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# Lessons Learned from the February 21, 2008 Wells, Nevada Earthquake

By

NEVADA EARTHQUAKE SAFETY COUNCIL

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## **LESSONS LEARNED FROM THE FEBRUARY 21, 2008 WELLS, NEVADA EARTHQUAKE**

**October 16, 2009**

The importance of good building design and construction, the virtues of a well-trained emergency response group, and the resiliency of a rural community executing an admirable recovery effort were all demonstrated when a magnitude 6.0 earthquake severely shook Wells, Nevada on February 21, 2008. The earthquake damaged half of the non-residential buildings in Wells, 10 of these severely, and caused widespread nonstructural damage; the damaged buildings were of older construction and some were in poor condition prior to the earthquake. Fortunately, the early morning earthquake caused only four relatively minor injuries and no deaths. But the nearly instantaneous disaster cost over \$10.5 million dollars and severely disrupted daily life in the community of Wells for several months.

The Wells earthquake was a background event of a type that can occur anywhere in Nevada. It is the kind of event that all Nevada communities need to be prepared for in order to survive and recover from. Unfortunately, earthquakes as large as magnitude 7.5 can occur near several of our communities, so these communities should prepare for much stronger and longer shaking than Wells received. On the fortunate side, people are the most important participants in making their lives safer from earthquakes; people have the power to make their homes, offices, and stores safer from falling contents, to create places to take cover from falling things, and to learn the potentially life-saving behavior of “Drop, Cover, and Hold” for when an earthquake occurs.

Studying a major earthquake and its effects on a community is critical for learning how to design for, prepare for, respond to, and recover from future Nevada earthquakes. Even reaffirming expected types of damage, such as partial collapse of unreinforced brick buildings, should kindle a determination to rid our communities of this potential risk through strengthening, controlling access to, or demolition of these buildings. When viewing a community that has been struck by an earthquake, we look at things that went “wrong” and devise strategies to avoid these in the future, but we also have to look at what went “right” for clues to do even better. These lessons are powerful because they occurred in a Nevada community within recent memory, helping to remove the doubt of whether such an event can happen, which can be a hindrance to action.

The Nevada Earthquake Safety Council wants to gain insight into this event and note the major lessons learned from the 2008 Wells earthquake. What was done well that should be emulated, what can be improved, and how can these findings be applied to Nevada to reduce our earthquake risk?

As with all recommendations given for earthquake readiness, these lessons do not guarantee your safety during an earthquake. They are some common-sense ideas intended to enhance safety and minimize property loss from future earthquakes. They are presented to highlight some lessons from one of Nevada’s most recent damaging earthquakes and to promote a dialog on how we can best survive future Nevada earthquakes.

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- Nevadans should secure, relocate, or remove dangerous items that can fall on people and hurt them.
- If you are inside a building during an earthquake, stay inside; if you are outside, get away from buildings.
- Volunteers are essential to the success of the response and recovery.
- After a strong earthquake occurs, check on your neighbors.

### **Lessons about Buildings**

- Seismic provisions in modern building codes are important to use in Nevada.
- Unreinforced masonry buildings and unanchored masonry veneers are extremely vulnerable to earthquake damage and failure.
- Balconies and sidewalk coverings may be able to be strengthened to provide protection against falling bricks and other debris.
- Crowning bond beams on top of walls are particularly dangerous elements of unreinforced brick buildings during earthquake shaking.
- Buildings that are in severe disrepair, have partially collapsed, or have incomplete structural systems may be subject to total collapse during earthquakes.
- Unreinforced brick and masonry chimneys can collapse during earthquakes, causing injuries and severe damage.
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- Research should be conducted to assure that standard propane tank practices in Nevada are adequate to prevent liquid propane leaks from the strongest shaking that can occur in the state.
- A well-maintained electrical system stayed intact throughout and following the earthquake, which helped in numerous ways.

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- Emergency resource allocations and emergency personnel training contributed to a successful emergency response and should continue throughout the Nevada.
- Communication can be severely hampered during an emergency response if robust, uniform or otherwise connected communication systems are not used.
- All Nevada communities should have emergency plans that can be used for rapid decision-making and that include redundant Incident Command Post locations.
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## LESSONS FOR NEVADANS

### ***Earthquakes can occur anywhere in Nevada.***

All of Nevada has a significant earthquake threat, and earthquake preparedness needs to be taken seriously. The earthquake hazard in Wells is moderate at a national scale, but for Nevada, it is one of the lowest hazard areas of the state. Seismic hazard map ratings may lull some communities into a false sense of security with a low probability of occurrence of a significant earthquake. The Wells earthquake is an excellent example of this. According to the U.S. Geological Survey's probabilistic seismic hazard analysis (accessible online at this link: <http://eqint.cr.usgs.gov/eqprob/2002/index.php>), the hazard for Wells is actually less than that for the Las Vegas urban area and much less than that for the Reno-Carson City urban area. Specifically, the probability of a magnitude 6.0 earthquake occurring within 50 km (about 31 miles) of Wells, Nevada within 50 years is approximately 9%, while the probability of the same magnitude earthquake occurring within 50 km of many other Nevada communities is considerably higher: 12% for Las Vegas, 67% for Reno, and 70% for Carson City. The next damaging earthquake won't necessarily occur where we think earthquakes are most likely. Because an earthquake the size of the 2008 Wells event can occur anywhere at any time in Nevada, all people and communities in Nevada need to be prepared for earthquakes.

### ***Nevadans need to know what to do if there is a strong earthquake. Make sure you, family, friends, and employees know to "Drop, Cover, and Hold" during an earthquake and how to turn off natural gas if there is a gas leak.***

There were two residential gas line breaks from the 2008 Wells earthquake and in both cases, the residents identified the gas leak by the smell and turned off their gas, preventing a possible explosion or fire. This was a great response, but not all Nevadans know how to turn the gas off in a similar situation. All Nevadans need to be prepared for earthquakes and know how to appropriately respond to an earthquake. Preparation also includes having at least five days of provisions (water, food, medications) in order to survive on one's own until help can arrive. Nevada business owners also need to be prepared, to mitigate shaking hazards, and to have a post-earthquake action plan.

### ***Nevadans should secure, relocate, or remove dangerous items that can fall on people and hurt them.***

Falling building contents caused two injuries that occurred during the earthquake and caused some close calls that could have resulted in death or serious injury. Nevadans need to secure the areas where they, their loved ones, their friends, their employees, and their customers spend a lot of time, making sure they are free from falling hazards. *Safety spots*, such as a sturdy table or desk where people can take cover from falling objects should be identified in each room. When an earthquake occurs: "Drop, Cover, and Hold"—*drop* to a lower level, taking *cover* under an object that can protect you, and stay under it by *holding* onto it. Exit ways that will be needed following an earthquake should be kept clear of falling hazards as well.

### ***If you are inside a building during an earthquake, stay inside; if you are outside, get away from buildings, especially older ones, if it is safe to do so.***

Some of the potentially most deadly situations from the 2008 Wells earthquake occurred at exitways and along the sidewalks adjacent to buildings, especially in the historical old town, where bricks and concrete beams fell from the shaking. Fifty-five percent of unreinforced brick building exits had deadly debris shed across them, whereas only one building collapsed, and other partially collapsed buildings had survivable interior space (several people were inside one partially collapsed building and survived uninjured). Thus, it was clearly safer to have stayed inside the buildings, implementing "Drop, Cover, and Hold" than to have run outside.

***Volunteers were essential to the success of the response and recovery efforts at Wells. Nevadans need to continue to be willing to help their own or neighboring communities in earthquakes and other disasters. Nevadans should be encouraged to establish Community Emergency Response Teams (CERT).***

The citizens of Wells, their neighbors in Elko County, other Nevadans, and people from as far away as Utah, Idaho, and California all came together during and following the 2008 earthquake to help with relief and recovery of the town. There were “Fix-up Saturdays” when hundreds of volunteers helped clean up damage and make repairs to homes and community centers. A Wells Recovery Rally put on by volunteers produced \$110,000 in donations of recovery money. Another \$100,000 was donated by Nevadans to help Wells citizens and businesses recover. In future disasters, Nevadans will need to lend a hand to their neighbors in a similar fashion, which not only helps the affected community, but keeps us strong as a state. Community Emergency Response Team (CERT) training can give formal training to Nevada citizens who want the skills to help in an emergency response. CERT teams can be critical to helping in the overwhelming early response to an earthquake, when professional emergency responders’ capacities are exceeded.

***After a strong earthquake occurs, check on your neighbors, and make sure they are all right and that no dangerous situations exist for them.***

Wells residents checked on each other and especially checked on people who might have needed a little more help getting around or cleaning up. In a similar or larger earthquake in Nevada, some of the success of the emergency response may depend on neighbors checking on each other, identifying when there are injuries or dangerous situations, and communicating these to emergency personnel. Checking on each other also reaffirms the strong social connection we have with one another that can help in coping with situations such as strong earthquakes. Furthermore, many non-emergency 911 calls may be eliminated if people have the opportunity to talk to another person.

## **LESSONS ABOUT BUILDINGS**

***The seismic provisions in modern building codes are important to use in Nevada.***

Most of the modern and well-built buildings in Wells survived the 2008 earthquake structurally intact. Wells uses building codes which likely contributed to this success. Seismic events can strike anywhere in the state, therefore it is wise to have the basic requirements for buildings that provide life safety during earthquakes, which is the building code’s primary goal.

***Unreinforced masonry buildings and unanchored masonry veneers are extremely vulnerable to earthquake damage and failure.***

Engineers will quickly point out that this is not a new observation, but there are many unreinforced masonry buildings in Nevada’s rural communities and in its cities, such as Reno, so it is important to reiterate this point. Earthquake damage in Wells exposed rubble infill of walls, use of weaker unfired bricks and adobe bricks, and large areas where brick courses in walls were not tied together with soldier-course cross-bricks, especially in the upper parts. These defects appear to make these walls even weaker than might be expected during shaking. Unreinforced buildings remain one of Nevada’s greatest earthquake risks and a hazard to both life and property. These were the most severely damaged buildings from the 2008 Wells earthquake. Damage from unreinforced masonry buildings can also severely impact adjacent buildings.

Unreinforced masonry buildings in Nevada should be inventoried to understand the extent of the risk, and Nevada needs a long-term strategy to make these types of buildings more seismically resistant or to eliminate them.

***Balconies and sidewalk coverings may be able to be strengthened to provide protection against falling bricks and other debris from unreinforced masonry buildings during earthquakes.***

In one case, a balcony caught all the bricks that fell off the building, thus protecting an exit way, and in another case, an awning caught bricks, thus protecting a bench adjacent to the building. It is possible that balconies and sidewalk coverings around unreinforced brick buildings can be strengthened to capture and hold falling bricks (and other debris) which could provide some protection to people in those areas. Obviously there are limits that any covering can take, but this or similar measures should be considered as short-term safety enhancements for exitways from unreinforced masonry buildings and public sidewalks around these buildings. Even if people stay inside these buildings as is suggested, they will have to exit after the shaking stops.



***Crowning bond beams on top of walls are particularly dangerous elements of unreinforced brick buildings during earthquake shaking and are particularly susceptible to falling as large, coherent masses. Crowning bond beams on unreinforced buildings should be braced and anchored to the structure to keep them in place, or should be removed.***

A crowning bond beam is a concrete cap on the top of an unreinforced brick wall. These were one of the most destructive and potentially deadly failures of the unreinforced masonry buildings from the 2008 Wells earthquake. In one case, large coherent sections of the beam fell, smashing through a balcony so fast and hard that the columns were left standing in place. In another case a parked car's passenger compartment was crushed by a crowning bond beam. Additionally, the upper parts of walls with crowning bond beams tend to be weaker with fewer cross-ties and a minimum two-brick wide thickness, apparently relying on the weight of the bond beam to provide strength.

***Buildings that are in severe disrepair, have partially collapsed, or have incomplete structural systems may be subject to total collapse during earthquakes.***

A building that was in disrepair collapsed during the 2008 Wells earthquake. These buildings may be off-limits to the public, but they may be populated by workers beginning to renovate the building. Bracing and safety boxes should be considered in such situations to protect workers until the building is strengthened.

***Unreinforced brick and masonry chimneys can collapse during earthquakes, causing injuries and severe damage.***

Although many communities in Nevada have changed from having unreinforced brick and stone chimneys to having stove pipes in new construction, many of these chimneys remain standing across Nevada. During the 2008 Wells earthquake, 10% to 15% of the masonry chimneys were damaged and several of these had significant sections collapse. Residents in buildings should take note of brick or stone chimneys and stay away from the area around chimneys during and following a major earthquake. They should also know to extinguish any fires following an earthquake and not to start any fires until the chimney can be inspected to avoid possibly setting fire to the house because of breaks that expose flammable parts of the house or building.

***Earthquake insurance is a wise investment and should be considered seriously by communities and individuals.***

The Wells city government, school district, and county government had earthquake insurance on their buildings, contents, and for business disruption which helped them financially survive the earthquake damage and helped in the overall recovery of the town. Of the three lost homes, one of them had earthquake insurance, which ended up paying off the mortgage of the destroyed home. Unfortunately, very few homes in Nevada have earthquake insurance.

Most people do not realize that earthquakes are not covered on the typical insurance policy and must be added to their policy as a form of endorsement. A larger earthquake will result in very large uninsured losses today. Nevada is earthquake country and for significant losses that may be hard to recover from, earthquake insurance should be considered.

## LESSONS ABOUT UTILITIES

***Liquid propane leaks are particularly dangerous because the liquid expands 270 times into a vapor cloud and requires a local evacuation. Research should be conducted to assure that standard propane tank practices in Nevada are adequate to prevent liquid propane leaks from the strongest shaking that can occur in the state. Temporary propane tanks pose significant seismic risks if they are not installed properly.***

A propane tank on a temporary, unapproved foundation was toppled by the 2008 Wells earthquake, breaking the connection and the turn wheel, leaking liquid propane, and creating a potentially explosive propane cloud. Although it is unlikely that the tank would have toppled had it been on a proper foundation, the leak, the situation, and the associated evacuation highlight this potential hazard. Given the consequences of this situation, it would be prudent to ensure that standard practices in Nevada are adequate to prevent liquid propane leaks under levels of shaking that are near the largest that can reasonably be expected. Preventing such leaks would help protect people and property and help limit the scope of the required emergency response to an earthquake.

***The electrical system stayed intact throughout and following the earthquake, which helped in numerous ways, such as keeping people warm on very cold nights and having power for the emergency response. A well-maintained electrical system is partly credited with this success.***

With cold temperatures and damaged chimneys, home and space heaters were the only source of heat for many homeowners and businesses. It was a great benefit to the people of Wells and the emergency response, relief, and initial recovery efforts that the electricity stayed on immediately following the 2008 earthquake. The local power company credits this partly to a very robust power system that is frequently subjected to other natural hazards, such as high winds and dirty rains. A major transformer was shifted on its foundation to its functioning limits by the earthquake. Had the transformer shifted farther and severed connections, or just become too dangerous to operate, the power system to Wells would have been turned off and might have been off for a day or more until a crane that could lift the transformer could be brought in to make the repair. Consideration should be given to anchoring large electric transformers which would mitigate this potential loss due to ground motion.

## LESSONS ABOUT EMERGENCY RESPONSE TO EARTHQUAKES

***The resources and trained emergency personnel available in Wells, Elko County, and the State of Nevada were adequate and effective for the scope of the 2008 earthquake disaster. Similar emergency resource allocations and emergency personnel training should continue throughout the State.***

The emergency response for the 2008 Wells earthquake was admirable, with the most critical incidents being handled by the Wells personnel within the initial 40 minutes, before the first outside help arrived. The incident command structure, in the final iteration, helmed by a trained incident commander from the Nevada Division of Forestry, worked well in coordinating response efforts, and the personnel involved were well trained and practiced, making the operation effective. About 600 safety inspections were conducted on the first day. Even though a larger disaster would have begun to tax the system, the success of this emergency response indicates Nevadans are on the right track in preparing to respond to disasters and should continue making sure that emergency response training and resources continue in the State. Earthquake disasters require a familiarity with the different levels of response and protocols needed to obtain needed resources.

***Communication can be severely hampered during an emergency response if robust, uniform communication systems are not used. Cellular telephones should not be used as primary emergency response communication systems.***

Cellular telephones are unreliable in an earthquake disaster and will likely be saturated by users causing a long delay in obtaining a dial tone. Additionally cellular telephone towers may suffer damage from the shaking. The Wells Volunteer Fire Department used cellular telephones during the 2008 Wells earthquake and experienced delays in getting dial tones when trying to call for additional personnel for incidents. A professional radio system is recommended. There were also two different emergency radio systems in use during the Wells earthquake, a VHS system and an 800 MHz system that initially could not talk to each other. A Nevada Department of Transportation communications expert patched the two systems together on Day Two. An inventory of the emergency communication systems used in Nevada and what potential

patches might be needed to different communication systems which might be combined would speed up the needed interoperability of emergency communications in future disasters. Cellular telephones are not sufficient for a primary emergency response communication system. An additional communication resource during disasters is the Amateur Radio Emergency Service.

***All Nevada communities should have emergency plans that can be used for rapid decision making and should include redundant, safe Incident Command Post locations.***

Emergency plans were used in the response to the 2008 Wells earthquake and were effective for this event. One aspect that stretched the plan to its limit was that the first and second choices for locating the Incident Command Post were deemed unsuitable because of damage, and the search for a suitable location had to be conducted during the response operation. Several potential ICP locations should be listed in community emergency response plans that have been inspected and found suitable for emergency response needs and safety. A mobile command center might also be considered for earthquake-prone areas.

***A satellite-communication truck may be important for incident command and emergency response communications, especially if an alternative command location is being used that has fewer capabilities than needed.***

Initially, there was only one telephone available at the Incident Command Post for the 2008 Wells earthquake, and cellular telephones had to be used. This was corrected relatively quickly, but a satellite-communications truck would have significantly enhanced communications early on in the response, especially if the cell telephone system had failed.

***A large number of color-coded placards for posting the condition of buildings should be stored at multiple locations within each county and should be distributed to earthquake-affected areas within a day.***

In Wells, responders were clever and used what was available to indicate the condition of buildings, but the spray painting of snow was too temporary and flagging was a bit confusing because flags were similar in color and were combined. Green, yellow, and red placards work the best, but they have to be made before an earthquake and stored regionally to get them to the community as fast as possible after an event occurs. When the placards are used, the public needs to be educated as to what the placards indicate and how long they are to be left up.

## **LESSONS ABOUT COMMUNITY RECOVERY FROM AN EARTHQUAKE DISASTER**

***A rapid and effective recovery from an earthquake disaster is critical for maintaining a community's existence and vitality. Plans for recovering from a major earthquake disaster should be developed by Nevada communities.***

Recovering from an earthquake disaster must occur rapidly if the negative effects of procrastination are to be avoided. One of the largest of these negative effects is the failure or relocation of businesses out of a community, which means less income for individuals and local government and the loss of services to a community. The City of Wells placed a high priority on restoring businesses and government services rapidly, and consequently only a single business failed because of the earthquake, and that was because it was in a highly damaged building. They inspected businesses first, encouraged early relief aid to business reconstruction, and were responsive to requests from the businesses when safety allowed. This is an example of a good recovery strategy.

An important tool for having a rapid recovery, especially in Nevada's larger cities, is having in place a pre-event Disaster Recovery Plan. The stressful post-earthquake environment is not the best situation for decision makers to envision solutions and strategies that can help avoid cascading failures of businesses, seek out opportunities, and get a community on a track to rapid recovery. It is much easier to tailor the strategies of an existing recovery plan to the situation at hand than to have to create them on the spot in response to arising needs.

## LESSONS FOR EARTHQUAKE MONITORING IN NEVADA

***An adequate statewide seismic monitoring system must be completed to rapidly and accurately locate major earthquakes in Nevada.***

During the Wells earthquake a temporary array of state-of-the-art seismometers happened to be operating in Nevada (the Earthscope, <http://www.earthscope.org>, USArray; a National Science Foundation experiment) which provided coverage in the eastern part of the state. Permanent station seismic monitoring in eastern Nevada is very poor otherwise and most earthquakes below magnitude 3 are not recorded. The USArray network allowed the Nevada Seismological Laboratory to develop a reliable initial earthquake location for the  $M_w$  6.0 Wells event. By August of 2008, the USArray instruments had been removed from Nevada, and the ability to accurately locate earthquakes in northeastern and eastern Nevada returned to the pre-USArray level. In order to accurately locate and develop reliable earthquake magnitudes, permanent seismic monitoring in large portions of Nevada must be increased. The presence of more seismic monitoring stations could record foreshocks to a larger earthquake event giving communities some indication of increasing seismicity in areas near rural communities.

## LESSONS FOR EARTHQUAKE FAULT STUDIES IN NEVADA

***Significant previously unrecognized Quaternary faults (those that have moved in the last 2.6 million years), capable of magnitude 6 or larger earthquakes, have been discovered near Wells. Quaternary faults should be mapped and studied within 25 miles of each Nevada town to ensure that earthquake hazards are adequately characterized for these communities.***

Quaternary fault studies are commonly focused on the higher-risk urban cities, leaving smaller communities relatively unstudied and their earthquake hazards potentially inadequately characterized. Studies should be conducted that identify and characterize all known, previously unrecognized, or suspected Quaternary faults within 25 miles around each Nevada community (farther when needed for fault studies). More detailed studies (such as trench exploration) may be required for certain faults to understand their paleoearthquake history and how active they are. Completing these studies is a long-term endeavor, but steady progress must be made to achieve this goal, and the sooner the information is gained, the sooner it can be incorporated into the planning and building design within the community. Detailed mapping of Quaternary faults in Nevada's rapidly expanding urban communities is also critical in order to delineate areas that should be avoided by construction to prevent earthquake surface rupture damage to new structures.