Lessons Learned from the 2008 Wells Earthquake

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The Wells, Nevada Earthquake is a testament to good building design and construction, the virtues of an excellent emergency response, and the resiliency of the rural environment executing a recovery effort that many can only dream about. It was a background earthquake, one that can occur anywhere in Nevada. It is the kind of event that all of our communities need to be able to survive and recover from.

Studying an earthquake and its effects is far more powerful than the experiments and theories we work on between earthquakes. Are earthquake-resistant designs applied making buildings safer from strong shaking? This requires endorsement by community leadership through adoption of building codes and conscientious construction according to design. Are the emergency response systems adequate in Nevada? When viewing a community that has been struck by an earthquake, we also have to look for clues within what went "right" to do even better. Sometimes there are subtle effects that are insights into what could be really terrible effects in our next earthquake. The Nevada Earthquake Safety Council wants to gain these insights and expose any lessons we can learn from the 2008 Wells Earthquake. What was done well that we can emulate, what can be improved on, 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 Nevada's most recent damaging earthquake and promote a dialog on how we can best survive future Nevada earthquakes.

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. According to the U.S. Geological Survey's probabilistic seismic hazard analysis (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 of Wells, Nevada within 50 years is approximately 9%, but the probability of the same magnitude earthquake

occurring within 50 km (~31 miles) 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. An earthquake the size of the 2008 Wells event can occur anywhere 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 includes having at least five days of provisions (water, food, medications) to survive on your own until help can arrive. Nevada business owners also need to be prepared, mitigate shaking hazards, and 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 the 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 exit ways and along the sidewalks adjacent to buildings, especially in 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 a partially collapsed building and survived uninjured). Thus, it was clearly safer to have stayed inside the buildings, and *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 earthquake and other disasters. Nevadans should be encouraged to get Community Emergency Response Training (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 where hundreds of volunteers helped clean-up damage and make repairs to homes and community centers. There was a Wells Recovery Rally put on by volunteers and donations that produced $110,000 of recovery money. There was $100,000 donated by Nevadans that were used in helping Wells citizens and businesses recover. All of these were important to helping the recovery of Wells. 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 responder's capacities are exceeded.

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

Wells residents checked on each other and especially checked on people who might need 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 a strong social connection we have with one another, that can help in coping with situations such as strong earthquakes. Further, 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 the point. Earthquake damage in Wells exposed rubble infill of walls, use of weaker un-fired bricks and adobe bricks, and large areas where brick courses in walls are 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 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 from unreinforced masonry buildings during earthquakes.

In one case a balcony caught all the bricks that fell off the building protecting an exit way and in another case an awning caught bricks 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 exit ways 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.

Crown 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. Crown bond beams on unreinforced buildings should be braced and anchored to the structure to keep them in place, or should be removed.

A crown 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 crown bond beam. Additionally, the upper parts of walls with crown bond beams tend to be weaker with fewer cross-ties and a minimum two-brick wide thicknesses, 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, there remain many of these chimneys 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 the chimney 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 was a wise investment in Wells and should be considered seriously by communities and individuals.

The 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 be assured 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 electric system stayed intact through, and following, the earthquake which helped in numerable 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 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 further and severed connections, or just become dangerous to operate, the power system to Wells would have been turned off and may have been off for a day or more as a crane that could lift the transformer was brought in and the repair made. Consideration should be given to anchoring large electric transformers mitigating this potential loss from 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 Nevada Department of Forestry, worked well 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 get 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 include redundant 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 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-affected 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 could have significantly enhanced communications early on in the response, especially if the cell telephone system had failed.

A large number of 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 they had to indicate the condition of buildings, but spray painting 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. When used the public has to be educated as to what the placards indicate and how long they are to be left up.

Lessons for Earthquake Monitoring in Nevada:

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

During the Wells Earthquake a temporary array of state-of-the-art seismometers was operating in Nevada (the Earthscope, http://www.earthscope.org, USArray; a National Science Foundation Experiment) providing coverage in the eastern part of the state. Seismic monitoring in eastern Nevada is very poor otherwise and most earthquakes <M3 are not recorded. The USArray network allowed the Nevada Seismological Laboratory to develop a reliable initial earthquake location for the Mw 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 has returned to the pre-USArray level. In order to accurately locate and develop reliable earthquake magnitudes, seismic monitoring in large portions of Nevada needs to be increased.

Lessons for Earthquake Fault Studies in Nevada:

Significant Quaternary faults (those that have moved in the last 1.8 million years), capable of earthquakes of magnitude 6 or larger, have been discovered near Wells that were previously unrecognized. Quaternary faults should be mapped and studied within 25 miles of each rural Nevada town to assure 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 (further 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 has to 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.