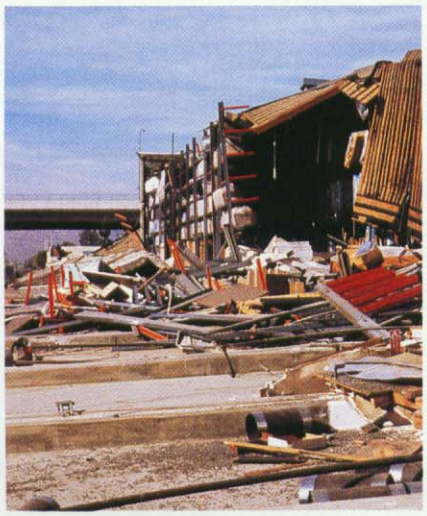
EARTHQUAKES

WHAT YOU SHOULD KNOW WHEN LIVING IN UTAH

The National Earthquake Hazard Reduction Act, passed by Congress in 1977, established the National Earthquake Hazard Reduction Program (NEHRP), a long-term effort to reduce the risks to life and property from earthquakes. The U.S. Geological Survey, the National Science Foundation, and the National Institute of Standards and Technology work individually and in cooperative alliances to accomplish the goals of the NEHRP, governed by the Federal Emergency Management Agency (FEMA). Some of the responsibilities include: improving building codes and land use practices, post-earthquake investigations and education, and improvements to design and construction techniques.

Although the NEHRP agencies have expanded the nation's understanding of national earthquake hazards, much remains to be learned.



Recently, a strategy was formulated to enhance the existing elements of the NEHRP and mobilize and coordinate the actions of numerous federal programs into an aggressive, focused National Earthquake loss reduction Program (NEP). An important feature of this national strategy is the establishment of nine major goals, each supported by specific targets, products, and proposed timelines that provide a framework for measuring progress and mapping a path forward. The NEP goals are: 1) provide leadership and coordination for federal earthquake research; 2) improve technology transfer and outreach; 3) improve engineering of built environment; 4) improve data for construction standards and codes; 5) continue the development of seismic hazards and risk assessment tools; 6) analyze seismic hazard mitigation incentives; 7) develop understanding of social implications and responses related to earthquake hazard mitigation; 8) analyze medical and public health consequence of earthquakes; and 9) continue documentation of earthquakes and their effects.

This publication represents a joint project between FEMA and the State of Utah through the Utah Division of Comprehensive Emergency Management's Earthquake Preparedness Information Center (EPICenter). Other contributing state agencies are the Utah Geological Survey and the University of Utah Seismograph Stations.

The Utah Division of Comprehensive Emergency Management (CEM): Lorayne Frank, Director; Bob Carey, EPICenter Manager. Thanks to Judy Watanabe and Mikki Easton, CEM; Gary Christenson, Utah Geological Survey; Sue Nava, and Deedee O'Brien, University of Utah Seismograph Stations.

A special thanks to Jim Tingey for his vision and direction on this document.

UTAH
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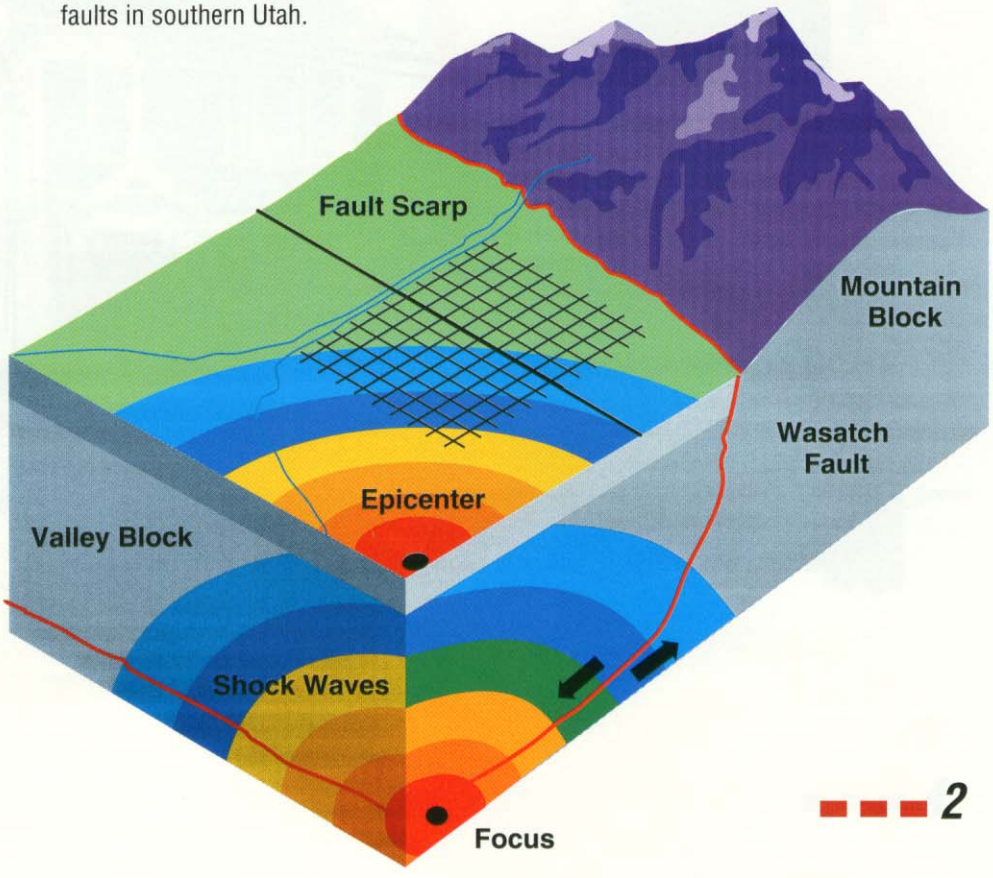
EARTHQUAKE PREPAREDNESS INFORMATION CENTER

THE EARTHQUAKE HAZARD IN UTAH

Utah experiences about 700 earthquakes every year. Of this number, not counting foreshocks, aftershocks, and human-triggered seismic events, there are about 6 earthquakes that are Richter magnitude 3.0 or greater. The smaller magnitude earthquakes are rarely felt by people and obviously do not cause damage. However, these small rumblings are important in studying our vulnerability to larger earthquakes. Earthquakes occur on faults or cracks in the Earth's crust. Utah has many active faults which could produce damaging earthquakes. For a detailed explanation of the Richter scale and other earthquake measurements, see page 20.

WHEN CAN WE EXPECT "THE BIG ONE?"

We define "The Big One" or the largest expected earthquake in Utah, as a magnitude 7.0-7.5 on the Richter scale. Young active faults capable of such a large earthquake include the central segments of the Wasatch and the Bear River faults. Other potentially active faults include the East Cache near Logan, the East Bear Lake, the Hansel Valley at the north end of the Great Salt Lake, East Great Salt Lake, Oquirrh in Tooele Valley, the West Valley, and Utah Lake faults in north-central Utah; Strawberry, Joe's Valley in Emery County, and Gunnison faults in central Utah; and the Hurricane, the Paragonah, and the Sevier faults in southern Utah.



A large earthquake occurs on the central segments of the Wasatch fault on average every 350 years. This means that there is a 25% chance of having a 7.0-7.5 earthquake in the next 100 years. The last such earthquake appears to have occurred between Mona and Nephi about 400 years ago.

Earthquake histories of other faults are not well enough known to give other probabilities, but a conservative and correct attitude is that, although rare, a large earthquake could occur at any time on any of the known faults and perhaps in unexpected locations. Read more about how often earthquakes occur on page 19.

WHY PREPARE?

Most injuries, deaths and economic loss in an earthquake are due to man-made problems. These include damage to buildings and homes, roads and bridges, lifelines, and business and industry. Most of these problems can be avoided. A pre-disaster hazard assessment could help identify and correct problems ahead of time to reduce potential damage and the associated risk to life, property, and the environment.

Many of the techniques to reduce loss are simple and inexpensive. Securing your water heater and other vulnerable articles, preparing a 72-hour supply of essentials, and emergency planning for homes and businesses can all be done with minimal expense. The added cost to construct a new home or building with additional seismic bracing is also very low.

WHAT TO DO BEFORE AN EARTHQUAKE:

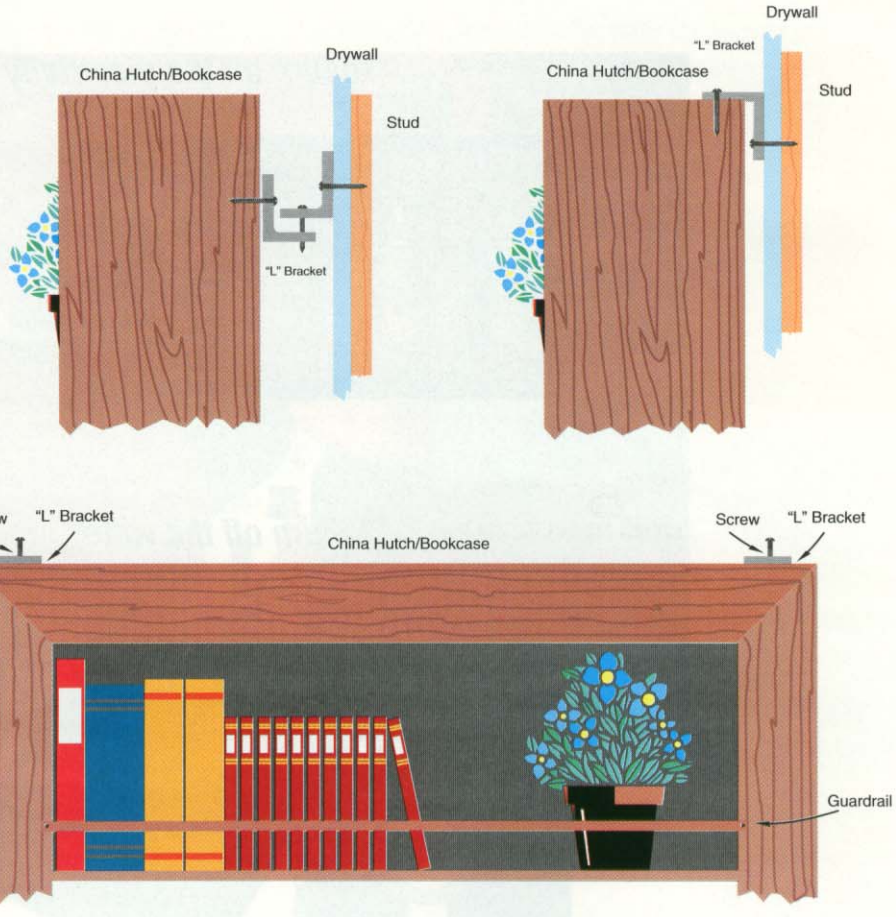
Most casualties result from partial building collapses, and falling objects and debris, like toppling chimneys, fallings bricks, ceiling plaster, and light fixtures. Many of these conditions can be prevented by taking a few steps now to prepare. A brief survey of your home and office will indicate what hazards exist.

• **Secure fixtures such as lights, cabinets, bookcases, and top-heavy objects** to resist moving, coming loose, or falling during the shaking. Place large and heavy objects on lower shelves and securely fasten shelves to walls. Special care should be taken to remove hazardous objects from above sleeping areas. Do not hang plants in heavy pots that could swing free of hooks.

• **Store bottled goods, glass, vases, china,** and other breakables in low or closed cabinets and use non-skid padded matting, hold-fast putty, or Velcro whenever possible.

Secure your furniture by using:

- ***"L" brackets, corner brackets or "anodized" aluminum molding to attach tall or top-heavy furniture to the wall.***
- ***Corner brackets or eye bolts to secure items located a short distance from the wall.***
- ***Attach a wooden or metal guardrail on open shelves to keep items from sliding or falling off.***
- ***Fishing line can be used as a less visible means of securing an item (guardrail).***



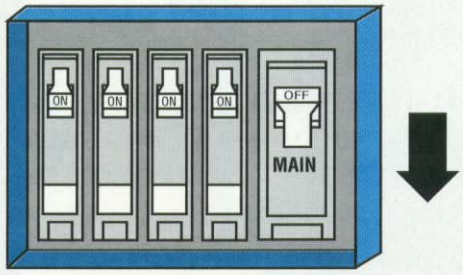
• **Check the electrical wiring and connections to gas appliances.** Defective electrical wiring, leaking gas, or inflexible connections are very dangerous in the event of an earthquake.

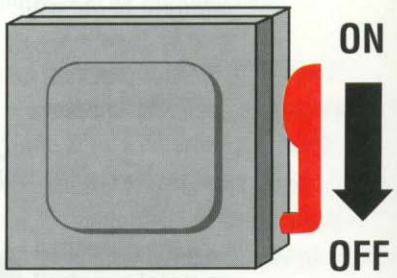
• **Develop a family plan** which addresses what to do if the earthquake occurs while family members are at home, school, or work. This plan should include a possible central meeting location for family members after the earthquake and an out-of-area contact person so other family members can find out information concerning their loved ones in the disaster area. It is usually easier to call out of a disaster area than it is to call into one.

• **Hold drills** so each member of your family knows what to do in an earthquake.

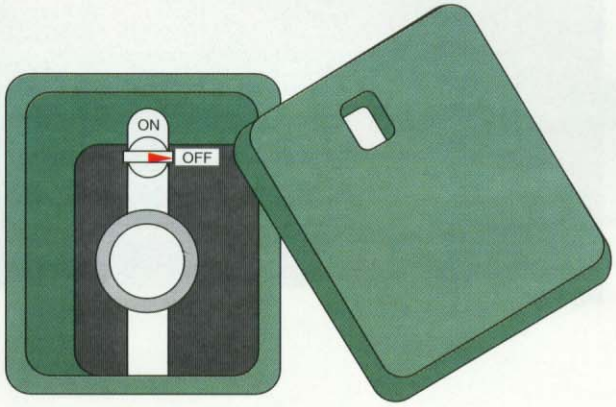
• **Locate master switch and shut-off valves** for all utilities and teach all responsible family members how to turn them off. Your local utility company can show you how.

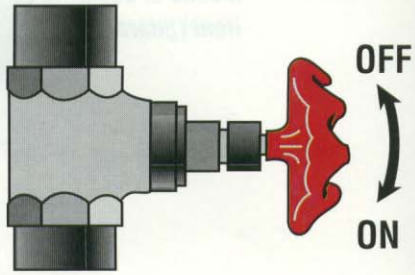
To turn off the electricity



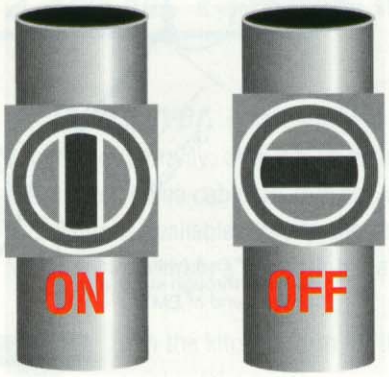


To turn off the water





To shut off the gas



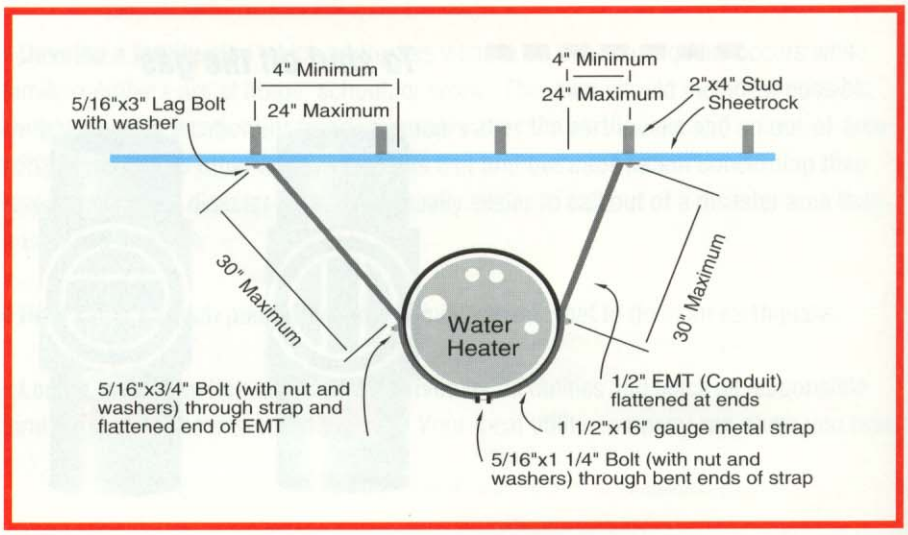
If you smell gas, open windows and evacuate the house.

To shut off gas in an emergency, use a large wrench.

Attach a wrench to the valve key.

Turn in either direction until key is crosswise to pipe (closed).

Don't turn it on without the help of a utility worker or plumber.



Materials needed:

(2) 6' lengths of 1-1/2" 16 gauge pre-drilled strap

(1) 10' length 1/2" EMT tube (conduit)

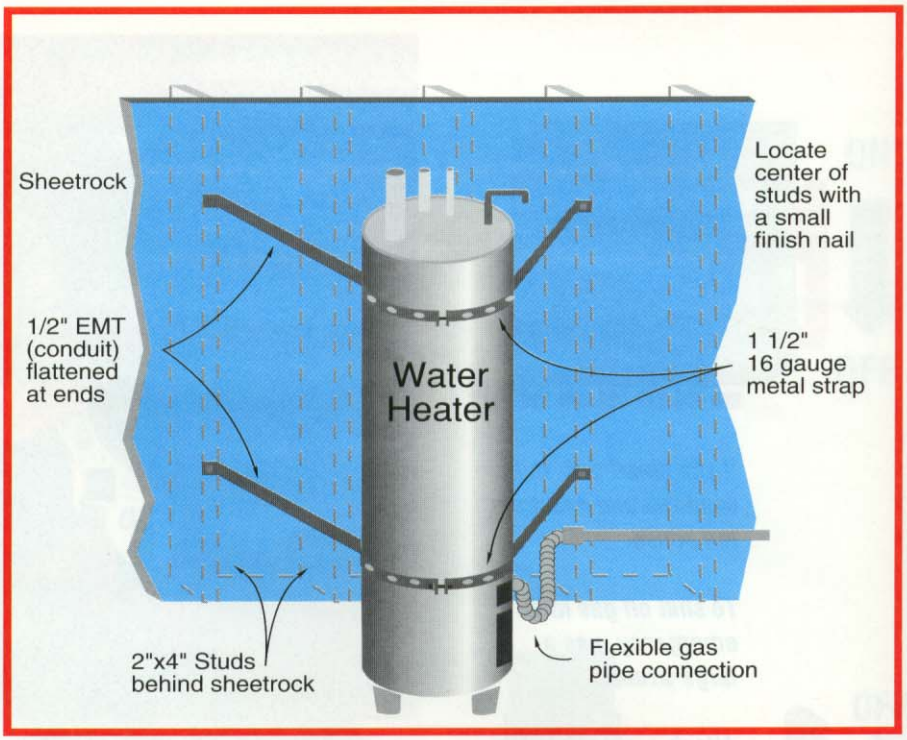
(4) 5/16"x3" lag bolt with washers

(4) 5/16"x3-4" long hex head machine bolts with 4 nuts and 8 washers

(2) 5/16"x1-1/4" hex head machine bolt with 1 nut and 2 washers

Tools needed:

Tape measure
Hammer
Hack Saw
Crescent Wrench
Vise or Clamp
Power Drill
3/8" Drill Bit
3/16" Drill Bit
Center Punch



Secure your water heater by strapping it to the wall or bolting it to floor. This will help prevent broken gas and water pipes and possible fires.

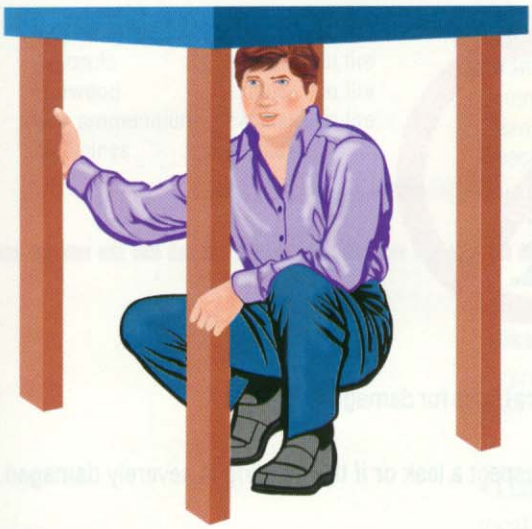
WHAT TO DO DURING AN EARTHQUAKE:

Inside

1. Stay calm. First and foremost, having a plan will help you to stay calm.

2. Stay put. If you are inside, stay inside; if you are outdoors, stay there.

3. Take cover. If indoors, take cover under a desk, table, or bench, stand in a supported doorway, or along an inside wall or corner. Stay clear of windows, bookcases, china cabinets, mirrors, and fireplaces until the shaking stops. If no protection is available, drop to the floor and cover your head with your hands. Never try to restrain a pet during the shaking.



If in the kitchen, turn off the gas stove at the first sign of shaking and quickly take cover.

If in a high-rise building, get under a desk or table and stay away from windows and outside walls. Stay in the building on the same floor. Don't be surprised if the electricity goes out or if the fire alarm or sprinkler systems go on. **Do not use the elevators!**

If in a crowded public place, do not rush for the doorway since other people are going to have the same idea. Move away from display shelves containing objects that fall.

Outside

If outdoors, get into the open, away from buildings, trees, walls, and power lines. The greatest danger from falling debris is just outside exterior doorways and close to outer walls. Stay in the open until the shaking stops.

In a Car

If in a car, pull over to the side of the road as quickly as is safely possible and stop. Never stop on top of or underneath a bridge or under powerlines. Stay in your car until the earthquake is over. When you drive on, watch for hazards created by the earthquake, such as fallen or falling objects, downed electrical wires, or broken or undermined roadways.

WHAT TO DO AFTER AN EARTHQUAKE:

- **If you are at home,** make sure everyone is all right; don't move the seriously injured unless they're still in danger. Administer first aid if appropriate.

- **Do not use the telephone** unless there is a severe injury.

- **Only use your car** if a critical situation exists.

- **Keep children safe and relaxed.**

- **Wear sturdy shoes** in areas near fallen obstacles and broken glass.

- **Do not use matches,** candles, or other open flame until you are sure there is no leaking gas.

- **Check gas, water, and electrical** lines for damage.

- **Turn off the gas** only if you suspect a leak or if the building is severely damaged.

- **Switch off the electricity** if there is damage to your house electrical wiring.

- **Do not touch downed power lines or broken appliances.**

- **Check water supply systems,** if water is leaking, shut-off water at the main valve (inside your home or at the meter in the street). If you do not know how to shut off natural gas or other utilities, do not attempt to do it - get help!

- **Check your home for cracks and damage,** particularly the chimney or brick walls.

- **Do not use fireplaces** unless the chimney is undamaged and without cracks.

- **Leave homes or buildings** that have been damaged until a safety assessment can be made.

CHEMICALS

Kitchen

Cleansers	reactive
Detergents	reactive
Cooking oil	flammable
Aerosols	explosive in fire

Bathroom

Aerosols	explosive in fire
Alcohol	flammable
Nail polish remover	narcotic, flammable
Medicines	see label

Bedrooms

Aerosols	explosive in fire
Firewood	explosive in fire
Gun ammunition	explosive in fire
Medicines	see label

Workshops

Paints	toxic
Paint thinner	toxic, flammable
Adhesives	toxic, flammable

Garage

Gasoline	toxic, flammable
Automobile fluids	
Antifreeze	toxic, flammable
Brake fluid	toxic, flammable
Transmission fluid	toxic, flammable
Oil	flammable

Laundry Room

Detergents	reactive
Cleansers	reactive
Bleach	reactive

Gardening

Pesticides	toxic, reactive
Fertilizers	toxic, reactive
	Most flammable or explosive when mixed with gasoline.

General

Natural gas	flammable, explosive
Sewer gases from broken sewer pipes	toxic, explosive

- **Use caution when cleaning up hazardous materials** (glass, spilled medicine, cleaning products, bleaches, gasoline, etc.) and beware of chemical reactions from mixed spills.

- **Listen to your portable radio** for official information concerning what to do, locations of emergency shelters, and the extent of damage in your area.

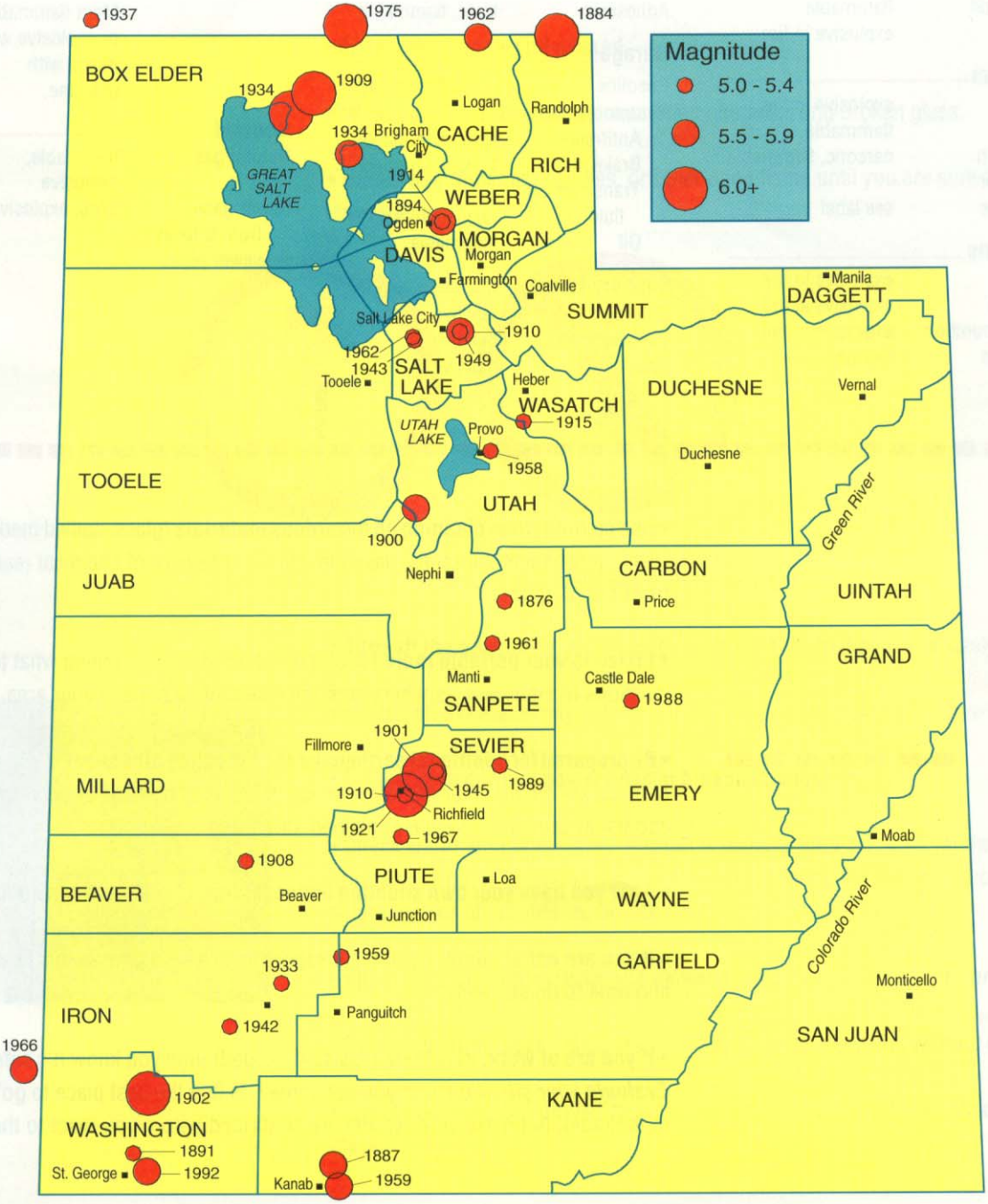
- **Be prepared for additional earthquake shocks called aftershocks.** Although most of these are smaller than the main shock, some may be large enough to cause additional damage or topple weakened structures.

- **After you have your own situation under control,** check on your neighbors.

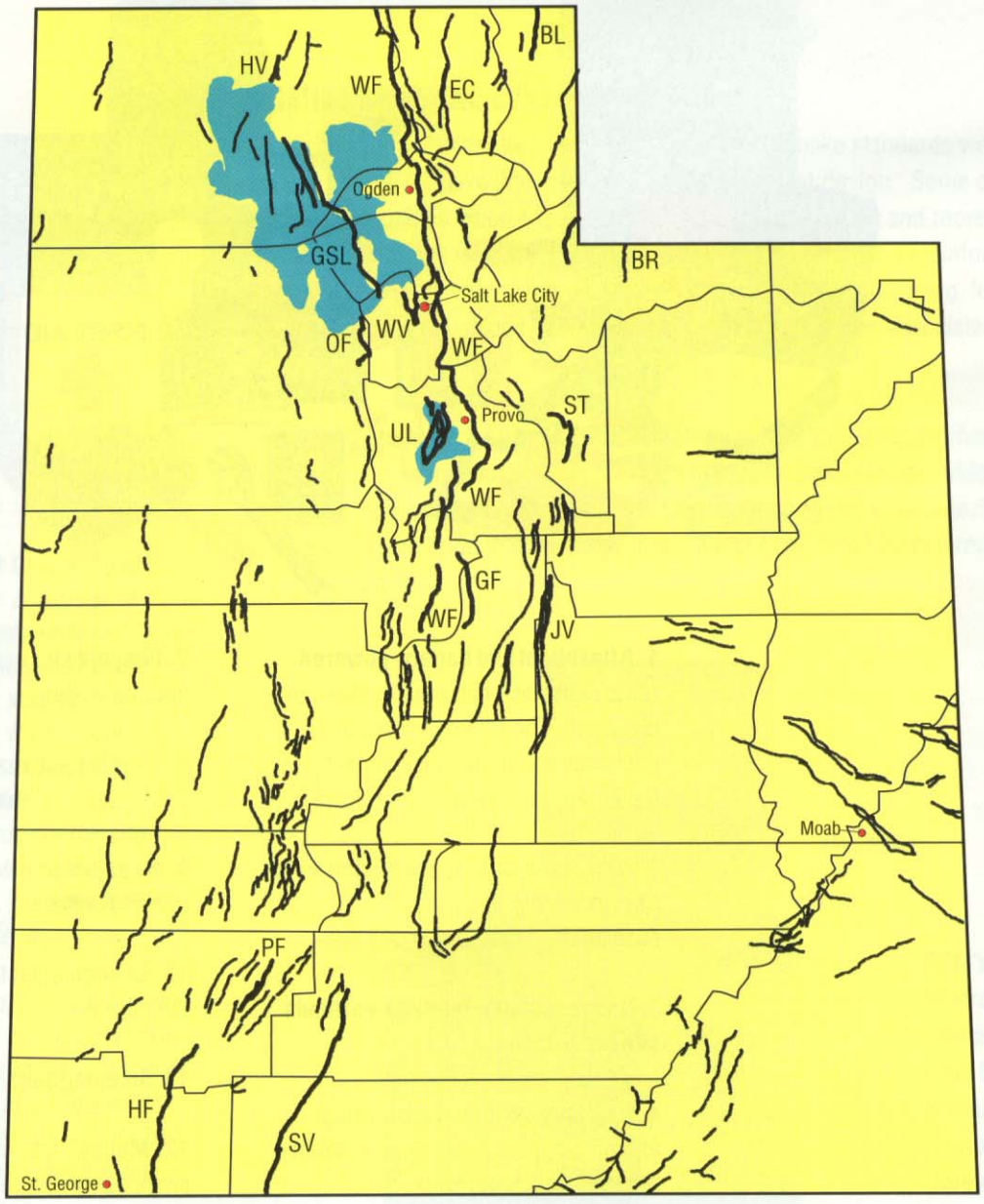
- **If you are not at home,** getting back together is a high priority, but take the care and time to do so safely.

- **If you are at work,** stay there (assist, if needed) until you know it's safe to leave. ***Evaluate your situation:*** Can you get home? Is that the best place to go? Listen to the radio, but make sure reports are confirmed before you react to the news.

Since 1850, there have been at least 35 earthquakes of magnitude 5.0 or greater in and around Utah. (Courtesy of the Utah Geological Survey, 1996)



Faults capable of generating earthquakes are shown on this map. The most active faults are the Wasatch (WF) and Bear River (BR) faults. Other active faults include the East Cache (EC), East Bear River (BL), Hansel Valley (HV), Oquirrh (OF), West Valley (WV), East Great Salt Lake (GSL), and Utah Lake (UL) faults in north-central Utah; the Hurricane (HF), Paragonah (PF), and Sevier (SV) faults in southern Utah; and the Strawberry (ST), Joes Valley (JV), and Gunnison (GF) faults in central Utah. (Courtesy of the Utah Geological Survey, 1996)



A 72 hour kit which includes the items below as well as other emergency supplies can be invaluable to you and your family in the days following the disaster. Have on hand:

1. **A flashlight and battery-powered radio** with fresh batteries in case power is cut off. The official source of information during a disaster is through the Emergency Alert System (EAS).

2. **A three day supply of drinking water.** Approximately one gallon per day for each adult.

3. **Nonperishable, ready-to-eat foods and a can opener.**

4. **Hygiene products such as soap,** feminine supplies, toothpaste, toothbrushes, and toilet paper.

5. **Food for family pets.**

6. **A fire extinguisher** (Class C is designed to use safely on any fire, including electrical, grease, and gas).

7. **First aid kit.** Include medications you may need.

8. **Candles and matches** dipped in wax and kept in a waterproof container.

9. **An adjustable wrench** for turning off gas and water.

10. **Change of clothing** for everyone in the family.

11. **Sleeping bags.**

12. **Money.** During a disaster, cash in small denominations is generally the most preferred form of payment. Some businesses may not accept checks or credit cards.

PREPARING THE STRUCTURE OF YOUR HOME

NEW HOMES AND BUILDINGS

The building code used in Utah contains requirements for seismic strengthening of homes and other buildings. When building a new structure, at a minimum, make sure these requirements are followed. Special design and additional bracing may be necessary and desirable in some cases. Discuss this possibility with your engineer, architect, and contractor before you build. Any additional cost is usually minimal.

EXISTING HOMES AND BUILDINGS

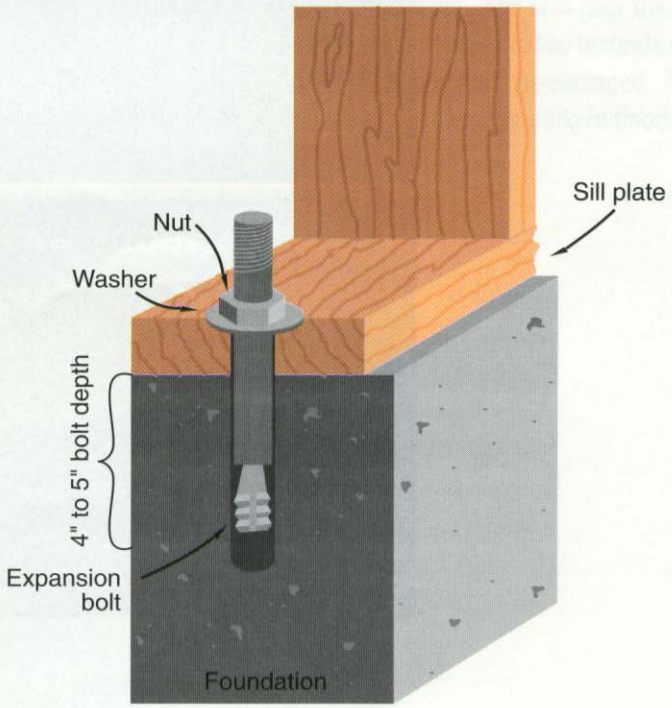
Many houses and other buildings, built before earthquake standards were used (about pre 1970), have little or no earthquake-resistant design. Some of these structures, such as wood-frame homes, may be fairly flexible and more resistant to shaking. The large number of pre 1970 structures in Utah are unreinforced masonary and present a great challenge. Careful long-term planning, leading to the upgrade of these buildings, will substantially reduce the risks associated with earthquakes.

Improving the safety of pre-1970 structures may involve bolting the house or building to its foundation; attaching the floors to the walls and the walls to the roof, and otherwise increasing the strength of the building system. Architects and engineers specializing in earthquake improvement can help you determine the best course of action.

Check to see if your house or garage is securely fastened to the foundation. If your home was built before 1970, it probably does not have bolts securing the wood structure to the concrete foundation. If not, take the following steps:

• Using a hammerdrill and a carbide bit, drill a hole through the sill plate into the foundation. Holes should be approximately 6 feet apart.

• Drop a 1/2"x7" expansion bolt into the hole and finish by tightening the nut and washer.



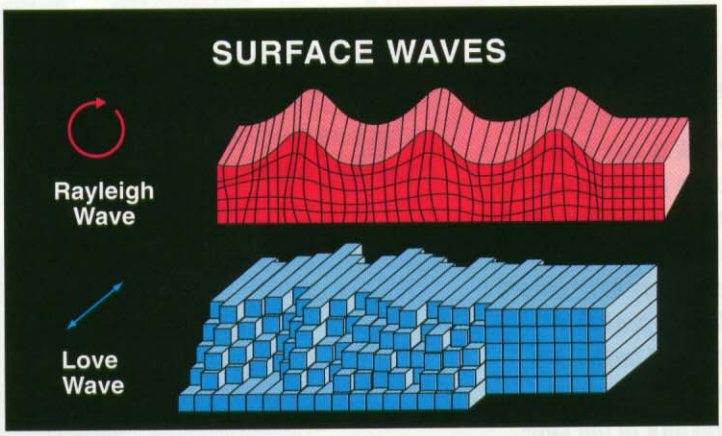
CEM's EPICenter has a retrofit guide available called, "The Utah Guide for the Seismic Improvement of Unreinforced Masonry Dwellings."

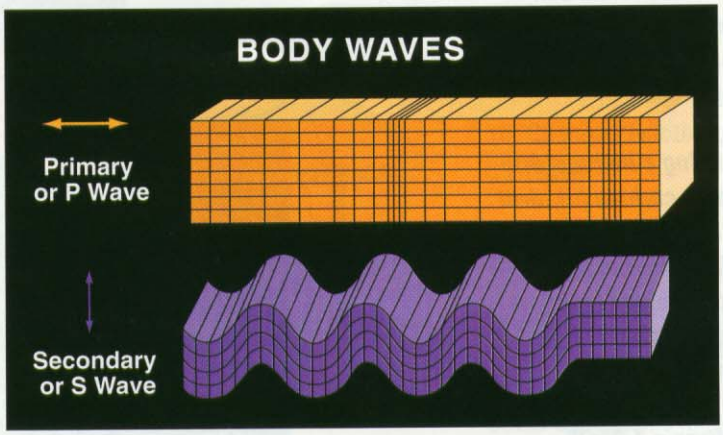
GEOLOGICAL HAZARDS ASSOCIATED WITH EARTHQUAKES

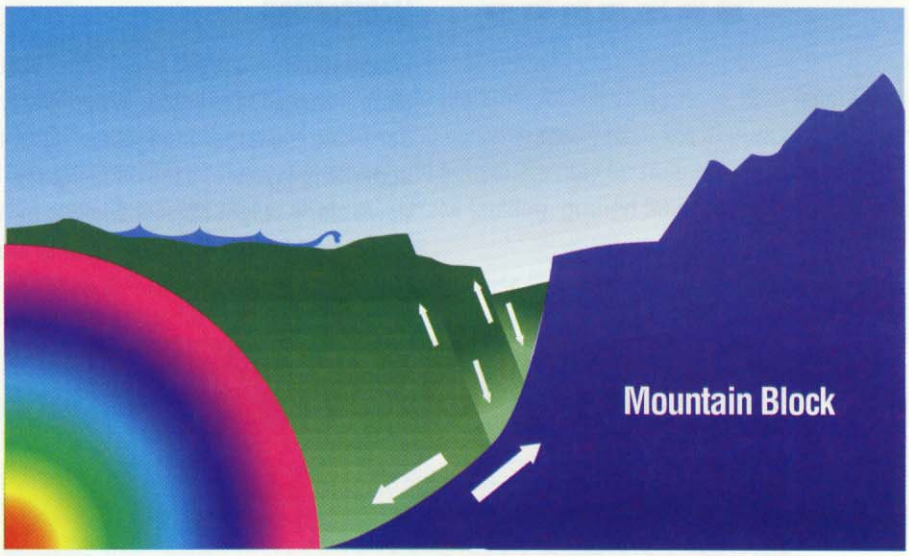
GROUND SHAKING

All earthquakes produce both vertical and horizontal ground shaking. The motion we feel is the result of several kinds of seismic vibrations. The primary or **P waves** are compressional, the secondary or **S waves** have a shear motion. These **body waves** radiate outwards from the fault to the ground surfaces where they cause **ground shaking**. The fast-moving P waves are the first waves to cause the vibrations of a building. The S waves arrive next and may cause a structure to vibrate from side to side. **Rayleigh (R)** and **Love (L) surface waves,** which arrive last, mainly cause low-frequency vibrations, which are more likely than P and S waves to cause tall buildings to vibrate. **Surface waves** decline less rapidly than body waves, and as the distance from the fault increases, tall buildings at relatively great distances from the epicenter, could be damaged.

Certain soil conditions, which may be present in our valley floors, could cause ground motion to become amplified. Amplified ground motion could increase the damage of an earthquake.







FAULT RUPTURE, GROUND DEFORMATION AND SUBSIDENCE

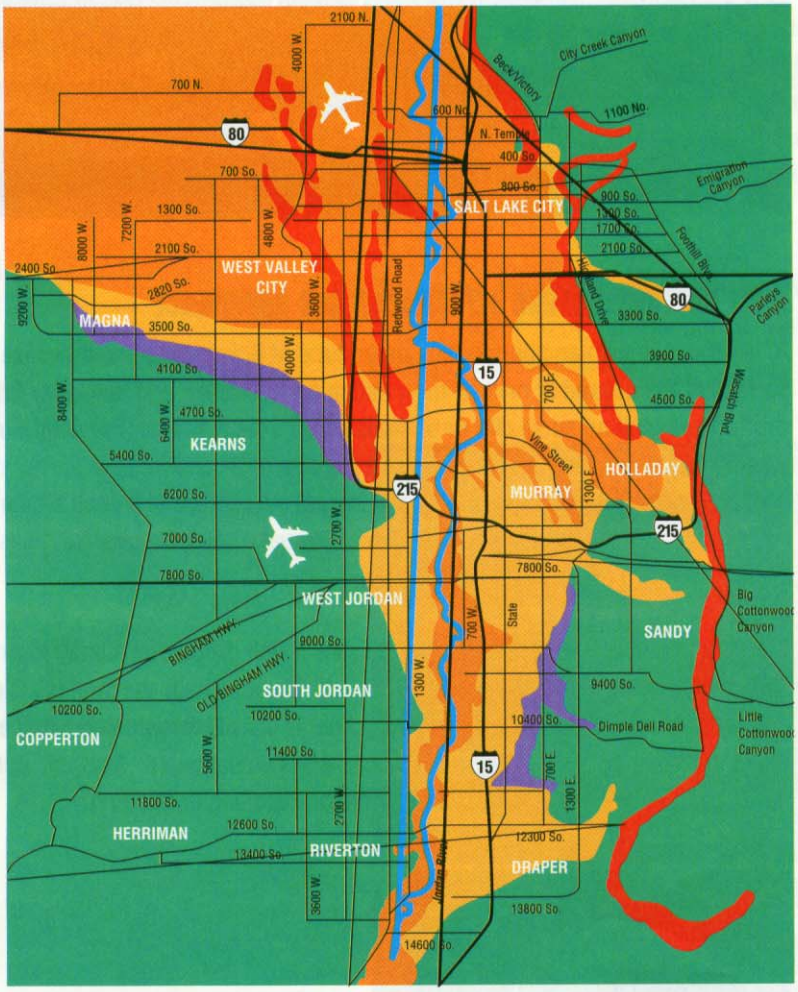
An earthquake with an approximate magnitude of 6.5 or above could cause the surface of the ground at or near the existing fault to break and the valley floor may drop. The resulting small cliff or offset is called a **fault scarp**. The length of the fault rupture and amount of drop depends on the size of the earthquake (larger quakes produce longer fault rupture and larger scarps). A rupture of a central segment of the Wasatch Fault from a magnitude 7.5 earthquake could be over 20 miles long and produce a scarp up to 15 feet high.

The area near the fault, especially on the side which drops down, may experience severe deformation and tilting of the ground. The area near the fault is called the **zone of deformation.** Tilting of the valley floor is called **tectonic subsidence.** Buildings built on or near the area of fault rupture will be damaged. Tectonic subsidence may cause water to flow in a reverse direction resulting in flooding.

Potential flood areas, light blue in color, along the eastern shores of the Great Salt Lake from accompanying large Wasatch fault earthquakes between Brigham City and Salt Lake City. Subsidence will only occur adjacent to the part of the fualt that ruptures. A lake elevation of 4,205 feet prior to the earthquake is assumed (modified from Keaton, 1987). (Courtesy of the Utah Geological Survey)

LIQUEFACTION

Liquefaction is caused when water-saturated, sandy soils react to vibrations and temporarily act like liquid. Many low-lying areas of the state, mainly in the valleys bordering the larger mountain ranges, are vulnerable to liquefaction. When the underlying layers of sandy soil liquefy, large masses of earth may begin to move down slope. Light objects such as buried tanks and pipelines may rise to the surface, while heavy objects tend to sink and tilt.



Lowest

Low

Moderate

High

Fault Zone

LIQUEFACTION POTENITAL

(Modified from Anderson, et al, 1994)

SLOPE FAILURE AND SNOW AVALANCHES

Landslides, rock falls, and other types of slope failure could be triggered by ground shaking. **Slope failure** is usually confined to mountainous or canyon areas. However, steep ravines and slopes within city limits could also experience slope failure. The extent of slope failure depends upon the severity of ground shaking, steepness of slope, moisture content, and type of soil or rock.

If the earthquake occurs in the winter months, snow avalanches may constitute the greatest slope failure hazard.

SEICHES

Standing bodies of water are susceptible to earthquake ground motion. Water in lakes and reservoirs may be set in motion and slosh from one end to the other, much like in a bathtub. This motion is called a **seiche** (pronounced "saysh"). A seiche may lead to dam failure or damage along shorelines.

OTHER EARTHQUAKE-INDUCED HAZARDS

FLOODING

Earthquakes could cause flooding due to the tilting of the valley floor, dam failure and seiches in lakes and reservoirs. Flooding can also result from the disruption of rivers and streams. Water tanks, pipelines, and aqueducts may be ruptured, or canals and streams altered by ground shaking, surface faulting, ground tilting, and landsliding.

Flooding due to dam failure could possibly cause the most property damage and loss of life. Major dams that may affect the Wasatch Front are Pineview and Causey (Ogden Canyon); Echo, Rockport, Lost Creek, and East Canyon (Weber Canyon); Jordanelle and Deer Creek (Provo Canyon); and Mountain Dell and Little Dell (Parley's Canyon). Their failure(s) could threaten all low-lying areas along the flood paths, including parts of Ogden, Provo, and Salt Lake City. Other dams that could be affected by earthquakes include Huntington North, Millsite, and Joe's Valley (Emery County); Soldier Creek (Wasatch County); Starvation (Duchesne County); Scofield (Carbon County); Sevier Bridge (Juab County); Gunnison and Nine Mile (Sanpete County); Minersville (Beaver County); Otter Creek and Piute (Piute County); and Enterprise, Gunlock, Ash Creek, and Quail Creek (Washington). In addition to these larger dams, there are hundreds of smaller privately-owned dams that could cause local flooding if they were to fail.

FIRES

Earthquake-caused fires are often the result of broken natural gas lines. Aftershocks, the shifting of damaged structures, and the turning on and off of utilities could ignite new fires after the initial shock. Structural fires from homes and apartments were in the 1994 Northridge and 1995 Kobe Earthquakes. There were approximately 110 reported in the Northridge quake and over 350 reported fires in the Kobe quake. An earthquake along the Wasatch Front could displace and many as 25,000 people as the result of fires. Besides natural gas, other causes of fires may include petroleum products, broken electrical wires,and chemical spills.

HAZARDOUS MATERIALS

A hazardous material spill during an earthquake carries significant consequences. For example, in the Northridge earthquake of 1994, over 380 hazardous materials incidents were reported. The scale and consequences of these incidents varied from "major" to "minor." This type of hazard may start as a liquid spill, but may quickly develop into an airborne hazard. At home there are household products that when combined, create toxic gases (Refer to page 10). It is important to know what chemicals you have in your home, and the proper first aid procedures to reverse their effects. For additional information about household products and their effects, contact your local fire department or emergency management office.

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FLOODING

Earthquakes could cause flooding due to the tilting of the valley floor, dam failure and seiches in lakes and reservoirs. Flooding can also result from the disruption of rivers and streams. Water tanks, pipelines, and aqueducts may be ruptured, or canals and streams altered by ground shaking, surface faulting, ground tilting, and landsliding.

Flooding due to dam failure could possibly cause the most property damage and loss of life. Major dams that may affect the Wasatch Front are Pineview and Causey (Ogden Canyon); Echo, Rockport, Lost Creek, and East Canyon (Weber Canyon); Jordanelle and Deer Creek (Provo Canyon); and Mountain Dell and Little Dell (Parley's Canyon). Their failure(s) could threaten all low-lying areas along the flood paths, including parts of Ogden, Provo, and Salt Lake City. Other dams that could be affected by earthquakes include Huntington North, Millsite, and Joe's Valley (Emery County); Soldier Creek (Wasatch County); Starvation (Duchesne County); Scofield (Carbon County); Sevier Bridge (Juab County); Gunnison and Nine Mile (Sanpete County); Minersville (Beaver County); Otter Creek and Piute (Piute County); and Enterprise, Gunlock, Ash Creek, and Quail Creek (Washington). In addition to these larger dams, there are hundreds of smaller privately-owned dams that could cause local flooding if they were to fail.

FIRES

Earthquake-caused fires are often the result of broken natural gas lines. Aftershocks, the shifting of damaged structures, and the turning on and off of utilities could ignite new fires after the initial shock. Structural fires from homes and apartments were in the 1994 Northridge and 1995 Kobe Earthquakes. There were approximately 110 reported in the Northridge quake and over 350 reported fires in the Kobe quake. An earthquake along the Wasatch Front could displace and many as 25,000 people as the result of fires. Besides natural gas, other causes of fires may include petroleum products, broken electrical wires,and chemical spills.

HAZARDOUS MATERIALS

A hazardous material spill during an earthquake carries significant consequences. For example, in the Northridge earthquake of 1994, over 380 hazardous materials incidents were reported. The scale and consequences of these incidents varied from "major" to "minor." This type of hazard may start as a liquid spill, but may quickly develop into an airborne hazard. At home there are household products that when combined, create toxic gases (Refer to page 10). It is important to know what chemicals you have in your home, and the proper first aid procedures to reverse their effects. For additional information about household products and their effects, contact your local fire department or emergency management office.

HOW OFTEN DO EARTHQUAKES OCCUR IN UTAH?

THE EARTHQUAKE HAZARD IN UTAH

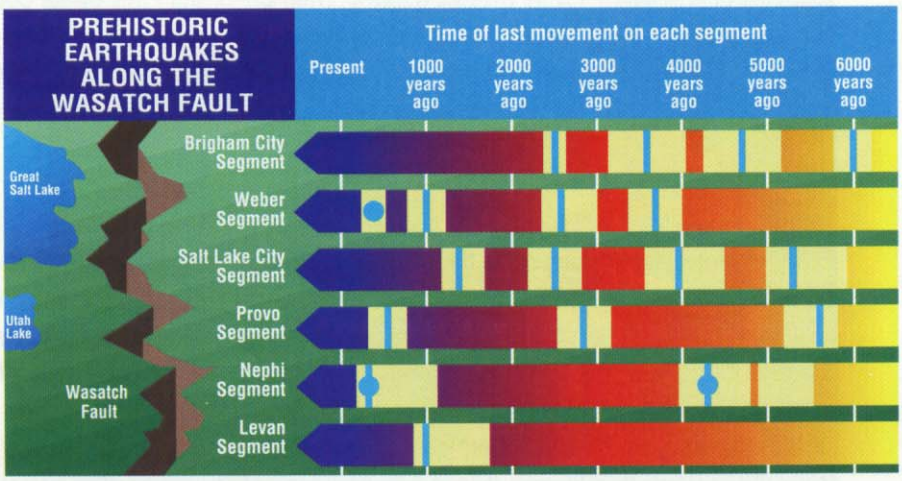
MAGNITUDE	AVERAGE FREQUENCY IN STATE OF UTAH
3.0 or greater	6 per year
4.0 or greater	1 per year
5.0 or greater	1 every 4 years
5.5 or greater	1 every 10 years
6.0 or greater	1 every 20 years
6.5 or greater	1 every 50 years
7.0 or greater	1 every 150 years

Courtesy of University of Utah Seismograph Stations, 1996.

The Seismograph Stations at the University of Utah record about 700 earthquakes each year in Utah. The table on the left illustrates the average frequency of earthquakes based on magnitude or size. Recent geological studies indicate that large earthquakes (magnitude 6.5 -7.5) occur on the central segments of the Wasatch fault about once every 350 years. The chance of a large earthquake on the Wasatch fault during the next 100 years is about 1 in 4 (25%).

The roughly 200-mile long Wasatch fault is broken into several segments. Each segment, approximately 20 to 30 miles long, may produce its own earthquake independent of other segments. The largest expected earthquake on an individual segment of the Wasatch fault will be near **Richter magnitude** 7.5.

Several faults which appear less active than the **Wasatch** or the **Bear River** are also capable of producing a large earthquake. These include the **Hurricane** in southwestern Utah, the **Sevier** in southcentral Utah, the **Hansel Valley** at the north end of Great Salt Lake, the **East Great Salt Lake**, and the **West Valley** systems in Salt Lake County, the **Oquirrh** near Tooele, the **East Cache** near Logan, the **East Bear Lake** in Rich County, and the **Joe's Valley** system in Emery County. There are probably many unidentified faults capable of causing damaging earthquakes in Utah.



The blue line represents the best estimate of when the last major earthquake occurred. The yellow areas denote the earliest and the latest dates those tremors could have happened.

WHY EARTHQUAKES OCCUR IN UTAH

The earth is a dynamic system, a huge factory where old crust is being melted and processed into new crust and mountain belts are simultaneously being uplifted, eroded, and recycled. The surface of the earth is made up of at least a dozen or so large plates. These plates are in continual motion, like huge rafts on a sea of molten rock. This process, known as **plate tectonics,** keeps the awesome forces that shape the Earth's surface in balance. As the Earth's crust moves, earthquakes are produced.

The Basin and Range physiographic province, which stretches from Reno, Nevada, on the west, to the Wasatch Range on the east (including parts of Idaho, Oregon, California, Arizona and New Mexico), is an active part of our drifting continent. This entire area is slowly being uplifted and pulled apart. As the crust of the earth stretches from west to east, cracks or **faults** appear. Portions of the area drop down along these north-south trending faults forming long, narrow valleys, while the mountain blocks move up, wedged between the dropped valleys.

When the extensional and gravitational forces acting on the area overcome the frictional forces holding the valley in place, we experience an earthquake. When this happens, a tremendous amount of stored energy is released. This energy travels in the form of shock waves or vibrations which radiate in all directions from the **focus** of the earthquake. The point on the ground directly above the focus is the **epicenter**.

EARTHQUAKE MEASUREMENT

Ground motion is recorded by instruments known as seismographs. The **magnitude** of an earthquake is a measure of the size of seismic waves. This magnitude is recorded on a seismograph and measured on the Richter scale. The measurement is logarithmic, meaning every whole number increase in magnitude represents a ten-fold increase in recorded ground motion.
Therefore, a magnitude 7 earthquake is ten times larger than a magnitude 6 and one hundred times larger than a magnitude 5. As an estimate of energy, each whole number step on the magnitude scale corresponds to a release of about 31 times more energy.

Earthquake **intensity** is a measure of the damage caused by a quake and it is measured on an index known as the **Modified Mercalli Intensity Scale (MMI)**.
The MMI scale, created in 1902 by an Italian scientist named G. Mercalli, is based on observation. It describes the ground shaking effects on people and structures at a specific location.

The Modified Mercalli Intensity Scale is divided from I to XII. The following is an abbreviated description of Mercalli's twelve levels of intensity, including its rough relationship with the Richter Scale.

The relationship between Richter Magnitude (RM) and the Modified Mercalli Intensity (MMI) Scale

RM	MMI	
2	I	NOT FELT EXCEPT BY A VERY FEW UNDER ESPECIALLY FAVORABLE CONDITIONS.
	II	FELT ONLY BY A FEW PERSONS AT REST, ESPECIALLY ON UPPER FLOORS OF BUILDINGS. DELICATELY SUSPENDED OBJECTS MAY SWING.
3	III	FELT QUITE NOTICEABLY BY PERSONS INDOORS, ESPECIALLY ON UPPER FLOORS OF BUILDINGS. MANY PEOPLE DO NOT RECOGNIZE IT AS AN EARTHQUAKE. STANDING MOTOR CARS MAY ROCK SLIGHTLY. VIBRATION SIMILAR TO THE PASSING OF A TRUCK. DURATION ESTIMATED.
	IV	FELT INDOORS BY MANY, OUTDOORS BY A FEW DURING THE DAY. AT NIGHT, SOME AWAKENED. DISHES, WINDOWS, DOORS DISTURBED; WALLS MAKE CRACKING SOUND. SENSATION LIKE A HEAVY TRUCK STRIKING BUILDING. STANDING MOTOR CARS ROCKED NOTICEABLY.
4	V	FELT BY NEARLY EVERYONE; MANY AWAKENED. SOME DISHES, WINDOWS BROKEN. UNSTABLE OBJECTS OVERTURNED. PENDULUM CLOCKS MAY STOP.
5	VI	FELT BY ALL, MANY FRIGHTENED. SOME HEAVY FURNITURE MOVED; A FEW INSTANCES OF FALLEN PLASTER. DAMAGE SLIGHT.
	VII	DAMAGE NEGLIGIBLE IN BUILDINGS OF GOOD DESIGN AND CONSTRUCTION; SLIGHT TO MODERATE IN WELL-BUILT ORDINARY STRUCTURES; CONSIDERABLE DAMAGE IN POORLY BUILT OR BADLY DESIGNED STRUCTURES; SOME CHIMNEYS BROKEN.
6	VIII	DAMAGE SLIGHT IN SPECIALLY DESIGNED STRUCTURES; CONSIDERABLE DAMAGE IN ORDINARY SUBSTANTIAL BUILDINGS WITH PARTIAL COLLAPSE. DAMAGE GREAT IN POORLY BUILT STRUCTURES. FALL OF CHIMNEYS, FACTORY STACKS, COLUMNS MONUMENTS, WALLS. HEAVY FURNITURE OVERTURNED.
7	IX	DAMAGE CONSIDERABLE IN SPECIALLY DESIGNED STRUCTURES; WELL-DESIGNED FRAME STRUCTURES THROWN OUT OF PLUMB. DAMAGE GREAT IN SUBSTANTIAL BUILDINGS, WITH PARTIAL COLLAPSE. BUILDINGS SHIFTED OFF FOUNDATIONS.
	X	SOME WELL-BUILT WOODEN STRUCTURES DESTROYED; MOST MASONRY AND FRAME STRUCTURES DESTROYED WITH FOUNDATIONS. RAILS BENT.
8	XI	FEW, IF ANY (MASONRY) STRUCTURES REMAIN STANDING. BRIDGES DESTROYED. RAILS BENT GREATLY.
	XII	DAMAGE TOTAL. LINES OF SIGHT AND LEVEL ARE DISTORTED. OBJECTS THROWN INTO THE AIR.

TERMS

Active Fault - a fault on which there has been recurrent movement in recent geologic time, usually indicated by modern earthquake activity and recent surface faulting.

Aftershock - an earthquake that follows a larger earthquake. The number and size of aftershocks normally decrease over time.

Epicenter - the point on the Earth's surface directly above the focus or hypocenter of an earthquake.

Fault - a fracture or fracture zone where there is displacement of the two sides in relation to one another.

Fault Displacement - the amount of movement of one side of a fault in relation to the other side.

Focus (or Hypocenter) - the initial point of rupture of an earthquake below the surface of the ground; the point within the Earth that is the origin of an earthquake.

Modified Mercalli Scale - subjective measure of damage, devised by Italian scientist G. Mercalli in 1902, to measure the intensity of an earthquake.

Richter Scale - a measure of earthquake magnitude as recorded on a seismograph. The measurement is logarithmic, that is, each whole number increase represents a ten-fold increase in recorded ground motion.

Seismic - pertaining to an earthquake or Earth vibration.

Surface Fault Rupture (Scarp) - the break at the fault, on the surface of the ground, resulting from movement on a fault.

Zone of Deformation - distortion, slumping, and cracking of the ground (mainly on the valley side) at or near the fault displacement.

SOURCES OF DISASTER PREPAREDNESS INFORMATION FOR THE SPECIAL NEEDS POPULATION

SERVICES NEEDED

CONTACT

Services for the Elderly:

Local Senior Centers
Salt Lake County Aging Services and Assistance for Seniors:
(801) 468-2480

Services for the Blind:

Utah Services for the Visually Handicapped
THE BLIND CENTER: (801) 323-4343
Utah Library for the Blind:
1-800-662-5540

Services for the Deaf:

Division of Deaf- Hard of Hearing Services: (801) 263-4860
Utah Deaf-Hearing RELAY: (TDD)
(801) 298-9484, 1-800-346-4128
Utah Division of Comprehensive Emergency Management: (TDD)
(801) 538-3789

Transportation for the Disabled:

FlexTran (801) 287-7443
Utah Transit Authority TDD
(801) 287-4657

PRINTED RESOURCES:

Are You Ready for an Earthquake?

American Red Cross
465 South 400 East, SLC, UT 84111
or
P. O. Box 3836, SLC, UT 84110
(801) 323-7000, Fax (801) 323-7018

Disaster Preparedness for Seniors by Seniors

Preparing for Emergencies: A Checklist for People with Mobility Problems

Salt Lake County Aging Services
2001 South State Street, SLC, UT 84190
(801)486-2480

Earthquakes: A Survival Guide for Seniors

SOURCES

Earthquake Safety Checklist
Federal Emergency Management Agency (FEMA)

Earthquakes in Missouri
Missouri Department of Natural Resources

Homebuyers's Guide to Earthquake Hazards in Utah
Utah Geological Survey (UGS) Public Information Series 38

Home Earthquake Preparedness Guide
Bay Area Regional Preparedness Project (BAREPP)

Liquefaction Potential Map of Salt Lake County, Utah
Utah Geological Survey, L.R. Anderson, J.R. Keaton, J.E. Spitzley, and A.C. Allen. 1994

National Earthquake Hazards Reduction Program: Overview
United States Geological Survey (USGS) Circular 918

Northern Utah Earthquake Handbook: Risk Assessment and Loss Estimation
Utah Division of Comprehensive Emergency Management (CEM) and Utah Department of Public Safety

Potential Consequences of Earthquake-Induced Regional Tectonic Deformation along the Wasatch Front.
Utah State University, Jeffery R. Keaton. 1987

Sunset's Guide to Help You Prepare for the Next Quake, The First of a Two-Part Series: Are You Prepared?
Sunset Magazine, October 1990

The Next Big Earthquake in the Bay Area May Come Sooner Than You Think: Are You Prepared?
United States Geological Survey

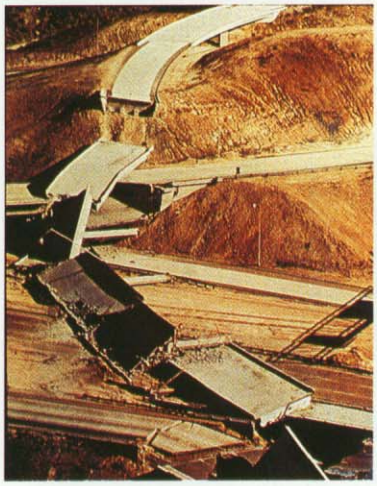
The Utah Guide for the Seismic Improvement of Unreinforced Masonry Dwellings
Utah Earthquake Preparedness Information Center (EPICenter), Utah Division of Comprehensive Emergency Management

The Wasatch Fault
Utah Geological Survey Public Information Series 40

Utah's Earthquake Hazard: Awareness and Preparedness
Utah Division of Comprehensive Emergency Management

Utah's Earthquake Threat
University of Utah Seismograph Stations

Utah Natural Hazards Handbook: Process-Impact-Mitigation
Utah Division of Comprehensive Emergency Management and Utah Geological Survey



Your County Emergency Management Office (CEM's EPICenter has list available).

FOR MORE INFORMATION ABOUT HOW YOU, YOUR FAMILY, BUSINESS, AND COMMUNITY CAN BECOME BETTER PREPARED, CONTACT:

Utah Division of Comprehensive Emergency Management (CEM)
1110 State Office Building
Salt Lake City, UT. 84114
tel. (801) 538-3400
fax (801) 538-3770
Internet-World Wide Web
http:www.dps.state.ut.us/cem/cemhome.htm

Utah Geological Survey (UGS)
1594 West North Temple
Salt Lake City, UT. 84114-6100
tel. (801) 537-3300
fax (801) 537-3400
Internet-World Wide Web
http://www.ugs.state.ut.us

University of Utah Seismograph Stations (UUSS)
705 W.C. Browning Building
Salt Lake City, UT. 84112
tel. (801) 581-6274
fax (801) 581-5585
Internet-World Wide Web
http://www.seis.utah.edu

Utah Seismic Safety Commission (USSC)
1594 West North Temple
Salt Lake City, UT. 84114-6100
tel. (801) 538-3400
fax (801) 538-3770
Internet-World Wide Web
http:www.dps.state.ut.us/cem/cemhome.htm

UTAH

EPICENTER

EARTHQUAKE PREPAREDNESS INFORMATION CENTER