Nevada's Earthquake History

Tens of thousands of microearthquakes occur in Nevada every year and from time-to-time, larger mountain-forming earthquakes occur. These larger events have damaged Nevada buildings, thrown Nevadans to the ground, and created widespread fear in communities. The stories of these earthquakes are commonly the most convincing evidence of the earthquake hazard, and emphasize the need to **be prepared for earthquakes in Nevada**.



Earthquakes in the Nevada region recorded from the1840s to 2012. (Nevada Seismological Laboratory)

An earthquake map of Nevada (above) shows earthquakes of magnitude 4 and greater that have occurred throughout the state over the last 170 years. The most earthquakes are in the western half of Nevada, where tectonic rates are highest. Based on this figure and many other studies, scientists conclude that a major earthquake can strike anywhere in Nevada and the chance of experiencing one or more earthquakes in western Nevada is high.



Major earthquakes in Nevada through time.

When we look at a graph of the largest Nevada earthquakes (M 6+) through time, it can be divided into an active period of many earthquakes from the 1840s to 1960, and a relatively quiet period of time since 1960. This graph illustrates why emergency managers and scientists emphasize earthquake preparedness in Nevada and why it can be a challenging task to convince people of the earthquake hazard. Prior

to 1960, Nevada had many earthquakes of magnitude 6 or greater and was known as an earthquake state. The potential for earthquakes was seriously considered and many Nevadans made very good decisions during and following historical earthquakes because they were prepared. We have had one major earthquake in the state since 1960, the 2008 Wells, Nevada earthquake, which caused \$11 to \$15 million of damage in that community. Most of Nevada's population has only experienced this seismically quieter period of Nevada's history and the folklore of earthquakes in Nevada has been lost. We shouldn't forget the past because understanding Nevada's earthquake history has many lessons to offer.

Major Historical Earthquakes in Nevada

Twenty-three earthquakes of magnitude 6 or greater have struck Nevada since the 1840s. Some were isolated events and some occurred close in time, the extreme being the 1954 magnitude 7.1 Fairview Peak earthquake followed four minutes and 20 seconds later by the magnitude 6.9 Dixie Valley earthquake.

The earliest reported earthquakes are anecdotal in nature and we don't know exact dates or locations of these events. There are stories of an earthquake occurring during the 1840s in the Winnemucca region and again in 1852 near Pyramid Lake, but we have not been able to learn more about these events other than the original stories.

During the period of 1855 to 1869, the region around Reno was rocked with six earthquakes with magnitudes ranging from 6 to 6.4. The first of these was a magnitude 6 earthquake near Sierraville, California. Two years later in 1857 a magnitude 6.3 earthquake occurred just north of Lake Tahoe. The effects of this earthquake in Nevada are not known, but it was documented in felt reports and

damage in the Sierra Nevada gold camps. Three years later, a magnitude 6.5 rocked western Nevada and eastern California on March 15, 1860. This earthquake severely shook the Carson City area, throwing goods from shelves, and causing people to run out of buildings and a few minutes of panic. People also ran out of buildings as far away as Sacramento, California. Rockfalls and possible aftershocks were noted in the Pyramid Lake area, indicating where the earthquake may have originated. The 1868 and 1869 earthquakes were located in the Reno-Virginia City area. On May 30, 1868, two similar sized events about 10 minutes apart shook western Nevada around 9:20 p.m. on a Friday night. The best estimate is that the first event was a magnitude 6 earthquake and the second event had a slightly smaller magnitude. This event strongly shook western Nevada, rattling dishes, windows, and nerves, knocked down plaster and cracked brick walls, but did not cause serious damage. The 1868 and 1869 earthquakes may have originated in the Virginia Range or Steamboat Springs where the effects were most pronounced. Following the 1868 earthquake, Steamboat Springs erupted hot mud instead of hot water and at least one strong aftershock was felt at Steamboat Springs that wasn't felt in Virginia City. The December 1869 earthquake sequence included two major earthquakes of magnitude 6.4 and 6.2 occurring about eight hours apart on the night of Dec. 26th and morning of the 27th. The first event occurred at about 6 p.m. on a Sunday night. People rushed to the streets in Virginia City and Gold Hill, and many walked the streets all night, afraid to go to bed. The second event occurred between 2:00 and 3:20 a.m. and several accounts believe it was as severe as the first event. These earthquakes caused serious damage to masonry walls, cracked and dropped plaster, and tossed goods from shelves in Virginia City, Steamboat Springs, and Washoe Valley.

A magnitude 6(?) earthquake occurred in central Nevada on November 12, 1872, and caused panic and minor damage in Austin. Very little is known about this earthquake except that it was a sharp shock in Austin; best estimates place its origin to the south of Austin. This event was part of period of earthquake activity in the Austin and Eureka region that lasted from 1868 to 1894.

On June 3, 1887, a violent earthquake damaged Carson City, Genoa, and other settlements in Carson Valley and eastern Lake Tahoe. The earthquake occurred at about 2:40 in the morning. It began with a heavy rumbling sound and only lasted 3 to 10 seconds, but was strong enough to throw some people in Carson City to the ground. People immediately exited buildings in the sleeping garments in Carson City, Genoa, and Virginia City. Miners coming into town could see the buildings of Virginia City vibrating, and noted when looking at the moon that "the vibrations were clearly visible to the organ of sight as was to the sense of feeling." People generally spent the rest of the morning outside until dawn brought the promise of another day. Several Carson City and Genoa buildings were damaged so severely from the earthquake that they had to be partially torn down and rebuilt. The Rosser Building in Carson City had severely cracked east-west walls and two-inch wide cracks where these joined with the north south walls. Many buildings in Carson City were cracked and had plaster thrown down, including the state capitol building, which had plaster down in the Supreme Court Room, the Senate Chamber, and the Governor's Office, as well as a half-inch wide crack in the west wall. In Carson Valley, the shaking was so strong that near surface sediments liquefied, or behaved like a fluid. This was evidenced by the formation of sand-bearing water spouts, ground fissures, shattered ground, and ground that sounded hollow to walk over because some sediment underneath had flowed away.

Smaller earthquakes ensued for about a decade in the Carson City and Virginia City areas following the 1887 event. These included the January 30, 1888 Carson City earthquake, the November 18 and December 18, 1894 Virginia City earthquakes, the

January 27, 1896 Carson City earthquake, and the May 15, 1897 southern Virginia Range earthquake.

In the fall of 1903, a magnitude 6ish earthquake occurred in west-central Nevada, near the town of Wonder. This event was not recorded and would have been lost had accounts not been reconstructed by Dr. Burt Slemmons of the University of Nevada and colleagues in 1959. There is a limited knowledge of this event, but it ruptured the ground in places that were re-ruptured by the 1954 Fairview Peak earthquake. The 1903 event was the beginning of a significant seismic event in Nevada's history, known as the Central Nevada seismic belt. The three earthquakes of magnitude 7+ occurred in this belt of activity.



Seismic belts in Nevada and eastern California and earthquakes of magnitude 6 and greater.

A sequence of earthquakes occurred near Tonopah Junction (Columbus Marsh area) in 1910. The main event, a magnitude 6.1 earthquake on November 21, 1910, was preceded by three days of foreshocks. An earthquake that broke windows and dishes in Goldfield occurred on November 7, 1910, but it is not clear where this

earthquake originated or whether it too was a foreshock. The mainshock is said to have shaken for two minutes, a time period that likely includes basin reverberations and aftershocks. This event broke windows at Tonopah Junction and threw a watchman's car from the tracks.

The years of 1914 and 1915 were geologically quite active for Nevada with two damaging earthquakes in Reno, the eruption of Mt. Lassen in California and its eastward drifting ash clouds, and the largest earthquake in Nevada's history, the 1915 Pleasant Valley earthquake. The first earthquake, a magnitude 6, occurred at 10:17 a.m. in the morning on February 18, 1914. The event began with 10 to 11 seconds of heavy shaking and gradually died out within half a minute. In Reno, the earthquake broke windows, cracked walls, and sent a section of a brick firewall crashing down to the street downtown. At the University of Nevada, Reno some bricks were thrown from chimneys and the seismoscope was active for 20 seconds. In Virginia City, several windows were broken in the Fourth Ward School, bricks were thrown down and plaster was cracked in buildings, and a weak building fell. Aftershocks continued into March and then activity quieted down.

Earthquake activity reportedly resumed at 4:02 a.m. April 23, 1914 with a slight foreshock, followed at 8:03 a.m. with a foreshock that created much excitement in Reno. The mainshock, a magnitude 6.4 earthquake, began at 12:34 a.m. the next morning, Friday, April 24th. This earthquake was felt throughout western Nevada and in the Sacramento Valley in California. It reportedly travelled through Reno in a southwesterly to northeasterly direction. Professor J.C. Jones of the University of Nevada commented that the offsets on the seismoscope in the Mackay School of Mines Building indicate that the wall that the seismoscope was attached to moved back-and-forth ³/₄ of an inch in an east-west direction and nearly as much in a north-south direction. Observing this record (shown below) it can be noted that the needle

jumped up-and-down on the plate as well, indicating some vertical motion, and the needle did not come to rest in the center of the plate, indicating some permanent deformation occurred to the building or wall (which was not reported) or the ground it rests on.



Seismoscope tracing from the April 24, 1914 Reno earthquake.

During the earthquake people dashed for the streets in Reno, Sparks, Virginia City and Carson City. Throughout Reno several buildings had cracked walls, broken windows, and several chimneys fell. Many aftershocks were felt over the next few days. On April 25th two earthquakes were felt and caused damage in Virginia City but not in Reno; these earthquakes appear to have had a separate epicentral location that was closer to Virginia City.

The largest earthquake in Nevada's history occurred at 10:53 p.m. on October 2, 1915, in Pleasant Valley, south of Winnemucca. This earthquake, a magnitude 7.3, shook central Nevada with damaging ground motion as far as two valleys away in all directions and was preceded by a remarkable foreshock sequence. Foreshocks occurred at 3:40 and 5:45 p.m. in the afternoon that were so strong that they were felt in Reno, about 140 miles away. The foreshock at 5:45 was a magnitude 6.1 earthquake. There was a wonderful description of this foreshock sequence by L.D. Roylance in 1915; this description is reproduced on page 2 of "Living with Earthquakes in Nevada" - Nevada Bureau of Mines and Geology Special Publication 27. Below is an excerpt of his description of the 3:40 p.m. event.

"the mountain side of Kennedy gave a lurch due north and then vibrated for about five seconds in a manner which I would say was rather violent, considering California disturbances. This shock had hardy subsided when another deep rumble was heard, followed by swaying motion, which appeared to be in a northerly direction. From this time on it was one continuous disturbance; one quake hardly died before a rumble announced another."

The Pleasant Valley earthquake ruptured the ground surface for about 37 miles, mostly along the base of mountains. The ground was offset vertically a maximum of 19 feet during this event. People were so alarmed by the earthquake that they ran out of buildings in Winnemucca, Battle Mountain, Elko, Fallon, Eureka, Reno, Sparks, and Virginia City, and Saturday night dances all across northern Nevada were interrupted.

A Modified Mercalli Intensity map of the 1915 earthquake is shown below. The Modified Mercalli Intensity scale is a description of the effects of an earthquake and is usually portrayed as Roman Numerals. The highest intensity was VIII-X which was an area where some masonry buildings collapsed or partially collapsed and there was substantial surface rupture. Intensity VII is assigned where shaking was strong enough for some chimneys to fall and severe cracks to occur in walls and windows. This area includes Winnemucca, where about half of the chimneys had cracks and some were thrown down. In areas of Intensity VI there were cracked walls, in areas of intensity V, everybody felt the event and sleeping people were awaken by the shaking, and in

areas of intensities II-IV, a few to all awake people felt the earthquake. As can be seen in the intensity figure, the 1915 earthquake was felt from San Francisco to Salt Lake City, and across most of Nevada.



Modified Mercalli Intensity map for the 1915 Pleasant Valley earthquake.

The next large earthquake in Nevada, the December 20, 1932 magnitude 7.1 Cedar Mountain earthquake, was near the southern end of the Central Nevada seismic belt. The 1932 earthquake had right-lateral strike-slip motion, like the San Andreas fault zone in California. During the earthquake, the western side moved over eight feet to the northwestward, relative to the eastern side. As an interesting side note, earthquake lights were reported during this earthquake as lightning bolts near the southern part of the rupture and as "mysterious lights" in Carson Valley (likely a surprising glow of light to the east).



The Modified Mercalli Intensity map for the 1932 earthquake (above) has a northwest-southeast elongation that mimics the faults the earthquake ruptured along. There was over 46 miles of discontinuous surface ruptures created by the earthquake along this orientation, with the largest offset, about 6.5 feet right lateral near the southern end of the surface breaks. The surface ruptures were mapped by Vincent Gianella, a professor at the University of Nevada who studied several Nevada earthquakes.

The Cedar Mountain earthquake occurred in a sparsely settled part of Nevada, with only a couple stone cabins in the epicentral area. Some cattlemen had driven their herd to Fingerrock Camp that night. They welcomed the cover the cabin provided for sleeping on the cold December night. When the earthquake began, the men managed to get out of the cabin before it collapsed. That was the extent of their good fortune, however, because the herd had stampeded and they were faced with digging out their bedding from the rubble.



Cabin at Fingerrock Camp that was collapsed by the 1932 Cedar Mountain earthquake.

In the towns of Luning and Mina, chimneys were thrown down and there was tremendous amount of damage to the contents inside of homes and businesses. There was chimney damage as far away as Fallon and in Reese River Valley. Windows and walls were cracked in Hawthorne and Reno. The shaking caused people to rush to the streets in Carson City, Virginia City, Reno in Nevada and in Sacramento, California. There were reports of a few injuries from this earthquake, including a skull fracture to a man, thrown against the engine of a small train in Rhodes Marsh.

Two major earthquakes occurred in the wake of the 1932 Cedar Mountain earthquake, the 1933 Wabuska earthquake (M 6) and the 1934 Excelsior Mountains earthquake (M 6.1). The June 25, 1933 Wabuska earthquake was widely felt, caused chimneys to fall in Carson City and Virginia City, and caused plaster to crack and rocks to fall on roadways as far away as the Lake Tahoe area. It struck at 12:45 p.m. on a calm Sunday afternoon. In the small community of Wabuska, all chimneys were thrown down, large quantities of dishes were broken, and merchandise was thrown from shelves. In Yerington, there was a 2 inch crack in the courthouse, a chimney fell, and plaster was shaken down. In Mason Valley there were areas of liquefaction.

The January 30, 1934 Excelsior Mountains earthquake was in a remote area and damage was fortunately limited. The earthquake had a small foreshock sequence and created a small surface rupture, high up in the mountains. The earthquake caused broken water mains, damaged chimneys, and the collapse of a section of a wall in Mina. In Candelaria there was a partial collapse of an adobe cabin. In Hawthorne, to the north, people ran out of buildings and concrete was cracked from the shaking.



Earthquake damage in Mina from the 1934 Excelsior Mountains earthquake.

The filling of Lake Mead in southern Nevada triggered numerous earthquakes. Reservoirs are the heaviest engineering projects humans build and put on the Earth's crust. The larger ones, like Lake Mead, actually depress the Earth's crust because of their weight. It is not surprising that seismic adjustments and triggered earthquakes can result. At Lake Mead, earthquakes of magnitude 4 to 5 occurred in 1939 (2 events), 1942 (2 events), 1947, 1948 (2 events), 1950, 1952 (4 events), 1958, and 1963 (2 events). There were also dozens of smaller felt earthquakes in Boulder City and at Hoover Dam through these years. Some of the largest events caused minor damage in Boulder City and were distinctly felt in Las Vegas. The Lake Mead earthquakes are important reminders that Nevada's earthquake hazards extend to the southern part of the state. The chances of having a major earthquake in southern Nevada are similar to the chances calculated for Wells, which had a damaging magnitude 6 earthquake in 2008. In 1948, a magnitude 6 earthquake struck the Nevada-California border town of Verdi. The earthquake was preceded by about 36 hours of foreshocks that prompted the Reno Fire Department to be put on alert prior to the event. The earthquake caused considerable damage to the community of Verdi including the failure of part of the general store's brick wall, fallen or twisted chimneys, cracked plaster and windows, and foundation damage to several homes. In Reno, several chimneys fell or were broken, concrete and plaster was cracked, and contents were thrown from shelves. About 400 aftershocks were recorded in Reno over the next three and a half months from the Verdi earthquake.

The 1954 earthquake sequence near Fallon illustrates how seismically active Nevada can be. There were five earthquakes of magnitude 6.1 to 7.1 over a six month period, with two events just minutes apart. Also remarkable was that all five earthquakes ruptured the ground leaving a clear mark on the Earth where they occurred. Seismic activity began on July 6 with a magnitude 6.2 earthquake in the morning at 3:13 a.m. and a magnitude 6.1 occurring 11 hours later, in the afternoon. Over 11 miles of scattered cracks and ground ruptures were formed by the earthquake. These events were only 17 miles to the east of Fallon and caused considerable damage to that town. In Fallon, more than a dozen buildings and many chimneys were damaged. A small dam failed and there was extensive liquefaction damage to the canal system in the Newlands Project irrigation system around Fallon. This resulted in President Eisenhower declaring this a disaster area and making available \$200,000 of disaster relief funding.

The area was shaken again August 23rd by the magnitude 6.8 Stillwater earthquake, which caused an additional 33 miles of surface rupture, with a maximum offset of 3 feet right-lateral strike-slip. Seven more buildings were damaged in Fallon by this earthquake, three so severely they had to be torn down, and more windows,

chimneys, and water mains were broken. This earthquake completely obliterated the remedial work being done to get the canal system repaired, and they had to start over.



Damage to a wall and building in Fallon from the July 6, 1954 earthquake. Part of an unreinforced brick wall of one building crashed through the adjacent building. Two buildings were damaged by one failure.

On December 16, 1954 a remarkable pair of large earthquakes occurred in the Dixie Valley - Fairview Peak area. At 3:07 a.m. a magnitude 7.1 cut loose near Fairview Peak, rupturing the ground for 40 miles with both normal dip-slip and right-

lateral strike-slip motion (the largest offset was 17 feet of vertical and right lateral shift). Four minutes and 20 seconds later, a magnitude 6.9 followed, and ruptured along the western side of Dixie Valley. This earthquake ruptured the ground an additional 29 miles, with normal dip-slip offsets, along a separate fault. Much of this was mapped in 1955 by Dr. David B. Slemmons.

The earthquakes were so close together that the Modified Mercalli Intensity map is a combination map from the two events. The Fairview Peak - Dixie Valley area was remote and sparsely settled, limiting the damage from these events. There was some damage to the homes in Dixie Valley. The ground motion was so severe that one woman was reportedly thrown from her bed, and in another home, a piano "kangarooed" across a living room during the earthquake. Dishes were broke and walls and chimneys were cracked in Austin, Luning, Mina, Rawhide, Fallon, Lovelock, Eureka, and Carson City. Water lines were broken in Lovelock, Mina, and Gabbs.



Modified Mercalli Intensity map of the 1954 Fairview Peak and Dixie Valley earthquakes.

On February 21, 2008 a magnitude 6.0 earthquake occurred near the town of Wells. The earthquake occurred at 6:16 a.m. and damaged many unreinforced masonry buildings in the historical district when it was largely unoccupied. More than half of the 80 commercial and government buildings in Wells were damaged, with 17 buildings severely damaged. Three homes were destroyed. Ten to 15 percent of the chimneys in town were damaged and there was some contents damage in nearly every household. The emergency response to the disaster was highly effective, and all emergency incidents were professionally engaged, contained, and mitigated by trained local personnel. The costs of the earthquake are estimated to be over \$10.5 million, \$4.8 million of which was covered by earthquake insurance.

2008 earthquake damage to a car from a fallen concrete beam that capped an unreinforced wall.





Modified Mercalli Intensity Map for the 2008 Wells earthquake.

The Modified Mercalli Intensity map for the 2008 Wells earthquake shows that most damage was in the town of Wells and that the earthquake was generally felt in northeastern Nevada, northwestern Utah, and southern Idaho.



Damaged chimney from the 2008 Wells earthquake. This chimney needed to be torn down as fast as possible to avoid further potential damage to the house from aftershocks.

Being Prepared for Earthquakes

Nevada is earthquake country. Although we have had a small reprieve from damaging earthquakes in the last few decades, with the exception of the 2008 Wells earthquake, major earthquakes will return to the Silver State, probably sooner than later. There are over 1,500 potential earthquake faults in the state, geodetic measurements indicate the crust is actively deforming, and the state is teeming with smaller, background seismic activity. Living with earthquakes is the price we pay for such a beautiful and resource rich state. It is important that we are prepared for earthquakes. We need to know how to protect ourselves when an earthquake occurs, make some preparations to reduce damage, and prepare to be self-sufficient for at least five days while businesses are closed and relief efforts are beginning. There are a lot of ideas and opportunities to get prepared. You can sign up for the Nevada ShakeOut earthquake drill. Continue browsing the ShakeOut Nevada web site for lots of useful information about becoming earthquake prepared. For additional information see "Living with Earthquakes in Nevada" on the Internet at http://www.nbmg.unr.edu/dox/sp27.pdf.

