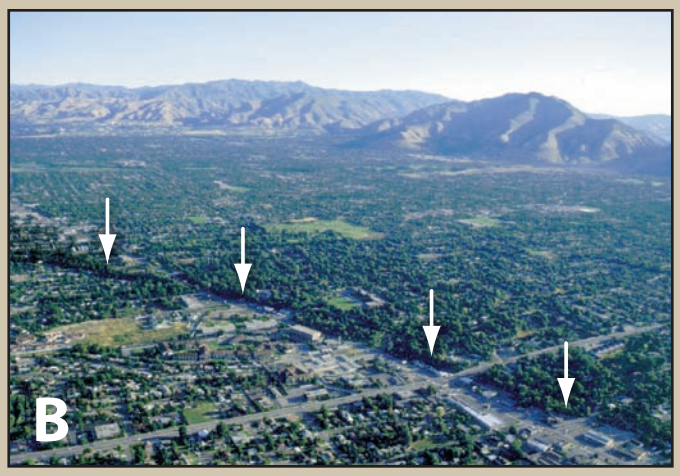
The Wasatch Fault

One of the longest and most active normal faults in the world, the 240-mile-long Wasatch fault extends from Malad City, Idaho, south to Fayette, Utah. The fault is subdivided into 10 segments, averaging 25 miles in length; each segment is generally thought to rupture independently and is a separate source of large earthquakes.

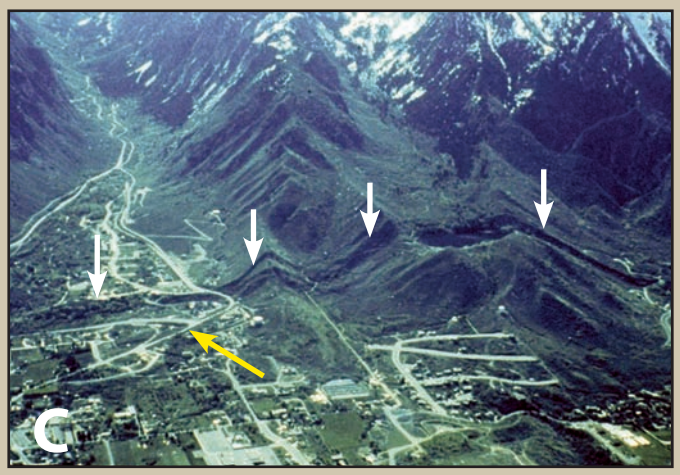
Although scientists are unsure about how many small- to moderate-size historical earthquakes can be attributed to slip on the Wasatch fault at depth, the geologic record shows that numerous large (magnitude 6.5-7.5) surface-faulting earthquakes have taken place on the Wasatch fault over the past 10,000 years.

Map showing the Wasatch fault (red line) and other faults (black lines) in Utah that may be the sources of large earthquakes. Source: Utah Geological Survey

A: The Wasatch fault (white arrows) typically extends along the base of the Wasatch Range, as seen in this view to the east near Mapleton in Utah County. (Photo courtesy of Rod Millar)



B: In some areas, the Wasatch fault (white arrows) trends away from the mountain front, as seen here in this view to the northeast in Salt Lake Valley along Highland Drive near 3900 South. (Photo courtesy of Rod Millar)

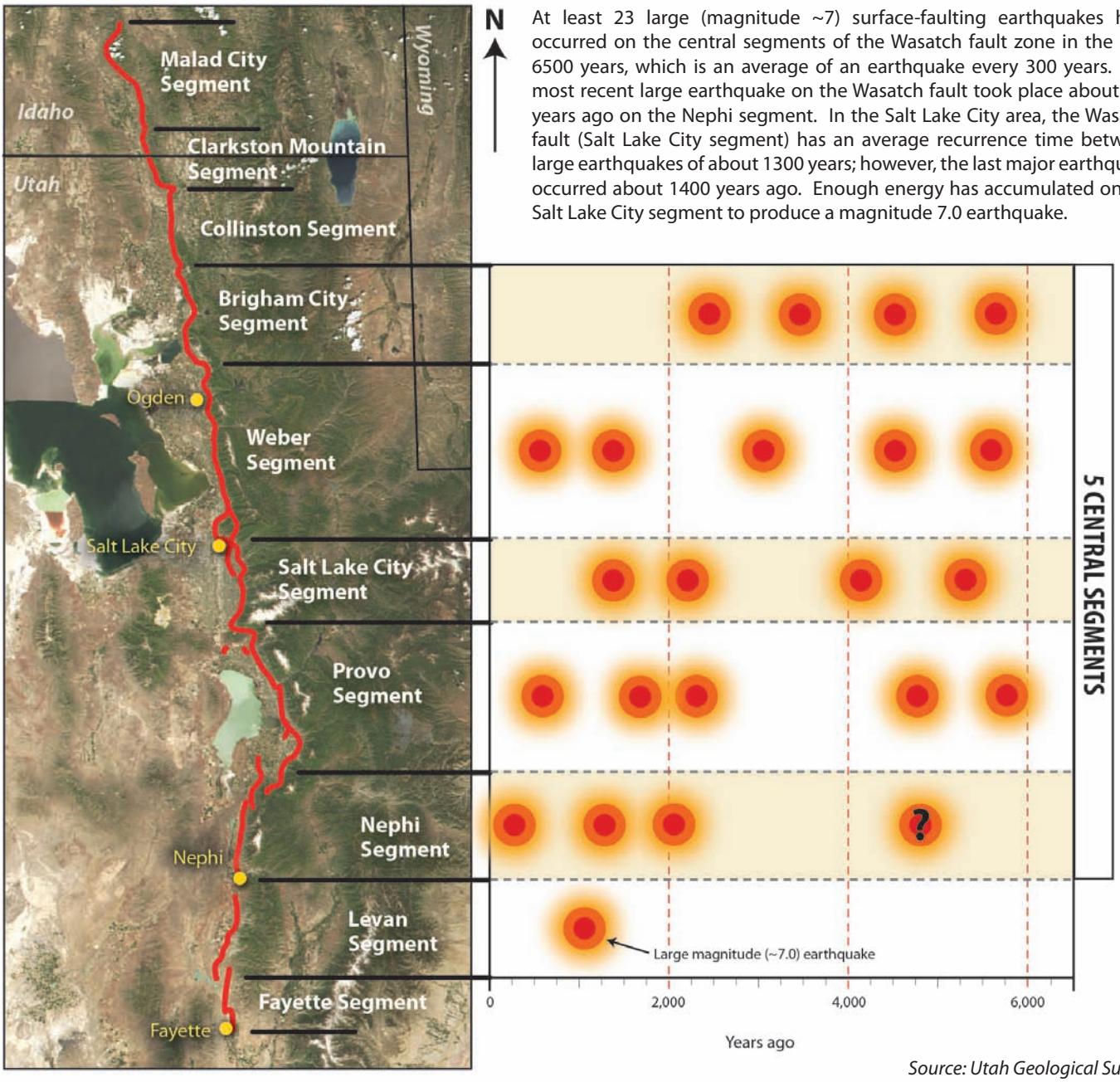


C: At the mouth of Little Cottonwood Canyon in Salt Lake Valley, the G.K. Gilbert Geologic View Park (yellow arrow) is along the Wasatch fault (white arrows). (Photo courtesy of UGS)

Geologic information for Wasatch fault earthquakes comes largely from trenches excavated across fault scarps. Twenty-five research sites, many of which had more than one trench, have been investigated on the Wasatch fault. These trench studies provide information on the timing and size of prehistoric surface-faulting earthquakes.

Radiocarbon dating of organic debris found in this trench (excavated in spring 2007) across the northern Weber segment indicates the timing of recent large earthquakes. During each of these earthquakes, the ground surface was displaced vertically about 10 feet. *(Photo courtesy of UGS)*

At least 23 large (magnitude ~7) surface-faulting earthquakes have occurred on the central segments of the Wasatch fault zone in the past 6500 years, which is an average of an earthquake every 300 years. The most recent large earthquake on the Wasatch fault took place about 300 years ago on the Nephi segment. In the Salt Lake City area, the Wasatch fault (Salt Lake City segment) has an average recurrence time between large earthquakes of about 1300 years; however, the last major earthquake occurred about 1400 years ago. Enough energy has accumulated on the Salt Lake City segment to produce a magnitude 7.0 earthquake.



Source: Utah Geological Survey

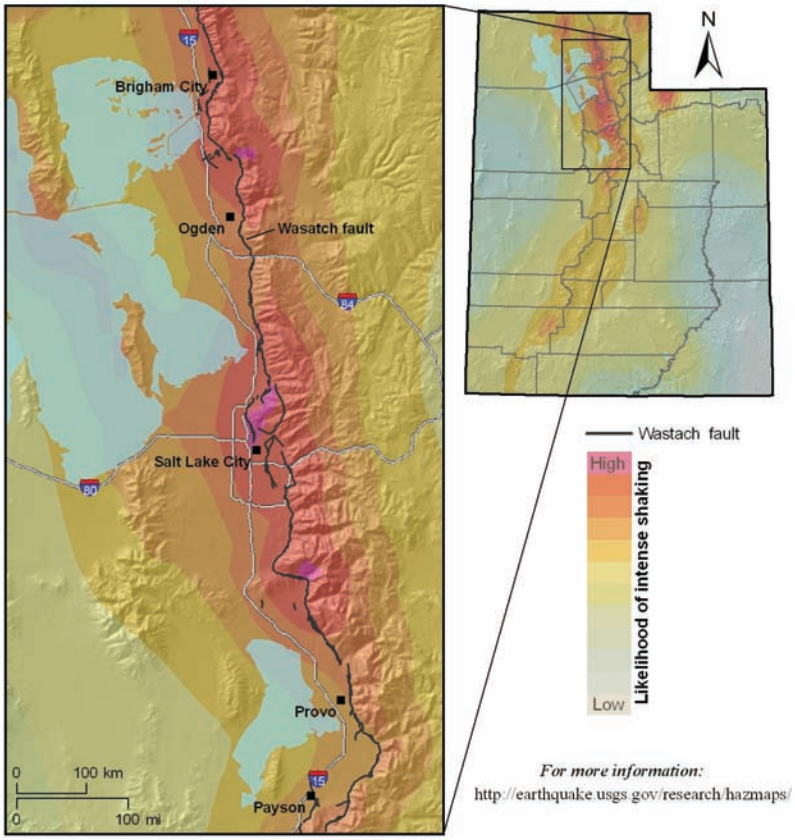
Most Earthquake Damage is Caused by Shaking

The intensity of shaking that a building or structure will experience during an earthquake is highly variable, but generally depends on three main factors:

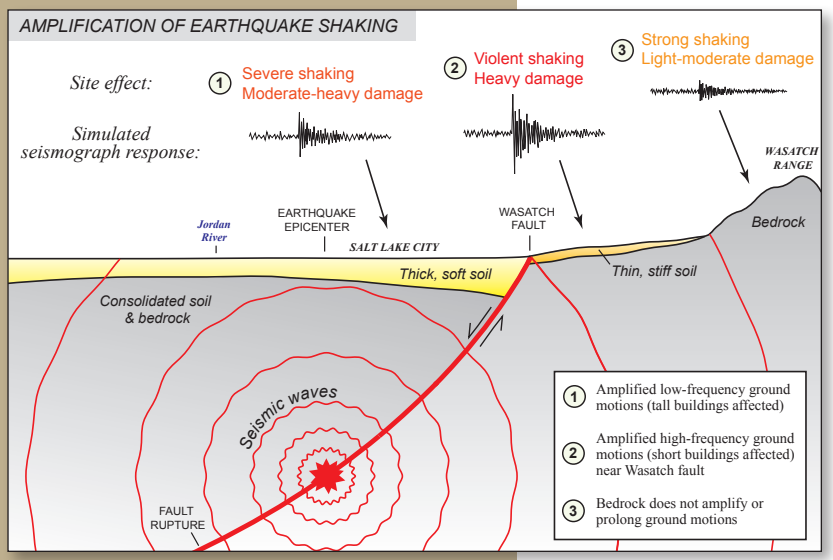
- The magnitude of the earthquake—in general, the larger the quake, the stronger the shaking and the larger the area affected.
- The distance from the earthquake—the closer to the source of the earthquake, the greater the shaking.
- The type of ground material beneath the structure—soils may amplify or deamplify the shaking relative to hard bedrock.

U.S. Geological Survey National Seismic Hazard Map of Utah

- On this map, the strongest shaking based on long-term forecasts is generally expected near major faults, such as the Wasatch fault, and in areas of greatest historical seismicity such as the Intermountain Seismic Belt.
- Intense shaking can damage even strong modern buildings and their contents.
- Much of Utah has a moderate to high likelihood of future intense shaking.



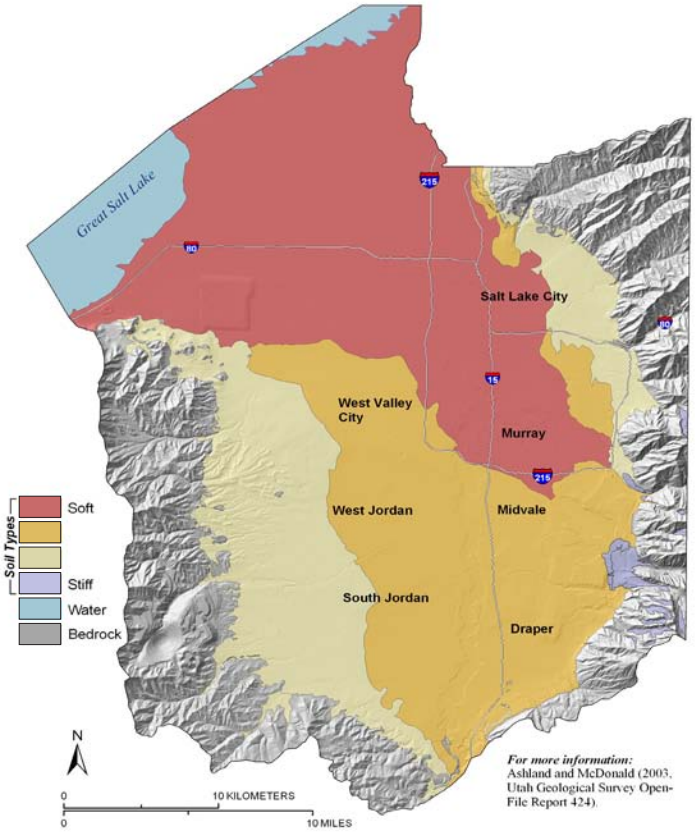
Compiled by Utah Geological Survey from: USGS National Seismic Hazard Maps.



Source: Utah Geological Survey

Generalized east-west cross section through the eastern part of Salt Lake Valley, showing the response to seismic waves generated during a Wasatch fault earthquake. Earthquakes generate seismic waves at a wide variety of frequencies, and certain frequency waves may be amplified by local soil conditions.

- In Salt Lake Valley, areas with thick, soft, clayey soil amplify low-frequency seismic waves, yielding slow rolling-type shaking that can damage tall buildings and long-span overpasses.
- Areas with thin, stiff (e.g., sandy and gravelly) soil over bedrock amplify high-frequency seismic waves, which yield vigorous ground vibrations that cause more damage to short (1-2 story) buildings, such as houses.



Geologic site conditions affect ground shaking

- This map shows the distribution of different soil types in Salt Lake Valley.
- The intensity of shaking is influenced by the type of materials underlying an area.
- Deep sediment-filled basins and soft soils such as wet clay amplify and prolong low-frequency shaking; shallow, stiff soils amplify high-frequency shaking.

Magnitude or Intensity?

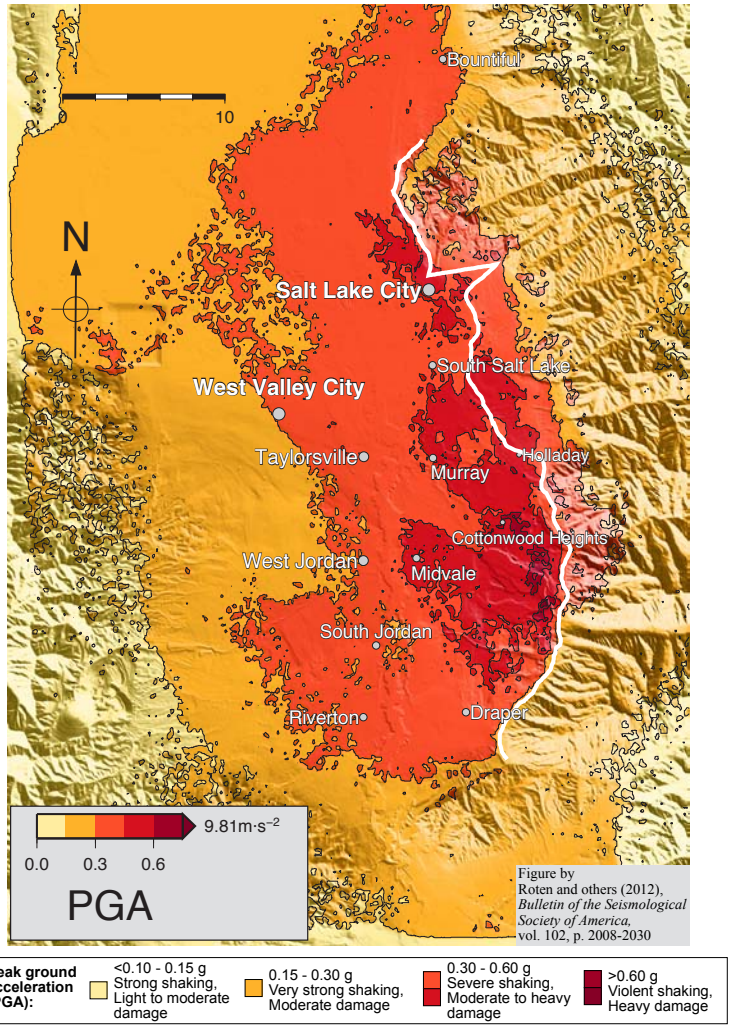
Magnitude is a measure of the energy released in an earthquake—a single value that depends on the area of fault rupture and amount of slip. For example, the 1934 Hansel Valley earthquake had a magnitude of 6.6. The largest expected earthquakes in Utah are magnitude 7.0-7.5.

Intensity is a measure of the strength of ground shaking at a particular place, and varies by location, proximity to the source of the earthquake, and type of material underlying the site. The intensity scale ranges from low (I) to high (XII). Near the epicenter of the Hansel Valley earthquake, the intensity reached VIII; however, in Salt Lake City, intensity levels were about VI.

Strong ground shaking from a magnitude 7 or greater earthquake along one of the segments of the Wasatch fault (see map, page 7) will cause major losses. However, we do not need to wait for these earthquakes to occur to estimate what they could do to Wasatch Front communities. Using the Federal Emergency Management Agency's Hazards U.S. loss-estimation model, we can estimate the extent of future damage and take actions now to reduce potential losses and plan for recovery.

Wasatch fault segment	Building losses ($ billions)	Displaced households	Life-threat-ening injuries and fatalities
Brigham City	3	14,000	500
Weber	16	57,000	3,000
Salt Lake City	42	150,000	9,000
Provo	14	48,000	3,000
Nephi	1	4,000	200

Losses estimated for a magnitude 7 earthquake on each of the central segments of the Wasatch fault (page 7)



Map showing levels of strong ground shaking expected in Salt Lake Valley based on six ground motion simulations for a magnitude 7.0 earthquake on the Salt Lake City segment of the Wasatch fault.

Earthquakes Also Cause Damage in Other Ways

Although most earthquake damage is caused by shaking, other damaging effects of quakes can be just as devastating. For example, in the 1992 magnitude 5.9 St. George earthquake, the greatest damage to houses was caused by a massive landslide in Springdale.

Damaged infrastructure

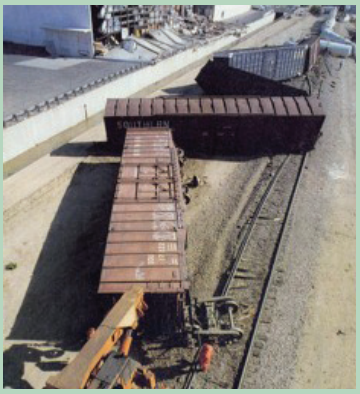
Earthquakes often damage roads and bridges, hindering rescue and recovery efforts and causing accidents. Water and sewer pipeline breaks can result in contamination of surface and ground water, and cause "sinkholes" that undermine roads and buildings. Damage to natural gas and electrical distribution systems can cause fires and major service outages. Damage to petroleum pipelines can cause oil spills. The photo below shows damage to a Santa Monica freeway bridge in Los Angeles in the 1994 magnitude 6.7 Northridge earthquake. This bridge was similar in construction to older bridges along Utah freeways.

(Photo courtesy of UGS)

(Los Angeles Times photo by Lacy Atkins)

Fires

Earthquakes in urban areas are often followed by destructive fires because gas lines break, electrical shorts ignite fires, damaged water tanks and broken pipes limit water for firefighting, and clogged roads and collapsed bridges prevent access for firefighters. The photo above is an aerial view of Balboa Boulevard in Granada Hills in the 1994 Northridge earthquake showing street flooding, flames due to a broken natural gas line, and burned homes.



(Los Angeles Times photo by Gail Fisher)

Hazardous materials

Earthquake damage can cause releases of hazardous materials from refineries and other chemical storage and distribution systems, research and industrial laboratories, manufacturing plants, and railroad tank cars. The photo above shows a train derailment in the 1994 Northridge earthquake that released sulfuric acid from a tanker car.

Dam failures and seiches

Earthquakes can make dams fail and generate waves (seiches) many feet high that flood shorelines and wash over dams. Hebgen Lake Dam, shown below, was damaged by ground shaking, and was also overtopped numerous times as waves sloshed back and forth in Hebgen Lake following the 1959 magnitude 7.5 earthquake in Montana.

(Photo from U.S. Forest Service Miscellaneous Publication 907)

Surface fault rupture

In a large earthquake, fault movement can break the ground surface, damaging buildings and other structures. In Utah, the Wasatch fault extends the entire length of the Wasatch Front through many urban neighborhoods. Near Hebgen Lake in Montana, the barn shown below was damaged when the Red Canyon fault moved in the 1959 Hebgen Lake earthquake.

(Photo from U.S. Forest Service Miscellaneous Publication 907)

Tectonic subsidence

Surface faulting on normal faults causes subsidence and tilting on the down-dropped side of the fault. The photo below shows abandonment of the south shore of Hebgen Lake in the 1959 earthquake as the lake bed tilted to the north toward the fault. Flooding may occur along the east shores of Great Salt Lake and Utah Lake due to subsidence from earthquakes on the Wasatch fault.

(Photo from U.S. Forest Service Miscellaneous Publication 907)

(Photo courtesy of Terry A. Humphrey, U.S. Bureau of Land Management)

Rock fall

One of the most common types of landslides caused by earthquakes are rock falls, triggered by ground shaking in areas of rock outcrops or loose rocks on hillsides. The photo above shows dust clouds created by numerous rock falls along cliffs near Price in the 1988 magnitude 5.3 San Rafael Swell earthquake.

Landslides

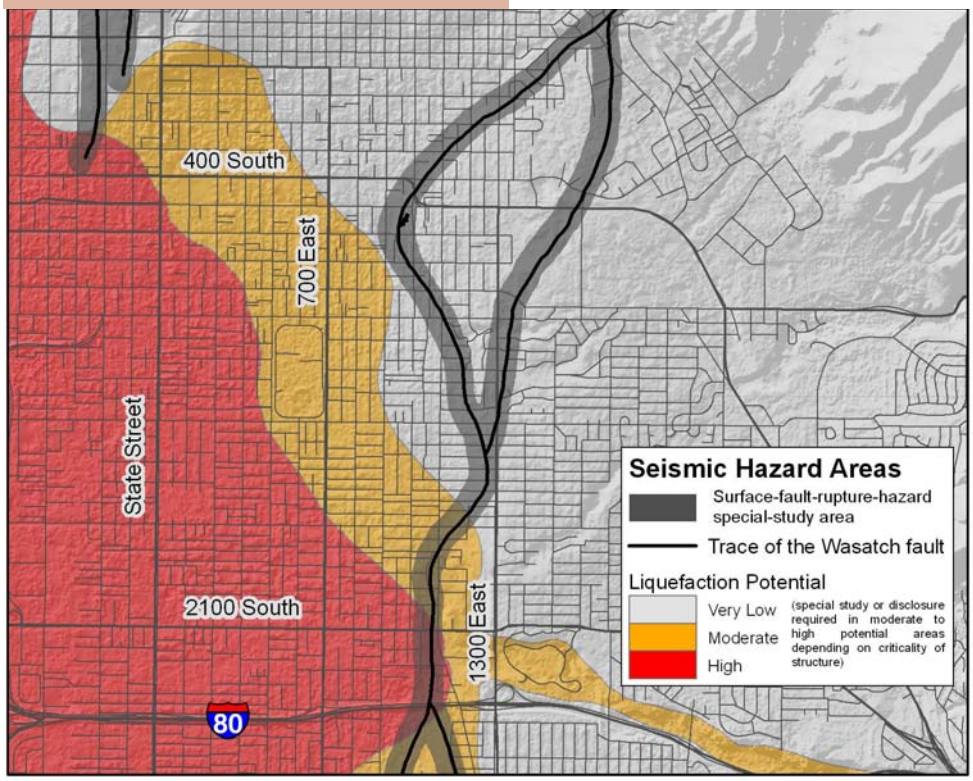
Earthquakes can trigger landslides that damage roads, buildings, pipelines, and other infrastructure. In Springdale, the home shown below was destroyed when a hillside gave way in the 1992 magnitude 5.9 St. George earthquake 27 miles to the west.

(Photo courtesy of UGS)

Liquefaction

Earthquake shaking can cause certain soils to behave like a liquid and lose their ability to support structures. Liquefaction often causes buried gas and water lines to break. The highest potential for liquefaction is in low-lying areas in saturated, loose, sandy soils and poorly compacted artificial fill. Geologic evidence in Utah indicates that severe ground deformation caused by liquefaction has occurred during large prehistoric earthquakes. The photo below shows liquefaction-related damage to a road at Moss Landing State Beach on Monterey Bay following the 1989 magnitude 6.9 Loma Prieta, California, earthquake.

(Photo by Dan Orange, University of California at Santa Cruz)



Source: Salt Lake County Planning and Development Services

Map Showing Potential Seismic Hazard Areas

This map of northeastern Salt Lake Valley shows areas where a surface-faulting or liquefaction hazard may exist and where site-specific studies addressing the hazards are recommended prior to development. Such special-study-area maps are available at most Wasatch Front county planning departments, and many cities have adopted them in their subdivision-approval process.

Response of Buildings to Earthquakes

Much like an automobile on a winding roadway, buildings sway to the effects of earthquakes. Foundations connect structures to the ground, and they play a very important role in determining how much force a building can resist. Engineers study this critical interface and may choose to "cushion" the effect by using special foundation designs.

The soil underlying buildings is an important ingredient in determining the effects of earthquakes on structures.

- *Soft, clayey soils tend to increase the motion at the ground surface and thereby amplify the effects on buildings and structures.*
- *Rock doesn't change the motion nearly as much as soil, so shaking is more predictable.*

A building's configuration and height also play an important role in determining the effects an earthquake will have on its performance.

- *Square or rectangular buildings typically perform better than irregular-shaped buildings.*
- *Tall buildings respond by swaying back and forth.*
- *Short structures are jarred from side to side as the earthquake releases its force at the ground surface.*

The materials from which a building is constructed help determine how it performs during an earthquake.

- *Steel and wood are considered flexible or "ductile" and tend to absorb the energy.*
- *Concrete and masonry are more "rigid" and can transfer the ground motion directly into the structure.*

Earthquakes shake buildings from the ground up, and an important consideration for performance is the length of time the ground shakes. The longer the ground shakes, the more likely the structure will be unable to resist the effects. Building materials can resist temporary "overstress," but when stretched beyond their limits, will break, much like a paper clip bent back and forth will eventually break.

A building's "skeleton" or structure is most important for protecting the lives and safety of its occupants. But so-called "nonstructural" elements such as bookcases, shelves, ceiling tiles, and light fixtures often fall to the floor or hurtle across rooms during earthquakes, injuring and possibly killing occupants. Such problems can be anticipated and addressed before an earthquake. Just as buildings should be designed and braced for earthquakes, nonstructural components require similar consideration.

Unreinforced Masonry Buildings

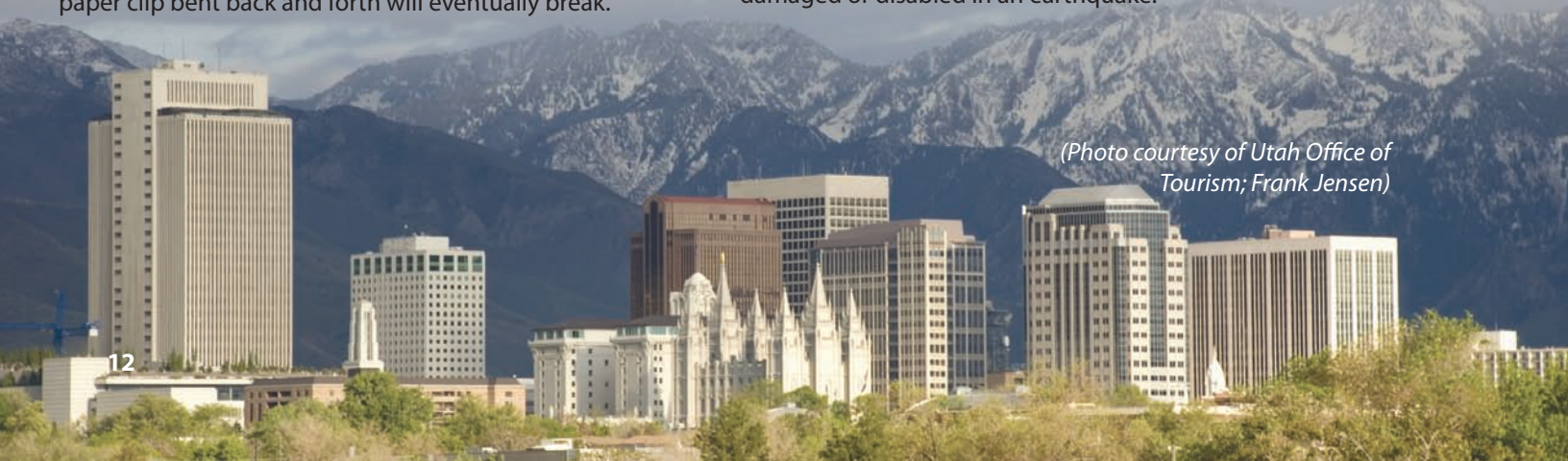
One building type of particular concern in Utah is masonry constructed without steel reinforcement. Unreinforced masonry buildings were popular when the state was first settled and continued to be built into the 1970s.

Bricks are created from clay which is burned in ovens at high temperatures. This material was both readily available here and familiar to the early settlers.

Many residences, in addition to commercial buildings, are unreinforced masonry buildings and were constructed without knowledge of how these structures performed in earthquakes. Unfortunately, experience now shows this is one of the most dangerous building types and evidence of its poor performance in earthquakes throughout the world is well documented.

In addition to buildings, virtually all structures are susceptible to damage from an earthquake. Dams, bridges, pipelines, storage tanks, and roadways are other structures that can be damaged by an earthquake's forces.

These infrastructure elements are often taken for granted and only after an earthquake are they viewed as critical components, necessary for maintaining our standard of living. The infrastructure we rely upon can be fragile in ways we may not understand until after it is damaged or disabled in an earthquake.



(Photo courtesy of Utah Office of Tourism; Frank Jensen)

The ABCs of Seismic Building Codes

Seismic building codes increase building integrity and help ensure the future safety of communities. These codes are designed to protect lives, but not to ensure buildings are undamaged or usable after an earthquake. Seismic codes are intended to protect people inside buildings by preventing collapse and allowing safe evacuation. Structures built according to the current code should resist minor earthquakes undamaged, resist moderate earthquakes without significant structural damage, and resist severe earthquakes without collapse.

A moderate earthquake that does not significantly damage a building still can seriously hurt or kill people. Buildings contain items such as light fixtures, heating ducts, windows, and suspended ceilings that can fall on people or block escape routes. The exteriors of buildings also can pose hazards to people walking by or exiting, including falling bricks, parapets, window glass, or other facades.

Damage to Interstate 5 in 1994 Northridge, California, earthquake. (Photo courtesy of FEMA)

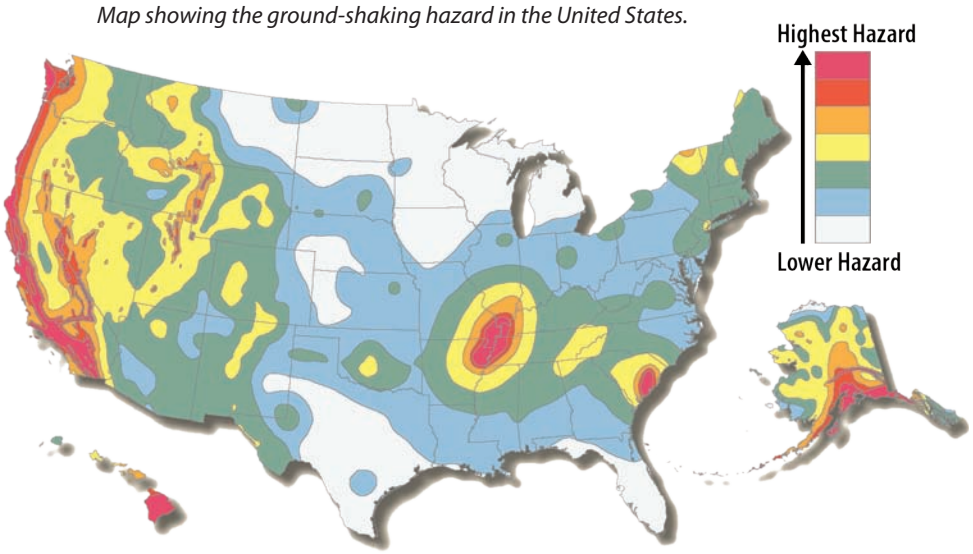
The seismic provisions of building codes are based on earthquake hazard maps (example at right) which show the probabilities of certain levels of earthquake shaking in particular areas. The code requirements reflect the fact that some places are more likely than others to have strong earthquakes. Utah has areas with a high likelihood of strong earthquakes, similar to states along the West Coast.

In Utah, seismic codes made substantial improvements in construction as early as the mid-1970s. Buildings constructed prior to this time may be seismically unsafe. However, buildings constructed in the 1980s would also not be as seismically safe as buildings constructed under today's seismic codes. To keep up with the current state of the art in seismic design, building codes are revised every three years to incorporate new knowledge.

Steel-frame tall buildings and newer wood-frame short buildings are usually (but not always) the safest structure types. Exceptions to these generalizations are due to variables such as the configuration of the building, the quality of construction and inspection, the design of connections, and the manner in which seismic waves strike a particular site.

Building codes provide minimum design and construction requirements for protecting lives. However, some structures with high occupancy, critical-response services (fire, police, hospitals), and vulnerable populations (schools, nursing homes) should be built above minimum requirements. Building codes use importance factors for designing above these minimum requirements. It also is important to protect utilities and infrastructure since damage to these critical structures leads to more deaths, larger economic loss, greater social disruption, and slower response to earthquakes.

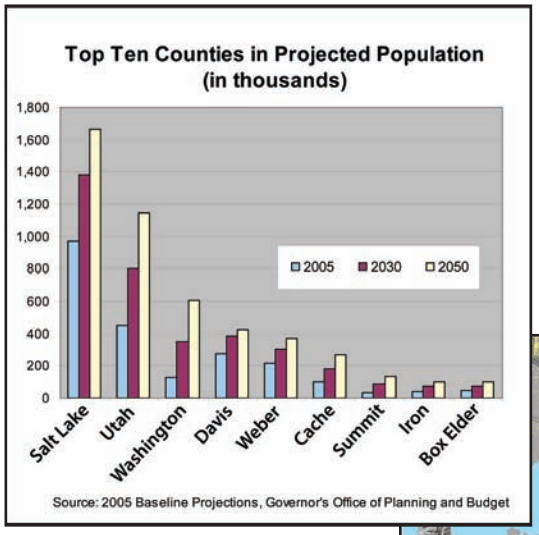
Map showing the ground-shaking hazard in the United States.



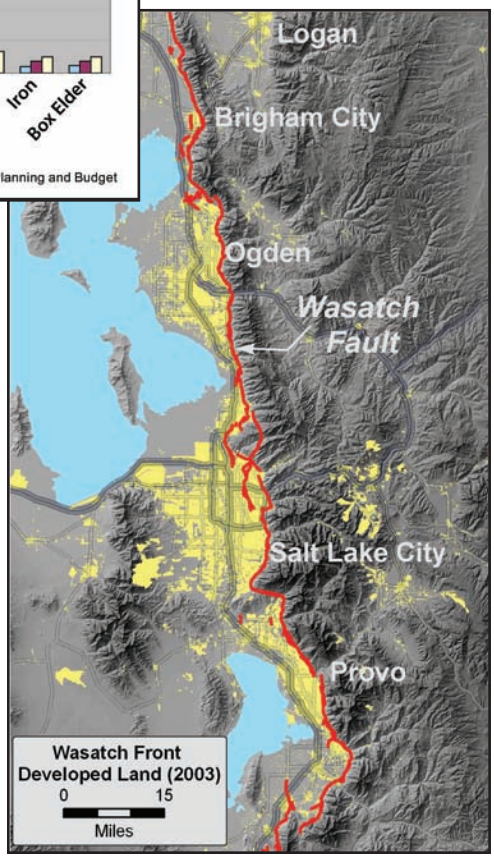
Source: USGS National Seismic Hazard Maps

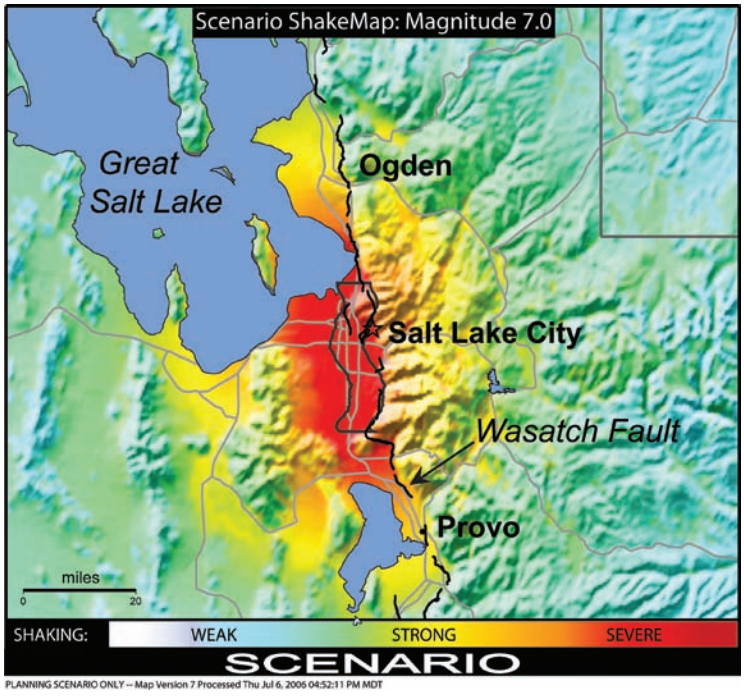
Utah's People, Economy, and Infrastructure are Increasingly Vulnerable to a Wasatch Fault Earthquake

- Nearly 80 percent of Utah's population lives within 15 miles of the Wasatch fault in the Wasatch Front area.
- More than 75 percent of Utah's economy is concentrated in Salt Lake, Utah, Davis, and Weber counties—above the Wasatch fault, which projects beneath the developed Wasatch Front valleys.
- Most of Utah's state government facilities are located within 15 miles of the Wasatch fault.
- Major interstate transportation corridors and the Salt Lake City International Airport are located within 15 miles of the Wasatch fault.
- By 2030 the population in the Wasatch Front area is projected to grow to 2.8 million, a 50 percent increase over 2005.
- To meet the needs of the dramatically growing population along the Wasatch Front, $14.4 billion of new transit and highway infrastructure is planned over the next three decades .



Earthquake risk (the probability of loss or damage) is increasing with population growth and development.





The Scenario ShakeMap (left) shows the predicted levels of ground shaking during a magnitude 7.0 earthquake on the Salt Lake City segment of the Wasatch fault (see page 32 to learn more about ShakeMaps). Severe shaking capable of causing moderate to heavy damage will extend beyond Salt Lake Valley—both northward into Davis County and southward into Utah County.

Compare the ShakeMap (left) with the map of developed land in the Wasatch Front area (above). Much of the Wasatch Front's population and an extensive part of its built environment will experience strong to severe shaking when the Wasatch fault unleashes a "Big One" in Salt Lake Valley.

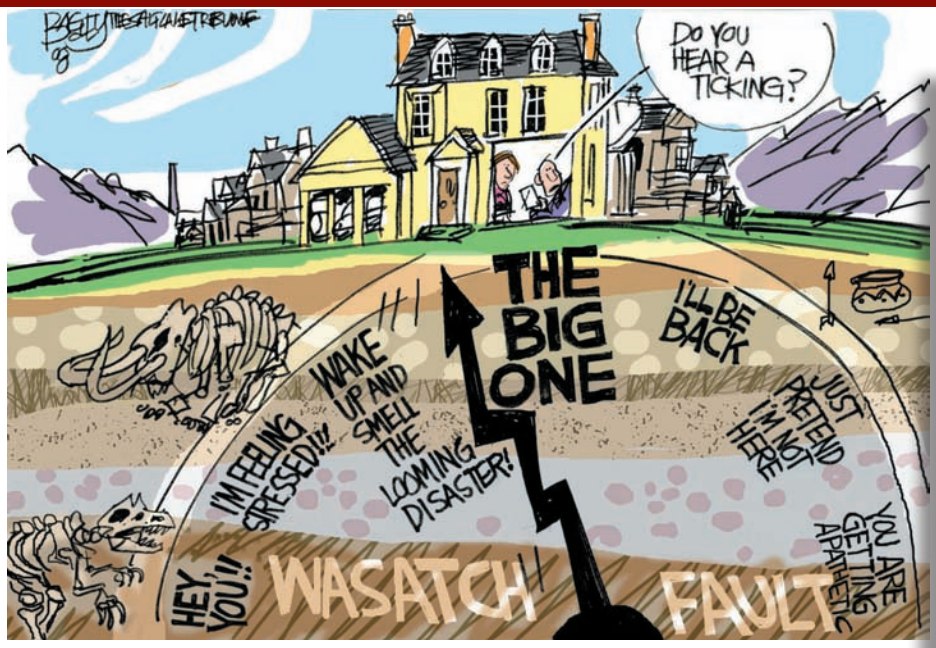


Illustration by Pat Bagley, *The Salt Lake Tribune.*

How Likely is a "Big One*"?

Earthquake Source	Annual Likelihood
Salt Lake City segment of the Wasatch fault	1 in 450 to 1 in 1,600
One of the Wasatch fault's five central segments (Brigham City to Nephi, page 7)	1 in 300 to 1 in 400
One of 30 active faults in the Wasatch Front region (page 6)	1 in 200

* A large surface-faulting earthquake of about magnitude 7

Sources: Likelihood calculated by the University of Utah Seismograph Stations from data provided in UGS, USGS, GeoHaz Consultants, and URS Corporation reports.

Average Frequency of Earthquakes* in the...

	Wasatch Front	Entire Utah Region (see map, page 4)
Magnitude	**Frequency**	**Frequency**
≥ 3.0	3 per year	8 per year
≥ 4.0	1 every 2 years	1 per year
≥ 5.0	1 every 10 years	1 every 5 years
≥ 5.5	1 every 20 years	1 every 10 years
≥ 6.0	1 every 50 years	1 every 30 years
≥ 7.0	*[based on geologic evidence, time scale of hundreds of years - page 7]*	

≥ Greater than or equal to
* Based on historical record and instrumental monitoring (largest historical shock was M 6.6 in 1934); excludes foreshocks, aftershocks, and human-triggered seismic events

Source: University of Utah Seismograph Stations

Reality Check
(for comparing to the chance of a "Big One")

Cause of Death	Your Annual Risk
Heart disease	1 in 450
Cancer	1 in 530
Stroke	1 in 2,100
Motor-vehicle accident	1 in 6,500

Source: Centers for Disease Control and Prevention; causes of death in the U.S. in 2005.

Don't be fooled!—Myth number 2

"UTAH ISN'T CALIFORNIA"

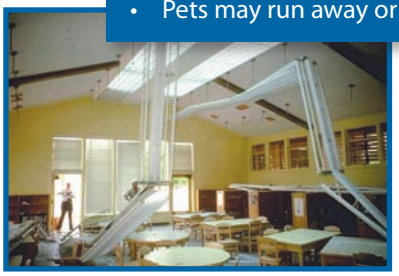
True, Utah is not California. However, many earthquakes are recorded and located each year in the Utah region (page 4)—about 800 per year on average, excluding mining seismicity. Most of these earthquakes are small and not felt. Since 1850, 16 damaging shocks of about magnitude 5.5 and larger have occurred in the Utah region. California certainly has more "wake-up calls," where earthquakes of about magnitude 6.5 and larger that cause fatalities and major structural damage typically occur once or twice per decade.

Scientific studies in Utah indicate that "Big Ones" occur somewhere in the Wasatch Front area on a time scale of every few hundreds of years. These are high-energy earthquakes of about magnitude 7. They suddenly displace the ground vertically about 10 feet at the fault line. Within tens of miles of the epicenter there is a high potential for major structural damage and casualties. In Utah, many seismically vulnerable buildings increase the damage potential. On a geologic time table, Utah is due for its next "Big One"—and, unfortunately, is a lot like California in this regard.

Your Life Could Change Unexpectedly in the Next Quake

Where will your family be?

- Your children may be at school, day care, or other activities.
- Family members may be at work or commuting.
- Pets may run away or be injured.



Failure of fluorescent light fixtures in the Dawson Elementary School Library during the 1983 Coalinga, California, earthquake. (Earthquake Engineering Research Institute photo)

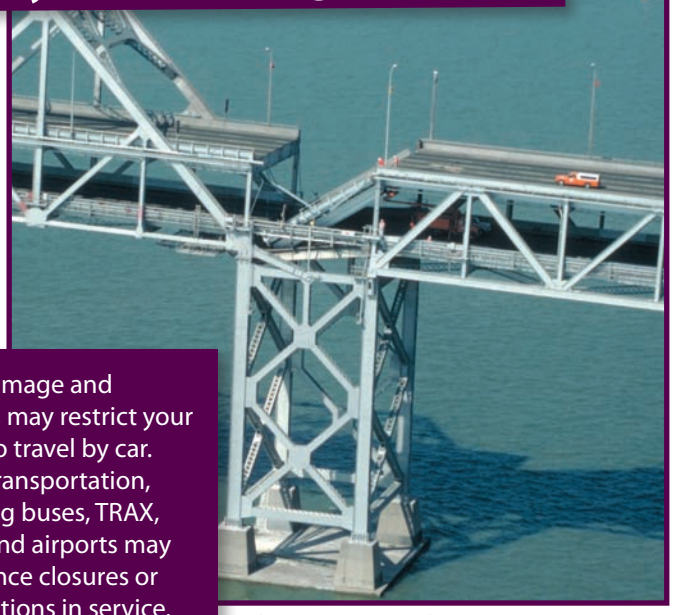
Pets are not allowed in most emergency shelters. Do you have a plan to feed and care for your animals after an earthquake?

Will you have medical services?

- The 911 emergency system will likely be overloaded.
- Hospitals and other medical facilities may be damaged.
- Emergency rooms and trauma centers may be overwhelmed.
- Assisted living, critical care, and other health services such as dialysis may not be operational.

This hospital in Sylmar, California, had to be demolished after the 1971 magnitude 6.7 San Fernando earthquake. (Photo courtesy of USGS)

Will you be able to get home?



- Road damage and closures may restrict your ability to travel by car.
- Public transportation, including buses, TRAX, trains, and airports may experience closures or interruptions in service.
- Commute times may be dramatically increased.

The 1989 magnitude 6.9 Loma Prieta earthquake caused this section of the San Francisco-Oakland Bay Bridge to collapse. (Photo courtesy of USGS)

Will you be able to stay in your home?

This porch on a wood-frame house failed during the 1989 magnitude 6.9 Loma Prieta earthquake. The "red tag" indicates that this home is unsafe and must not be entered or occupied. (Photo courtesy of USGS)

- Your home may be damaged and unsafe to live in.
- Your personal property may be damaged or destroyed.
- Construction materials and labor for repairs will be in limited supply and costs will increase.
- Rebuilding scams may be common.
- Availability of rental housing may be limited due to damage and high demand.

Can you live without the services you rely on?

Where will you get your water, food, medicines, and gasoline after an earthquake? (Photo courtesy of USGS)

- Water may be in short supply.
- Natural gas and electric power may be out for days or weeks.
- Garbage and sewage services may be interrupted.
- Telephone, Internet, cell phone, and wireless communications may be overloaded or unavailable.
- Mail service may be disrupted or delayed.
- Gasoline may be in short supply, and rationing may be necessary.
- Bank operations may be disrupted, limiting access to cash, ATMs, or online banking.
- Grocery, drug, and other retail stores may be closed or unable to restock shelves.

How will your job be affected?

- Businesses may sustain damage and disruption—many small businesses require a long time to reopen or do not survive disasters.
- Your income may be affected—payroll checks or direct deposits may be delayed.
- Your workplace may become a temporary shelter for you or others.
- Supplies and deliveries will be interrupted.

This business in Santa Cruz, California, was nearly destroyed in the 1989 magnitude 6.9 Loma Prieta earthquake. (Photo courtesy of USGS)

How will the American Red Cross Help?

After a damaging earthquake, the American Red Cross will help in the following ways:

- Opening and operating emergency shelters.
- Providing food at shelters and feeding locations and through mobile distribution.
- Obtaining and delivering other needed items such as water, baby supplies, and blankets.
- Assisting with the immediate mental-health needs of those affected.
- Providing for basic health needs at shelters and other locations.
- Helping with initial recovery through casework and referrals to other agencies and partners.
- Providing blood and blood products.

For more information go to: www.utahredcross.org

American Red Cross

Your Financial Situation Could Be Affected by a Quake

This store was temporarily closed following the 2001 magnitude 6.8 Nisqually, Washington, earthquake. (Photo courtesy of The Olympian, Olympia, Wash.)

Aid may not be available immediately following a major disaster. Without proper planning, the financial impact of an earthquake on you and your family could be devastating. Although many things are out of your control after a quake, your ability to recover financially depends on a number of factors that you can control. Prepare and follow a financial disaster recovery plan and you will be more likely to recover successfully. Consider the following:

This bank was damaged in the Nisqually Washington, earthquake, requiring customers to seek services elsewhere. (Photo courtesy of The Olympian, Olympia, Wash.)

Will you have money, food, and medicine?

- Bank operations may be disrupted, limiting access to cash, ATMs, or online banking.
- Food, drug, and other retail stores where you shop may be closed or unable to restock shelves.

Will you be able to recover financially?

- You are still responsible for your existing debts, such as mortgage, lease, car, and credit-card payments.
- You may not have access to important financial records.
- Your assets are at risk without sufficient earthquake insurance.
- If you have earthquake insurance and experience loss, begin working with your insurer to file a claim as quickly as possible.

Will your insurance cover your losses?

- Homeowner's and renter's insurance policies do not cover losses related to earthquakes.
- A separate earthquake insurance policy is one way to help protect your home, in addition to seismic retrofitting.
- Earthquake insurance also helps with additional living expenses in the days and weeks after earthquakes.
- Relatively few Utah homeowners have earthquake insurance.

Don't be fooled!—Myth number 3

"HOMEOWNER'S INSURANCE WILL COVER ANY DAMAGE TO MY HOME OR BELONGINGS CAUSED BY AN EARTHQUAKE."

Most residential property insurance policies do not cover damage resulting from earthquakes. A separate earthquake insurance policy is one way to protect your home and the investments you have made in personal belongings. Investigate your options carefully to ensure that your assets are sufficiently protected.

Does your small business have a recovery plan?

- A business disaster-recovery plan will make your business better able to survive in a post-disaster environment.
- Although physical assets can be replaced, emotional and social changes that affect businesses and their customers may remain long after a disaster.
- Businesses may not return to their previous revenue levels after a disaster; however, some businesses such as construction are likely to be in great demand following an earthquake.

What types of federal assistance may be available?

- Federal disaster-relief programs are designed to help you get partly back on your feet but not to replace everything you lose.
- The Department of Homeland Security's Federal Emergency Management Agency (FEMA) is responsible for responding to, planning for, and reducing the effects of disasters.
- After the president signs a major disaster declaration, FEMA cooperates with other agencies, such as the Small Business Administration (SBA), in providing disaster relief.
- For disaster relief, low-interest loans are made available through the SBA to eligible individuals, homeowners, and businesses to repair or replace damaged property and personal belongings not covered by insurance.
- The maximum SBA personal-property loan is $40,000, and the maximum SBA real-property loan for primary home repair is $200,000.
- FEMA disaster grants for emergency home repairs and temporary rental assistance are available to individuals and households.
- The average FEMA grant is less than $15,000 (the maximum is $28,800)—not enough to rebuild a home.
- The Farm Service Agency offers loans to assist agricultural businesses.

These small businesses in Santa Cruz, California, were heavily damaged in the 1989 magnitude 6.9 Loma Prieta earthquake, but both eventually reopened. (Photo courtesy of USGS)

This home in the Santa Cruz Mountains collapsed in the Loma Prieta earthquake. (Photo courtesy of USGS)

Useful Web sites

Ready Your Business:
http://beready.utah.gov/business/index.html

Business Disaster Planning:
http://utah.acp-international.com

Business Preparedness Information:
http://www.ready.gov/business/

The Seven Steps to Earthquake Safety

Earthquakes in Utah are inevitable, but damage from them can be reduced. Steps you can take before, during, and after earthquakes will help make you and your family safer and reduce your injuries, damage, and losses:

- First and foremost, plan for the personal safety of you and your loved ones.
- Look into the safety of your home, workplace, and child's school—don't be afraid to ask your landlord, boss, or school's principal if they are aware of the hazards and have taken measures to make these places safer and more earthquake resistant.
- Find out if your home, workplace, and child's school could be subjected to seismic hazards such as landsliding or liquefaction, in addition to strong shaking.
- Don't forget to think about likely economic impacts to you and your family from a major quake (see pages 18, 19, and 31).

The seven steps described in this section will help you to be safer in earthquakes. They are arranged as measures you should take before, during, and after quakes. In addition to following the steps at home, they should also be followed at schools and workplaces. If everyone makes an effort to follow these steps, billions of dollars could be saved, injuries avoided, and many deaths averted in the next big earthquake.

You've learned your earthquake hazards, now follow these seven steps:

BEFORE A QUAKE:

STEP 1. Identify potential hazards in your home and begin to fix them (page 22).

STEP 2. Create a disaster-preparedness plan (page 24).

STEP 3. Prepare disaster supply kits (page 25).

STEP 4. Identify your building's potential weaknesses and begin to fix them (page 26).

DURING A QUAKE:

STEP 5. Protect yourself during earthquake shaking (page 28).

AFTER A QUAKE:

STEP 6. After the earthquake, check for injuries and damage (page 29).

STEP 7. When safe, continue to follow your disaster-preparedness plan (page 30).

7
When safe, continue to follow your disaster-preparedness plan. (page 30)
6
After the earthquake, check for injuries and damage. (page 29)
5
Protect yourself during earthquake shaking–DROP, COVER AND HOLD ON. (page 28)
4
Identify your building's potential weaknesses and begin to fix them. (page 26)
3
Prepare disaster supply kits. (page 25)
2
Create a disaster-preparedness plan. (page 24)
1
Identify potential hazards in your home and begin to fix them. (page 22)

STEP 1 Identify Potential Hazards in Your Home and Begin to Fix Them

The first step to earthquake safety is to look around your home and identify all unsecured objects that might fall during shaking.

START NOW by moving heavy furniture, such as bookcases, away from beds, couches, and other places where people sit or sleep. Also make sure that exit paths are clear of clutter.

Simple and inexpensive things that you can do now will help reduce injuries and protect belongings in a quake. Most hardware and home-improvement stores carry earthquake-safety straps, fasteners, and adhesives that you can easily use to secure your belongings.

The following tips describe simple solutions to situations in your home that could be dangerous during earthquake shaking. If these have not yet been done in your home, take action now:

✓ Check the boxes!

Don't be fooled!—Myth number 4

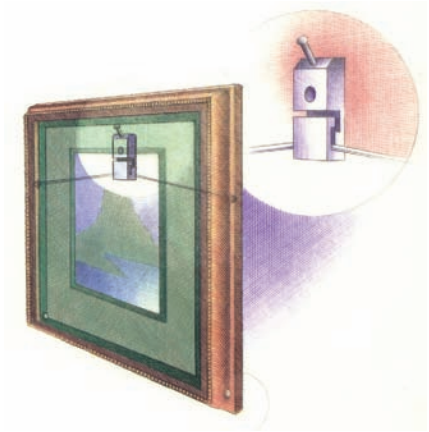
"QUAKE INJURIES ARE ALL FROM COLLAPSING BUILDINGS."

Many people think that all injuries in earthquakes are caused by collapsing buildings. Actually, most injuries in quakes are from objects that break or fall on people. For example, in the 1994 magnitude 6.7 Northridge earthquake, 55 percent of quake-related injuries were caused by falling objects, such as televisions, pictures and mirrors, and heavy light fixtures.

Hanging objects

Art and other heavy objects hung on walls may fall, and glass in pictures and mirrors may shatter.

- ☐ Place only soft art, such as unframed posters or rugs and tapestries, above beds or sofas.
- ☐ Hang mirrors, pictures, and other hanging objects on closed hooks.



Objects on open shelves and tabletops

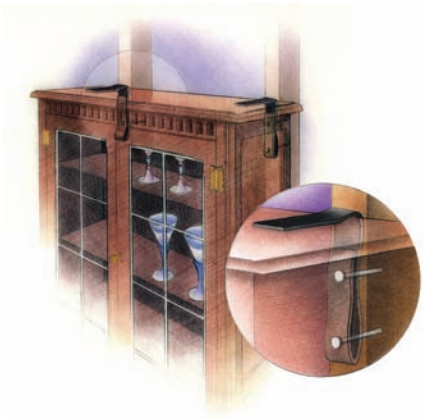
Collectibles and other loose objects can become dangerous projectiles.

- ☐ Hold collectibles, pottery, and lamps in place by using removable earthquake putty, museum wax, or quake gel.

Furniture

Tall, top-heavy furniture, such as bookcases and entertainment centers, may fall and injure you.

- ☐ Store heavy items and breakables on lower shelves.
- ☐ Secure both top corners of tall furniture into a wall stud, not just to the drywall.
- ☐ Flexible-mount fasteners, such as nylon straps, allow furniture independent movement from the wall, reducing strain on studs.



Water and gas pipes

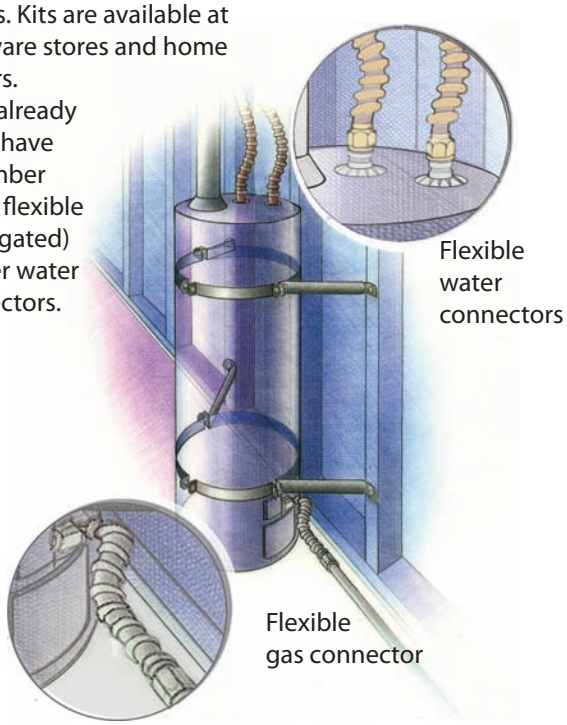
Water or gas pipes anywhere in your home can break. Water leaks can cause extensive damage, and gas leaks are a major fire hazard.

- ☐ Have a plumber evaluate, replace, and properly secure rusted or worn water and gas pipes.
- ☐ If not already done, have a plumber replace rigid gas connections to water heaters, stoves, dryers, and other gas appliances with flexible (corrugated) stainless-steel gas connectors (see below).
- ☐ Excess-flow gas-shutoff valves for individual appliances, which stop gas flow in case of a catastrophic leak, are also now available for use with flexible connectors.

Water heaters

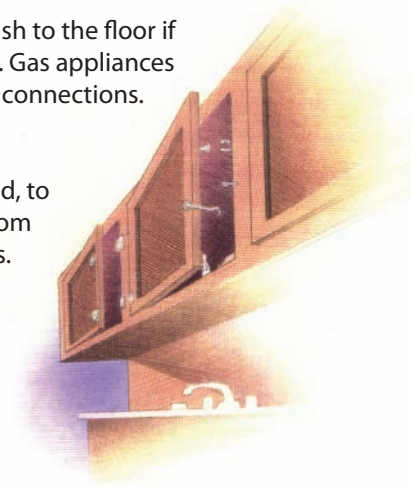
Unsecured water heaters may fall over, rupturing rigid water and gas connections.

- ☐ Water heaters should be anchored to wall studs or masonry with metal straps and lag screws. Kits are available at hardware stores and home centers.
- ☐ If not already done, have a plumber install flexible (corrugated) copper water connectors.



In the kitchen

Glassware and china may crash to the floor if cabinet doors are unsecured. Gas appliances can shift, rupturing their gas connections.



- ☐ Secure all cabinet doors, especially those overhead, to help prevent contents from falling out during quakes. Use latches designed for child-proofing or earthquake or boat safety.
- ☐ Secure refrigerators and other major appliances to walls using earthquake appliance straps.

In the garage or utility room

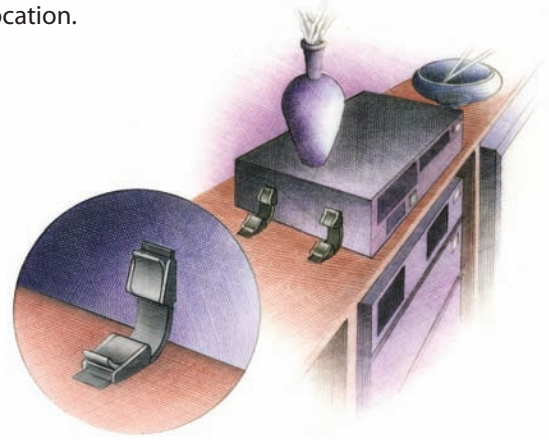
Items stored in garages and utility rooms can fall, causing injuries, damage, and hazardous spills or leaks.

- ☐ Move flammable or hazardous materials to low areas that are secure.
- ☐ Ensure that items stored above or beside vehicles cannot fall, damaging or blocking them.

Home electronics

Large electronic devices may fall, causing injuries and damage. They are also costly to replace.

- ☐ Secure TVs, stereos, computers, and microwave ovens with flexible nylon straps and buckles for easy removal and relocation.



For more information on making your home safer in earthquakes go to: http://beready.utah.gov

STEP 2 Create a Disaster-Preparedness Plan

Will everyone in your household know how to react during and after strong earthquake shaking? To be ready for the quakes that are certain to happen in Utah, it is important that your family have a disaster-preparedness plan. Hold occasional earthquake "drills" to practice your plan. Share your disaster plan with your neighbors and discuss key points with babysitters, house sitters, and house guests. Your plan should include most of the following:

Plan NOW to be safe during an earthquake

In a strong earthquake, individual survival skills will be crucial:

- ☐ Practice "DROP, COVER, AND HOLD ON." (See STEP 5, page 28)
- ☐ Identify safe spots in every room, such as under sturdy desks and tables.
- ☐ Learn how to protect yourself no matter where you are when an earthquake strikes. (See STEP 5, page 28)

Plan NOW to respond after an earthquake

Doing the following will enable you to help your family and others after a strong quake:

- ☐ Keep shoes and a working flashlight next to each bed.
- ☐ Teach everyone in your household to use emergency whistles and (or) to knock three times repeatedly if trapped. Rescuers searching collapsed buildings will be listening for sounds.
- ☐ Identify the needs of household members and neighbors with special requirements or situations, such as use of a wheelchair, walking aids, special diets, or medication.
- ☐ Take a Red Cross first aid and CPR (cardiopulmonary resuscitation) training course. Learn who in your neighborhood is trained in first aid and CPR.
- ☐ Know the locations of utility shutoffs and keep needed tools nearby. Know how to turn off the gas, water, and electricity to your home. Only turn off the gas if you smell or hear leaking gas. (See STEP 6, page 29)
- ☐ Get training from your local fire department in how to properly use a fire extinguisher.
- ☐ Install smoke alarms and test them monthly. Change the battery once a year, or sooner if the alarm emits a "chirping" sound (low-battery signal).
- ☐ Check with your fire department to see if there is a Community Emergency Response Team (CERT) in your area. If not, ask how to start one.

Plan NOW to communicate and recover after an earthquake

Don't wait until the next earthquake to do the following:

- ☐ Locate a safe place outside of your home for your family to meet after the shaking stops.
- ☐ Establish an out-of-area contact person who can be called by everyone in the household to relay information.
- ☐ Provide all family members with a list of important contact phone numbers.
- ☐ Determine where you might live if your home cannot be occupied after an earthquake or other disaster (ask friends or relatives).
- ☐ Learn about the earthquake plan developed by your children's school or day care, and keep your children's school emergency release cards current.
- ☐ Keep copies of insurance policies, financial records, and other essential documents in a secure location, such as with your household disaster kit. Include a household inventory (a list and photos or video of your belongings).

Your family may be sleeping when the next strong quake hits Utah. After the shaking stops, the lights may be out and broken glass and other dangerous debris may litter the floor, making it unsafe to walk barefoot. Keep a flashlight and a pair of sturdy shoes secured to or within reach of everyone's bed. A good way to do this is to use a drawstring bag tied to a bedpost at the head of the bed for each occupant. (Photo courtesy USGS)

STEP 3 Prepare Disaster Supply Kits

(Photo courtesy of American Red Cross)

Personal disaster kits

Everyone in your family should have their own personal disaster kits. These kits are collections of supplies they may need when a quake strikes.

Personalize these kits and keep them where they can easily be reached—at home, in the car, at work or school. A backpack or other small bag is best for these kits so that they can be easily carried in an evacuation. Include the following items:

- ☐ Medications, a list of prescriptions, copies of medical insurance cards, doctors' names and contact information.
- ☐ Medical consent forms for dependents.
- ☐ First aid kit and handbook.
- ☐ Spare eyeglasses, personal hygiene supplies, and sturdy shoes.
- ☐ Bottled water.
- ☐ Whistle (to alert rescuers to your location).
- ☐ Emergency cash.
- ☐ Personal identification.
- ☐ List of emergency contact phone numbers.
- ☐ Snack foods high in calories.
- ☐ Emergency lighting—light sticks and (or) a working flashlight with extra batteries and light bulbs (hand-powered flashlights are also available).
- ☐ Comfort items, such as games, crayons, writing materials, and teddy bears.

A Special Note About Children

Before the next earthquake, spend time with your kids to discuss what might occur. Involve them in developing your disaster plan, preparing disaster kits (ask them what game or toy they want to include), and practicing "DROP, COVER, AND HOLD ON."

In the days after a quake, kids need extra contact and support. They may be frightened and under great stress, and aftershocks won't let them forget the experience. Parents may have to leave children with others in order to deal with the emergency, and this can be scary. Whenever possible, include your children in the earthquake recovery process.

Resources for kids to learn about disaster preparedness:
http://www.fema.gov/kids/
http://earthquake.usgs.gov/4kids/

Household disaster kit

Electrical, water, transportation, and other vital systems can be disrupted for several days or more after a large earthquake. Emergency response agencies and hospitals will likely be overwhelmed and unable to provide you with immediate assistance.

To help your family cope after a strong earthquake, store a household disaster kit in an easily accessible safe location. This kit, which complements your personal disaster kits, should be in a large portable watertight container and should hold at least a 3- to 5-day supply of the following items:

- ☐ Drinking water (minimum one gallon per person per day).
- ☐ First aid supplies, medications, and essential hygiene items, such as soap, toothpaste, and toilet paper.
- ☐ Emergency lighting—light sticks and (or) a working flashlight with extra batteries and light bulbs (hand-powered flashlights are also available).
- ☐ A hand-cranked or battery-operated radio (and spare batteries).
- ☐ Canned and packaged foods and cooking utensils, including a manual can opener.
- ☐ Items to protect you from the elements, such as warm clothing, sturdy shoes, extra socks, blankets, and perhaps even a tent.
- ☐ Heavy-duty plastic bags for waste and to serve other uses, such as tarps and rain ponchos.
- ☐ Work gloves and protective goggles.
- ☐ Pet food and pet restraints.
- ☐ Copies of vital documents, such as insurance policies and personal identification.

Note: Replace perishable items like water, food, medications, and batteries on a yearly basis.

For more information on safety, preparedness, and disaster kits, go to:

Telephone book:
The front section of your local phone book
Be Ready Utah
http://beready.utah.gov
Rocky Mountain Power
http://www.rockymtnpower.net/Article/Article36707/html
Questar Gas
http://www.questargas.com/brochures/index.html#SAFETY

STEP 4 Identify Your Building's Potential Weaknesses and Begin to Fix Them

Is your house, condo, or apartment strong enough to withstand an earthquake?

Use the following quiz to see if your home is likely to be so badly damaged in a future earthquake that people might be injured or that it would be unsafe to occupy. If your home scores above 17 on the quiz, you probably should have a structural engineer evaluate it unless it has been strengthened in the last few years. The engineer will check to see if your home is strong enough to keep you and your family reasonably safe in an earthquake by looking for the following:

- Is your house properly connected to the foundation?
- Is there plywood on the exterior walls of your house?
- Are there anchors attaching the roof and floor systems to the walls?
- Is your house constructed out of unreinforced masonry?
- Do you have large openings like a garage door that may require better bracing?

The following quiz will help you to determine the adequacy of your house in resisting a seismic event. Once you have identified the areas requiring retrofitting, prioritize how and when to fix them, and get started. Local building departments and the Structural Engineers Association of Utah are excellent resources.

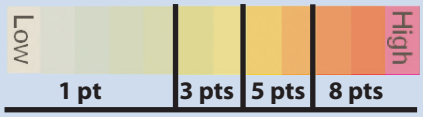
Don't be fooled!—Myth number 5

"WE HAVE GOOD BUILDING CODES, SO WE MUST HAVE SAFE BUILDINGS."

The best building code in the world does nothing for buildings built before the code was enacted. Although building codes used in Utah have strict seismic provisions, many older buildings, particularly unreinforced masonry buildings, have not been "retrofitted" to meet updated codes. Retrofitting—fixing problems in older buildings—is the responsibility of a building's owner.

Structural-Safety Quiz for Homes and Other Buildings

1. When was your home built?
   - ☐ Before 1970 = **6 points**
   - ☐ 1970 – 1980 = **3 points**
   - ☐ After 1980 = **1 point**
2. How many stories and what style is your home?
   - ☐ 2 or more stories above grade with stepped floors, split levels, or large openings in floors = **5 points**
   - ☐ 2 or more stories above grade with flat floors, no steps in the floor, and no large openings in floors = **3 points**
   - ☐ 1 story rambler above grade = **1 point**
3. What is the construction material of the exterior walls?
   - ☐ Unreinforced masonry bearing walls = **7 points**
   - ☐ Wood or reinforced masonry with full height brick veneer = **3 points**
   - ☐ Wood or reinforced masonry = **1 point**
4. What are the foundation walls constructed from?
   - ☐ Stacked rock or brick, with basement = **5 points**
   - ☐ Stacked rock or brick, no basement = **3 point**
   - ☐ Concrete, with or without basement = **1 point**
   - ☐ Slab on grade, no basement = **0 points**
5. Where is your house located? *(see map, page 8)*



Total points = _____

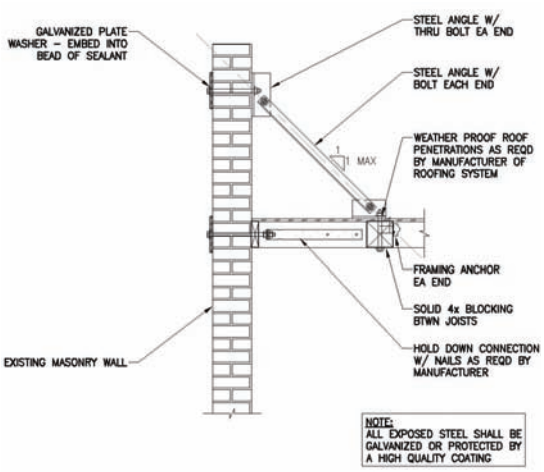
If your home scores 17 or more points on the quiz, you probably should have an engineer, architect, or contractor evaluate it.

EXAMPLES:

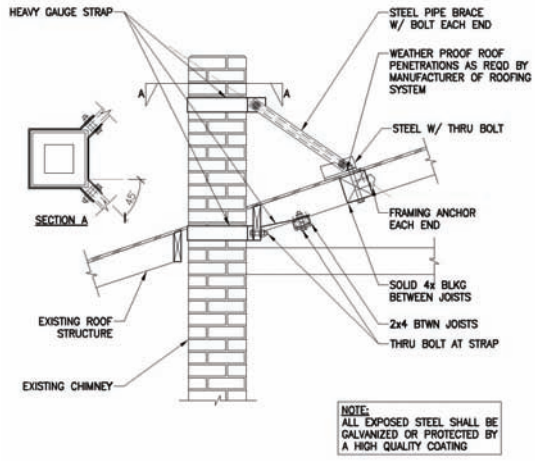
1. 1958, 1 story, unreinforced masonry, concrete foundation, Salt Lake City: **6+1+7+1+8 = 23**
2. 1995, 2 story (flat), wood (brick veneer), concrete foundation, Ogden: **1+3+3+1+8 = 16**
3. 2006, 2 story (large openings), wood, slab on grade, St. George: **1+5+1+0+3 = 10**

Utah Parapet Ordinance

On October 28, 1983, two children, ages 6 and 7, were killed by falling debris from a parapet (a wall-like barrier at the edge of a roof) on a business in Challis, Idaho, as they walked to school. Challis is about 13 miles north of the epicenter of the 1983 Borah Peak earthquake (magnitude 7.3). Photos 1 and 2 were taken of damaged buildings from this earthquake in the nearby town of Mackay, Idaho. These deaths were the first caused by an earthquake in the United States since 65 people were killed in the San Fernando earthquake in California on February 9, 1971.



PARAPET BRACING



CHIMNEY BRACING

The 1962 Cache Valley earthquake (magnitude 5.7) is another example of falling debris from parapets. Arrows in photo 3 show the path of bricks that tumbled from the parapet of a drugstore onto the roof of the City Cafe in Lewiston, Utah. Luckily this cafe in Lewiston was not open when the earthquake occurred (see photo 4). Photo 5 shows damage to an unreinforced masonry building in the 2008 magnitude 6 Wells, Nevada, earthquake.

In response to the damage from past earthquakes, a parapet-bracing ordinance was enacted in 1991 in Utah. This ordinance requires that a licensed engineer evaluate the adequacy of parapet bracing and the connection of the walls to the roof when a commercial building (built prior to 1975) is to be re-roofed. This ordinance can be found in the State Construction Code Administration and Adoption of Approved State Construction Code Rule (R156-15A-402).

The bracing of parapets, creating strong wall-to-roof connections, and bracing or elimination of other roof appendages (chimneys and cornices) are among the simplest and most cost-effective seismic upgrades that can be made to a building.

The figures at left show how to brace parapets and chimneys. These figures are based on a State of Utah publication titled "The Utah Guide for the Seismic Improvement of Unreinforced Masonry Buildings" and may be viewed online at http://publicsafety.utah.gov/emergencymanagement/utahhazards/earthquake.html

(Photos 1 and 2 by O. Kasteler, courtesy of the Deseret News; photos 3 and 4 courtesy of the Salt Lake Tribune; photo 5 courtesy of Craig dePolo, Nevada Bureau of Mines and Geology)

1

2

3

4

5

STEP 5 Protect Yourself During Earthquake Shaking

The previous pages have concentrated on getting you ready for future earthquakes in Utah, but what should you do when the shaking starts?

If you are indoors...

- DROP, COVER, AND HOLD ON. If you are not near a desk or table, drop to the floor against an interior wall and protect your head and neck with your arms.
- Avoid exterior walls, windows, hanging objects, mirrors, tall furniture, large appliances, and cabinets filled with heavy objects.
- Do not go outside until well after the shaking stops!

In bed

Hold on and stay there, protecting your head with a pillow. You are less likely to be injured staying where you are. Broken glass on the floor can cause injuries; be sure to put shoes on before stepping on the floor.

In a high-rise building

DROP, COVER, AND HOLD ON. Avoid windows. Do not use elevators. Do not be surprised if sprinkler systems or fire alarms activate.

At work

DROP, COVER, AND HOLD ON. Know your workplace's earthquake safety plan and put it into action. When safe, move to a specified meeting location.

In a public building or theater

DROP, COVER, AND HOLD ON if possible. If in a theater seat, duck down and protect your head and neck with your arms. Don't try to leave until the shaking is over. Then walk out slowly, watching for fallen debris or anything that could fall on you in aftershocks.

If you are outdoors...

Move to a clear area if you can do so safely; avoid buildings, power lines, trees, and other hazards. Always assume fallen power lines are live.

Near tall buildings

Windows, facades, and architectural details are often the first parts of a building to collapse. Get away from this danger zone when shaking starts. Take refuge in a safe building or an open space.

Driving

When able, safely pull over to the side of the road, stop, and set the parking brake. Avoid overpasses, bridges, power lines, signs, trees, and other things that might collapse or fall on the vehicle. Stay inside the vehicle until the shaking is over. If a power line falls on the vehicle, stay inside until a trained person removes the hazard.

In a stadium

Stay at your seat and protect your head and neck with your arms. Don't try to leave until the shaking is over. Then exit slowly, avoiding debris and watching for anything that could fall in aftershocks.

DROP, COVER, AND HOLD ON

If you are indoors, when you feel strong earthquake shaking, drop to the floor, take cover under a sturdy desk or table, and hold on to it firmly until the shaking stops.

(Photo courtesy of USGS)

Below a dam

Dams can fail during a major earthquake. Catastrophic failure is unlikely, but if you are downstream from a dam, you should know flood-zone information and have prepared an evacuation plan. For more information on possible flood areas, go to the Utah Division of Water Rights Dam Safety Program at http://www.waterrights.utah.gov/cgi-bin/damview.exe, click on the dam of interest, and view Dam Break Map.

Don't be fooled!—Myth number 6

"THE TRIANGLE OF LIFE SURVIVAL METHOD IS THE BEST METHOD TO USE INSIDE A BUILDING TO SURVIVE AN EARTHQUAKE."

False. The best survival method inside a building is to Drop, Cover, and Hold On under a table, desk, or chair, rather than trying to get into a survivable void next to a large, bulky object as advocated by the Triangle of Life method. The Drop, Cover, and Hold On survival method protects individuals from objects falling from walls and shelves. It also provides a level of protection from structural failures. If a table or desk is not available, sit down with your back against an interior wall, using your hands and arms to protect your head and neck.

STEP 6 After the Earthquake, Check for Injuries and Damage

Once earthquake shaking has stopped, follow your disaster preparedness plans (see Step 2, page 24). Most importantly:

Check for injuries

NOTE: The manual in your first aid kit and the front pages of your telephone book have instructions on first aid measures.

- Check yourself for serious injuries before helping others. Protect your mouth, nose, and eyes from dust.
- If a person is bleeding, put direct pressure on the wound. Use clean gauze or cloth, if available.
- If a person is not breathing, administer rescue breathing.
- If a person has no pulse, begin CPR (cardiopulmonary resuscitation).
- Do not move seriously injured persons, unless they are in immediate danger of further harm.
- Cover injured persons with blankets or additional clothing to keep them warm.

Check for damage causing hazardous conditions

- **Fire**—If possible, put out small fires in your home or neighborhood immediately. Call for help, but don't wait for the fire department.
- **Gas leaks**—Turn off the gas only if you suspect a leak because of broken pipes or detect the odor or sound of leaking natural gas. Use a manual gas shut-off wrench to close your main gas valve by turning it counterclockwise. Don't turn gas back on by yourself—wait for the gas company! (Your telephone book has information on this topic.)
- **Damaged electrical wiring**—Shut off power at the main breaker switch if there is any damage to your home wiring. Leave the power off until the damage is repaired! (Your telephone book also has information on this topic.)
- **Downed utility lines**—If you see downed power lines, consider them energized and keep yourself and others well away from them. Never touch downed power lines or any objects in contact with them!
- **Falling items**—Beware of heavy items tumbling off shelves when you open closet and cupboard doors.
- **Spills**—Use extreme caution; when in doubt, leave your home. Spilled medicines, drugs, or other relatively non-toxic substances can be cleaned up. Potentially harmful materials, such as bleach, lye, garden chemicals, paint, and gasoline or other flammable liquids should be isolated or covered with an absorbent material, such as dirt or cat litter.
- **Damaged masonry**—Stay away from brick chimneys and walls. They may be weakened and could topple during aftershocks. Don't use a fireplace with a damaged chimney, as this could start a fire or trap toxic gases in your home.

If your home is seriously damaged

If your home is structurally unsafe or threatened by a fire or other secondary disaster, you need to evacuate. However, shelters may be overcrowded and initially lack basic services, so do not leave home just because utilities are out of service or your home and its contents have suffered moderate damage.

If you evacuate, tell a neighbor and your family point-of-contact where you are going. Take the following, if possible, when you evacuate:

Bring to a shelter:

- ☐ Personal disaster supply kits (see STEP 3, page 25).
- ☐ Supply of water, food, and snacks.
- ☐ Blanket, pillow, and air mattress or sleeping pad.
- ☐ Change of clothing and a jacket.
- ☐ Towel and washcloth.
- ☐ Diapers, formula, food, and other supplies for infants.
- ☐ A few family pictures or other small comfort items, such as dolls or teddy bears for children.
- ☐ Personal identification and copies of household and health insurance information.
- ☐ Books and games (especially for children).

However, do not bring

- Pets (service animals for people with disabilities are allowed—bring food for them).
- Large quantities of unnecessary clothing or other personal items.
- Valuables that might be lost, stolen, or take up needed space.

If you suspect a gas leak, use a manual gas shut-off wrench.

AFTERSHOCK
Go back to STEP 5

STEP 7 When Safe, Continue to Follow Your Disaster-Preparedness Plan

Once you have met your and your family's immediate needs after the next strong Utah earthquake, continue to follow your disaster-preparedness plan (see Step 2, page 24).

The first days after the quake

In the days following a damaging quake, pay special attention to the following:

Safety first

- Do not re-enter your home until you know it is safe.
- Be sure there are no gas leaks at your home before using open flames (lighters, matches, candles, or grills) or operating any electrical or mechanical device that could create a spark (light switches, generators, chain saws, or motor vehicles).
- Check for chemical spills, faulty electrical wiring, and broken water lines. Water in contact with faulty wiring is a shock hazard.
- Unplug broken or toppled light fixtures or appliances. These could start fires when electricity is restored.
- Never use the following indoors: camp stoves, kerosene or gas lanterns or heaters, gas or charcoal grills, or gas generators, as these can release deadly carbon monoxide gas or be a fire hazard in aftershocks.

Be in communication

- Turn on your portable or car radio and listen for information and safety advisories.
- Place all phones back on their cradles.
- Call your out-of-area contact, tell them your status, and then stay off the phone—emergency responders need the phone lines for life-saving communications.
- Check on your neighbors.

Check your food and water supplies

- If power is off, plan meals so as to use up refrigerated and frozen foods first. If you keep the door closed, food in your freezer may be good for a couple of days.
- If your water is off, you can drink from water heaters, melted ice cubes, or canned vegetables. Avoid drinking the water from swimming pools or hot tubs; use it to fight fires.

The first weeks after the earthquake

- This is a time of transition. Although aftershocks may continue, you will now work toward getting your life, your home and family, and your routines back in order. Emotional care and recovery are just as important as healing physical injuries and rebuilding a home. Make sure your home is safe to occupy and not in danger of collapse in aftershocks. If you were able to remain in your home or return to it after a few days, you will have a variety of tasks to accomplish while re-establishing routines:

Tasks

- If your gas was turned off, you will need to arrange for the gas company to turn it back on.
- If the electricity went off and then came back on, check your appliances and electronic equipment for damage.
- If water lines broke, look for water damage.
- Locate or replace critical documents that may have been misplaced, damaged, or destroyed.
- Contact your insurance agent or company to begin your claims process.
- Contact the Federal Emergency Management Agency (FEMA) to find out about financial assistance. For FEMA teleregistration, call 1-800-621-FEMA (3362).
- If you cannot live at your home, set up an alternative mailing address with the post office.

If you can't stay in your home

The American Red Cross offers immediate emergency assistance with housing needs. The Red Cross also supports shelter operations prior to a presidential declaration of a federal disaster.

Once a presidential declaration has been issued, FEMA may activate the Assistance for Individuals and Households Program. This program includes:

- Home-repair cash grants; the maximum federal grant available is $28,800 for all individual and family assistance.
- Housing assistance in the form of reimbursement for short-term lodging expenses at a hotel or motel.
- Rental assistance for as long as 18 months in the form of cash payment for a temporary rental unit or a manufactured home.
- If no other housing is available, FEMA may provide mobile homes or other temporary housing.

FEMA mobile homes being set up in Port Charlotte, Florida, to provide temporary housing for victims of Hurricane Charley (August 2004). Nearly a year after the storm, these trailers were still being used. (Photo courtesy of FEMA)

A Review of Money Matters: Financial Impacts of Earthquakes

Following a quake, disaster aid may not be immediately available, so you should plan ahead. If you have prepared a financial disaster recovery plan, you are more likely to recover successfully after a quake. Financial recovery planning resources are available from:

- **Operation Hope Emergency Financial First Aid Kit:**
  http://www.ncua.gov/Publications/brochures/EmergencyFinancialFirstAidKit.pdf
- **American Red Cross—Disaster Recovery: A Guide to Financial Issues (2003):**
  http://www.redcross.org/services/disaster/beprepared/FinRecovery/
- **Federal Emergency Management Agency (FEMA):**
  http://www.fema.gov/about/process
- **Small Business Administration:**
  http://www.sba.gov/disaster_recov/index.html

Your financial disaster recovery kit

After a damaging earthquake, you will need copies of essential financial documents, as well as emergency cash. Keep these items together, current, and stored in a fire-proof document safe. Consider purchasing a home safe or renting a safe deposit box. Some essential items in your financial disaster recovery kit are:

- ☐ Birth certificates.
- ☐ Marriage license/divorce papers and child custody papers.
- ☐ Passports and driver's licenses.
- ☐ Social security cards.
- ☐ Naturalization papers and residency documents.
- ☐ Military/veteran's papers.
- ☐ Critical medical information.
- ☐ Cash, in the event ATM or bank services are disrupted.
- ☐ Certificates for stocks, bonds, and other investments.
- ☐ Bank statements.
- ☐ Credit card numbers.
- ☐ A list of phone numbers for financial institutions and credit card companies where you have accounts.
- ☐ Insurance policies.
- ☐ An inventory of your household possessions.
- ☐ Appraisals of valuable jewelry, art, antiques, and heirlooms.
- ☐ Home improvement records.
- ☐ A backup of critical files on your computer (also keep a copy at work).
- ☐ A list of names, phone numbers, and e-mail addresses of critical personal and business contacts.
- ☐ Deeds, titles, and other ownership records for property such as homes, autos, RVs, and boats.
- ☐ Powers of attorney, including health-care powers of attorney.
- ☐ Wills or trust documents.

For help in the first week after an earthquake, contact:

Your county office of emergency services

American Red Cross:
http://utahredcross.org
1-800-328-9272

Utah Division of Emergency Management:
http://publicsafety.utah.gov/emergencymanagement/

Federal Emergency Management Agency (FEMA):
http://www.fema.gov/assistance

Don't be fooled!—Myth number 7

"I DON'T NEED TO WORRY ABOUT EARTHQUAKES— THE GOVERNMENT WILL SAVE ME!"

Many people wrongly believe that the U.S. government will take care of all their financial needs if they suffer losses in an earthquake. The truth is that federal disaster assistance is only available if the president formally declares a disaster. Even if you do get disaster assistance, it is usually a loan that you must repay, with interest, in addition to mortgages and other financial obligations you still owe, even on damaged property. If you don't qualify for loans, grants may be available to you. However, these are only designed to meet your most immediate needs, not to replace your losses (see pages 18 and 19).

Earthquake Information on the Web

After an earthquake, knowing more about what just happened can reduce fears and help you understand what to expect next. Online earthquake information products include:

Location and magnitude of recent earthquakes

Within 1 to 2 minutes of an earthquake, its location and magnitude are available at several Web sites, including:
http://quake.utah.edu/
http://earthquake.usgs.gov/

"ShakeMap"

Within 5 to 10 minutes of most felt earthquakes (magnitude 3.0 and greater in the Wasatch Front area), a "ShakeMap" is posted on the Web. This map shows the range of shaking intensities across a region. Every quake has only a single magnitude, but it produces a wide range of shaking intensity values over the area in which it is felt.

ShakeMaps use data from seismic instruments to provide a rapid picture of where the strongest shaking occurred. These maps help to identify areas where a quake's impact is greatest and are used by emergency managers to speed disaster response. ShakeMaps are available at:
http://quake.utah.edu/shake/
http://earthquake.usgs.gov/eqcenter/shakemap/

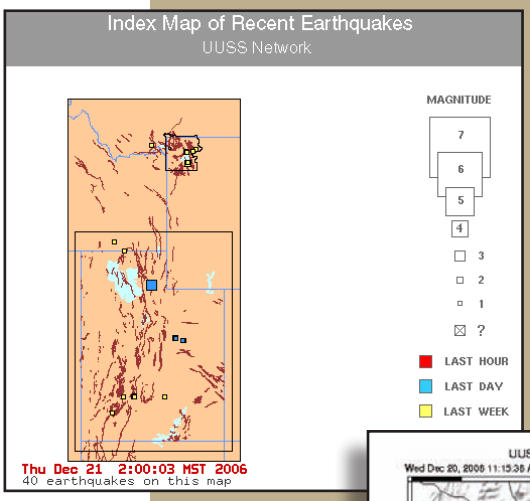
"Did You Feel It?"—Tell us what you felt!

Personal experiences of the effects of an earthquake are very valuable to scientists. When you have felt a quake, please report your observations by using a quick survey found on the U.S. Geological Survey "Did You Feel It?" Web site at http://earthquake.usgs.gov/dyfi/.
When you fill out the survey, your observations of actual damage and shaking are combined with those of thousands of other people. The quake's shaking intensities, derived from these observations, are displayed by ZIP code on a "Community Internet Intensity Map."

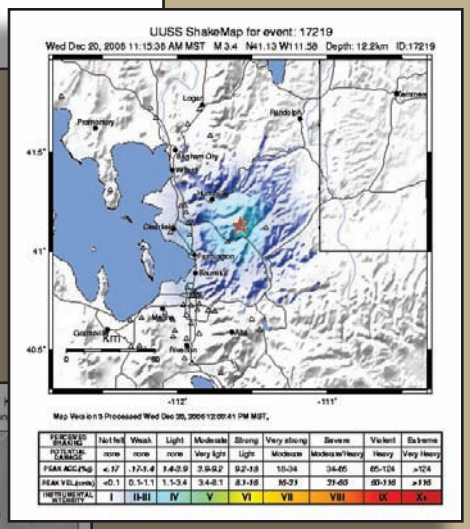
Who monitors Utah's earthquakes?

Seismic monitoring in the Utah region is conducted by the University of Utah Seismograph Stations in partnership with the U.S. Geological Survey as part of the Advanced National Seismic System.

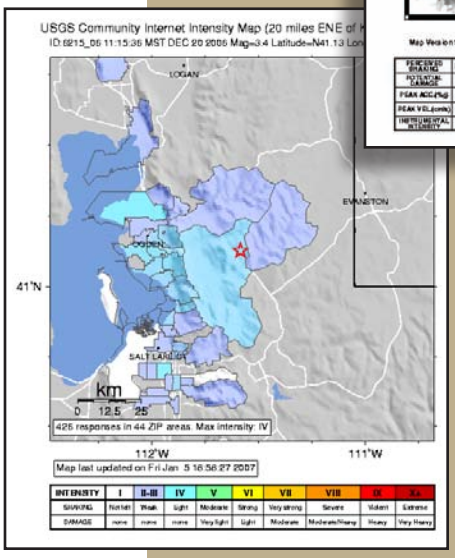
For more information go to:
http://quake.utah.edu/
http://earthquake.usgs.gov/research/monitoring/anss/



Map of recent earthquakes in the Wasatch Front and Yellowstone Park regions, one day after a magnitude 3.4 quake 20 miles east–northeast of Kaysville, Utah, on December 20, 2006.



"ShakeMap" for the December 2006 quake near Kaysville, Utah.



Community Internet Intensity Map ("Did You Feel It?") for the December 2006 quake near Kaysville, Utah. Although the quake originated under the Wasatch Range, it produced light shaking along the Wasatch Front from Ogden to Salt Lake Valley. More than 400 people reported their observations on this quake online.

Glossary

Aftershocks. Earthquakes that follow the largest shock of an earthquake sequence. They are smaller than the "mainshock" and can occur over a period of weeks, months, or years. In general, the larger the mainshock, the larger and more numerous the aftershocks and the longer they will continue.

Crust. Earth's outermost layer consisting of rigid oceanic and continental tectonic plates.

Epicenter. The point on Earth's surface above where an earthquake begins at depth in Earth's crust.

Fault. A fracture or crack along which the two sides slide past one another.

Fault rupture. The area of Earth through which fault movement occurrs during an earthquake. For large quakes, the section of the fault that ruptures may be several hundred miles in length. Ruptures may or may not extend to the ground surface.

Fault scarp. A steep, linear break or slope formed where a fault ruptures the ground surface.

Fault segment. A part of a fault that is thought to rupture independently of other parts of the fault. One or more segments may rupture in a single earthquake.

Foreshock. An earthquake that precedes the largest quake ("mainshock") of an earthquake sequence. Foreshocks may occur seconds to weeks before the mainshock. Not all mainshocks are preceded by foreshocks.

Intensity. A measure of ground shaking describing the local severity of an earthquake in terms of its effects on Earth's surface and on humans and their structures. The Modified Mercalli Intensity scale, which uses Roman numerals, is one way scientists measure intensity.

Landslide. A mass movement of soil, mud, and (or) rock down a slope.

Liquefaction. The process that occurs when an earthquake shakes wet sandy soil until it behaves like a liquid, allowing sand to "boil up" to the surface, buildings to sink, or sloping ground to move.

Magnitude (M). A number that represents the size of an earthquake, as determined from seismographic observations. An increase of one unit of magnitude (for example, from 4.6 to 5.6) corresponds approximately to a thirty-fold increase in energy released (by definition, a two-unit increase in magnitude —for example, from 4.7 to 6.7—represents a thousand-fold increase in energy). Quakes smaller than magnitude 2.5 generally are not felt by humans.

Mainshock. The largest quake of an earthquake sequence, possibly preceded by smaller foreshocks and commonly followed by aftershocks.

Mantle. The layer of heated viscous rock between Earth's crust and core.

Normal fault. An inclined fault along which the upper side moves downward relative to the lower side. Utah's Wasatch fault is a good example.

Parapet. A wall-like barrier at the edge of a roof.

Retrofit. Strengthening an existing structure to improve its resistance to the effects of earthquakes.

Seiche. Waves "sloshing" in a lake as a result of earthquake ground shaking. Waves caused by landsliding into a reservoir or displacement of the lake bed are termed a surge.

Seismic hazard. The potential for damaging effects caused by earthquakes. The level of hazard depends on the magnitude and frequency of likely quakes, the distance from the fault that could cause quakes, and geologic conditions at a site.

Seismic risk. The chance of injury, damage, or loss resulting from seismic hazards. There is no risk, even in a region of high seismic hazard, if there are no people or property that could be injured or damaged by a quake.

Seismograph. A sensitive instrument that detects and records seismic waves generated by an earthquake.

Strike-slip fault. A generally near-vertical fault along which the two sides move horizontally past each other. The most famous example is California's San Andreas fault.

Surface faulting (surface fault rupture). Propagation of an earthquake-generating fault rupture to the surface, displacing the surface and forming a fault scarp.

Tectonic plate. Earth's outer shell is composed of large, relatively strong "plates" that move relative to one another. Movements on the faults that define plate boundaries produce most earthquakes.

Tectonic subsidence. Downdropping and tilting of a basin floor on the downdropped side of a fault during an earthquake.

ONLINE RESOURCES

Why should I care? *(pages 1-11)*

Earthquakes & Utah: ***http://geology.utah.gov/online/pdf/pi-48.pdf***
Overview of Fault Movement in the Western United States:
http://earthquake.usgs.gov/regional/imw/imw_bnr_faults/
Recent Earthquakes in Utah: ***http://quake.utah.edu/***
Earthquakes and Geologic Hazards: ***http://geology.utah.gov/utahgeo/hazards/index.htm***
Earthquake Information Center: ***http://quake.utah.edu/EQCENTER/eqcenter.htm***
University of Utah Seismograph Stations: ***http://quake.utah.edu***
Utah Geological Survey: ***http://geology.utah.gov***
Utah Seismic Safety Commission: ***http://www.ussc.utah.gov***
U.S. Geological Survey Earthquake Hazards Program: ***http://earthquake.usgs.gov/***

Why should I prepare? *(pages 12-19)* and What should I do? *(pages 20-30)*

American Red Cross: ***www.utahredcross.org***
Be Ready Utah: ***http://beready.utah.gov***
Citizen Corps: ***http://citizencorps.utah.gov***
Federal Emergency Management Agency: ***http://www.fema.gov***
Structural Engineers Association of Utah: ***http://www.seau.org***
U.S. Department of Homeland Security: ***http://www.ready.gov/business***
Utah Association of Contingency Planners: ***http://utah.acp-international.com***
Utah Division of Emergency Management: ***http://publicsafety.utah.gov/emergencymanagement***

What else should I know? *(pages 31-33)*

Did you feel it? – Report it!: ***http://earthquake.usgs.gov/dyfi/***
Utah ShakeMaps: ***http://quake.utah.edu/shake/***

FUNDING ORGANIZATIONS

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