Nevada Bureau of Mines and Geology Special Publication 36

2008 Wells, Nevada Earthquake: Effects on Utility Systems

by

Craig M. dePolo[1] and Mike Ericksen[2]
[1]Nevada Bureau of Mines and Geology, University of Nevada, Reno
[2]Wells Propane, Inc.

2011

ABSTRACT

The 2008 Wells earthquake strongly shook the local utilities, and there was some damage, but overall the propane gas, electrical, and water systems survived the earthquake well, and there was gas, electricity, and water service in the aftermath of the event for people and for the emergency response. Given the sub-freezing nighttime temperatures and cold daytime temperatures for this February earthquake, the continued availability of utility service prevented a number of collateral effects, such as freezing pipes in homes.

There were three propane line breaks, one of which was a liquid propane leak that was quite serious. The liquid propane leak occurred when an improperly placed 500-gallon tank rolled, severing its connecting hose and the turn wheel on the valve. The leak was stopped after discharging about 100 gallons into the atmosphere. An experienced propane technician propped the tank up with 2" x 4" boards, which raised the valve into the vapor zone, thus changing the leakage from highly expansive liquid propane to gas propane. He then managed to get a pair of channel-lock pliers around the remaining valve steam and turned the valve off. Two other propane gas leaks occurred in manufactured homes where internal piping had been installed in a stressed state and was broken during the earthquake.

The electrical system stayed on throughout the earthquake. There were some house service lines damaged by falling bricks and shaking that had to be disconnected and electricity had to be cut to the damaged buildings in the historical district, but the only damage to the electric system itself was a 41-ton transformer that shifted on its pad. Some nonstructural damage at the electric company's main office forced it to be closed to customers the day of the earthquake.

The water stayed on and was pressurized throughout the earthquake, with the exception of a small part of Wells that lost water for a short period and had boil-water orders for three days. This was caused by two breaks in a water main that occurred on the first day, one from the mainshock and one from a major aftershock. These were completely repaired by the third day, and water was restored to the entire town. The total cost of the earthquake damage to the utility systems is documented at >$211,000, but probably is on the order of $250,000.

The survival of these utility systems was not just because of luck; the systems incorporated flexible connection hoses, were well maintained, and there were experienced personnel on hand ready to handle emergencies. This resulted in a relatively small number of incidents due to the earthquake shaking, and the few that did occur were handled expediently and correctly, limiting the impact due to the initial incident.

Several lessons learned from the earthquake's impact on the utility systems in Wells include the following:

- Proper placement of propane tanks so they are stable
- Educating people on how to turn the gas off to their buildings if they need to because of smelling a gas leak
- Importance of anchoring down large pieces of equipment that can shift during earthquakes
- The serious hazard posed by liquid propane leaks that expand by 270 times, rapidly creating large combustible clouds of gas.

INTRODUCTION

On the morning of February 21st, 2008, Wells, Nevada was struck by a magnitude 6.0 earthquake. At the time of the earthquake (6:16 a.m. PST), approximately 12 to 16 inches of snow covered the ground, the temperature was approximately 20°F, and the wind was calm. The earthquake began about 5.5 miles (9 km) northeast of Wells and ruptured in the subsurface to within about a mile of town. The shaking is reported to have lasted as long as 40 seconds.

Wells is a small community of 1,657 people that lies along the Interstate 80 corridor at the intersection with U.S. Highway 93, in the relatively remote northeast part of Nevada. There is a fairly modern public electrical company that services the area, Wells Rural Electric Company (WREC), and most businesses and residences have propane tanks for gas, which are serviced by Wells Propane Inc. Propane is brought into Wells by trucks. The local water system is maintained by the City of Wells, as is the sewer system.

The 2008 Wells earthquake was a background event that occurred on a previously unidentified fault, the kind that wouldn't be unusual to occur near any Nevada town. The kinds of utilities present are also common in rural Nevada towns. So an examination of the earthquake impact on the utilities of Wells is useful for other communities to consider, but must be tempered by the recognition that earthquakes of similar magnitude can cause different degrees of damage, and stronger ground motions and more widespread effects can occur with larger events in Nevada. Nevertheless, this is an example of strong shaking of rural utility systems making it valuable to study and document.

EARTHQUAKE IMPACT ON THE PROPANE GAS SYSTEM

The community of Wells uses approximately 500 propane tanks, ranging in size from 50 to 1,000 gallons, and all are served by Wells Propane Inc. Wells Propane has been in business for several decades and has experienced personnel who are well trained in dealing with propane leaks and propane fires.

With the exception of two tanks, all propane tanks remained in position on their support blocks and showed little or no signs of movement due to earthquake shaking. The two exceptions were an improperly placed temporary commercial tank and one residential tank. There were two gas propane leaks and one liquid propane leak (from the improperly placed tank) caused by the earthquake.

In the first instance, a temporary 500-gallon tank had been improperly moved by a building contractor at a truck-stop construction site and reset on an unlevel surface. This tank rolled over during the earthquake, severed the gas line, broke off its service valve, and began spraying liquid propane. The highly expansive liquid propane (liquid propane expands 270 times when it changes to a gas) formed a ground-hugging propane gas cloud about 1 m (3 - 4 feet) deep; there was no wind so the gas was accumulating in place.

Fire personnel who responded to the propane leak called Wells Propane to help with the leaking tank and called Wells Rural Electric to disconnect the power to the site. Fire personnel set up a 250-yard perimeter and requested that Interstate 80 and Highway 93 be closed by the Nevada Highway Patrol, who also evacuated a nearby truck stop. An experienced propane manager walked the perimeter of the cloud, propped the tank up with 2" x 4" boards to move the valve to the upside of the tank (so it was leaking gas rather than expansive liquid propane), and was then able to turn off the valve by grabbing the remaining valve stem with a pair of channel-lock pliers. After 10 to 15 minutes, the propane cloud dissipated and Interstate 80 was re-opened. Approximately 100 gallons of liquid propane had discharged into the atmosphere. The propane manager handled this very dangerous situation in an expeditious and professional manner, reflective of his experience and training. Cell phones were used during these communications which was difficult because the lines were saturated and there was a delay in getting a dial tone.

One 120-gallon tank moved off its supporting blocks during the earthquake, but remained in an upright position. A few other tanks were shifted slightly. No propane leaks occurred because of movement from these tanks, and all had flexible connections.

Wells Propane's work crews found broken gas piping in two homes; in both cases the residents had smelled the gas and turned their gas off. Both homes were "manufactured type" homes on permanent foundations. The gas piping in both of these homes had been installed by the factory at the time of manufacture. Due to the way the gas piping had been interlaced or woven through the framework of these homes, Wells Propane personnel believe that the gas piping had been subjected to stress and strain at the time of manufacture; the colder weather may have exacerbated this by contracting the pipes a little. The movement of the homes during the earthquake created additional stress causing the pipes to break. In both of these cases, the homeowners shut off their propane supply which prevented potential explosions and/or fires. Wells Propane is proactive about teaching customers how the meter works, how to shut off their propane, to know and respect propane gas

and not to fear it. As a result, a relatively high percentage of residents in Wells know how to turn the gas off in such a situation.

Figure 1. The tank has a flexible hose but is leaning on a rigid upright pipe feeder (left). **Figure 2**. Propane tank that shifted on its blocks by a few centimeters (about 1 inch) from the shaking (right).

Many water heaters and furnaces sustained some movement during the earthquake. In many instances, this movement resulted in separated venting connections. Wells Propane believes that the greatest potential danger to its customers was due to the risk of carbon monoxide poisoning from the continued use of gas appliances that required repairs to those venting systems in the hours and days after the earthquake. No water heaters failed, but a couple of them moved enough to begin to damage the minor supports they had (e.g., metal screws pulling out). Wells Propane has since begun a policy of strapping water heaters down for earthquake shaking.

Wells Propane completed inspections and any necessary repairs to all propane gas systems in the community within 72 hours after the earthquake. They also put out a public awareness flier reminding people to report any leaking gas smells and instructing them how to turn off the gas.

Lessons Learned for the Propane System (from Wells Propane Inc):

- Use flexible piping connections (standard practice) at tank, at building entry, and for appliances to allow some pipe movement during ground motion and prevent gas piping from breaking.
- Strap and secure gas appliances (particularly water heaters) to prevent them from toppling or moving in an earthquake.
- Don’t rely on cell phones for emergency communications. All cell phone lines were in use for many hours after the earthquake, making cell phone use nearly impossible.
- Accept “qualified” assistance from others to help handle emergencies. Wells Propane was offered assistance from many other propane companies and individuals but declined all but one of those offers because they were not certain that they were properly qualified. That individual worked with Wells Propane crews for the next 72 hours. They noted that after the first 48 hours a tremendous amount of fatigue was beginning to set in with their crew and they could have used more help, especially if it was a larger event. They have since made a list “qualified individuals” whom they could ask for help if ever in a similar situation.

EARTHQUAKE IMPACT ON THE ELECTRICAL SYSTEM

The 2008 Wells earthquake had a minimal impact on the electrical system. The system is owned and maintained by a local public power company, Wells Rural Electric Company (WREC). During the earthquake, a large 138 kV transformer was rotated slightly and shifted about 14 cm (about 5½ inches), but it did not fail, its service was not compromised, and it did not pose a safety issue. Electricity was disconnected from damaged buildings in the historical district and other locations at the request of customers on the day of the earthquake. There was nonstructural damage at the company's main office, but a nearby service building was undamaged. WREC personnel and equipment also assisted in some recovery efforts.

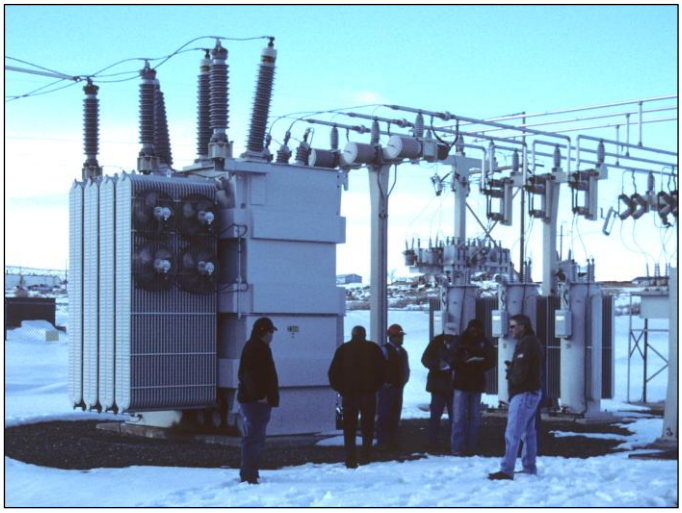
There were no power line or insulator failures from the earthquake. The power had to be turned off to the damaged buildings in the historical district (figure 3), where several service lines were cut to avoid being pulled down by further building damage. There were several requests to disconnect electric power: firemen requested the power be cut to the building under construction next to the liquid propane leak, and several WREC customers asked for power to be disconnected because of damage to homes and businesses. This damage included a meter box pulling away from a home, bricks from a chimney falling on a meter box, and electrical problems at a grocery store.

Figure 3. Wells Rural Electric Company linemen disconnecting power to a damaged building in the historical district. *Photo by the Utah Division of Homeland Security.*

When asked why the electrical system was so robust in the face of a local magnitude 6 earthquake, WREC representatives noted that it is a very well-maintained system. The power system is subjected to, and is built to withstand, severe winds and dust-laden rains which require good anchorage and attachment of components to survive. Furthermore, WREC is dedicated to customer service and "keeping the power on." This means that proactive steps are taken to identify and replace aging components before they become weak links, which also likely contributed to the success of the system during the earthquake.

During the Wells earthquake, a large 51-ton 138 kV station-class transformer was rotated slightly and shifted about 14 cm (about 5½ inches), and although it bent a connecting line bracket down a little and made the ground wire taut, the transformer did not fail, have its service compromised, or pose a safety issue (figures 4 and 5). Curiously, an old, unattached 46-ton transformer sitting a few meters away did not move at all.

It is worth noting that had the transformer failed or had to be shut down for safety reasons, the repair of the transformer would have required that the electrical system be shut down for several hours up to possibly as much as two days if the damage were so severe that internal parts to the transformer had to be found and brought in. Thus, Wells could have been out of power for as much as two days had the movement been worse. Repairs would require a crane that could lift the transformer to fix it. The movement of this transformer was nearing the design capabilities of the slack span of wire connecting the bushings to the substation structure. It is not unreasonable to assume that a larger earthquake with greater movement could move the transformer enough to damage the connections and bushings on the transformer, causing it to be shut down.



Figures 4 and 5. Above: A 51-ton 138 kV station-class transformer that shifted about 14 cm from the earthquake is shown above. Right: The transformer base is shown shifted from the mark of its prior position on the pad. The taut ground wire can be seen behind the man indicating the prior corner of the transformer. Note the anchorage hole in the base plate that was not used.

The power had to be turned off in a scheduled outage of 6 hours in order to reset the transformer. The power company did this work with its own personnel, and the crane cost $1,732 to rent. The transformer was reset, but was not anchored to prevent movement from future earthquakes.

Wells Rural Electric Company's main office sustained some damage and was closed to customer service the day of the event. Ceiling tiles had fallen, bookshelves, flat screen televisions fell and were broken (or had things fall on them), and there was other general content damage (figures 6, 7, 8). The company had several Internet servers operating on shelves that shifted; two of these fell to the desk below, but the servers were restricted from moving too far by the wire connections, and continued to operate during and after the earthquake. The staff cleaned up the offices that day (mostly cleaning up fallen tiles and picking up fallen objects) and the building inspector cleared the building for occupancy about 2 to 3 p.m. in the afternoon of the day of the earthquake.

Figures 6, 7, and 8. Nonstructural damage in the Wells Rural Electric Company's front office. Top: A fallen cabinet, open drawers, and damaged ceiling can be seen and a telephone lies off the hook in the foreground. Middle and Bottom: Ceiling tile damage. *Photographs by Layla Walz of Wells Rural Electric Company.*

Figure 9. Remarkably resilient servers used by Wells Rural Electric. Although two servers fell onto the desk and others shifted, they remained connected and operating through the earthquake and afterwards (the fall was cushioned a little by books and papers on the table). The servers on the floor rack do not appear to have shifted at all. *Photograph taken by Layla Walz of Wells Rural Electric Company*.

WREC employees assisted in response and recovery activities when they could. One resident recalled how he had a broken chimney and was worried the broken top would fall down during an aftershock. A WREC lineman came down the street and was able to use his bucket-and-crane and safely knock down the upper part of the chimney and put a piece of plastic over the top of the broken chimney for the man. This kind of "can do" attitude is partly why the response to and recovery from the earthquake was so successful.

EARTHQUAKE DAMAGE TO THE WATER SYSTEM

The water system was partially damaged from the earthquake, but except from a water main break, the damage was localized. The water stayed on for nearly all residences and businesses during the emergency response and only part of Wells had a few buildings with temporary loss of water or that had a boil-water order.

Figure 10. Digging to find a break in a water main located under a sidewalk and lamppost.

The broken water main was in the southern part of Wells, just north of the Interstate 80. It was an older line that broke once during the mainshock, and again in a major aftershock on the first day. This resulted in very visible runoff of water across the roadway. The break was isolated, the water line was turned off, and the line was fixed with the help of the maintenance people from Wendover (one of the nearest towns). After re-pressurization, the line failed again from an afternoon aftershock. This second break was more complicated, as it occurred under a sidewalk, near a lamppost (figure 10). All water-line breaks were fixed by the third day after the earthquake (figure 11).

Figure 11. The area of the main water break from the mainshock. The patch in the line can be seen in the lower center.

Large water-storage tanks in and near Wells appeared to shift side-to-side as evidenced by gaps in surrounding gravel beds (figures 12 and 13). One 1,000,000-gallon-tank that was nearly full developed a small "elephant's foot," or bulge at the base of the tank, on one side from the earthquake. The tank did not fail or leak but vacuuming the tank for better inspection revealed cracks and broken welds on a central column inside the tank. The earthquake rocked and shifted another water tank in a similar manner, slightly damaging an electrical conduit that was connected to it.

The water facilities, such as the water tanks, were covered by earthquake insurance, but the infrastructure, such as the water mains, were not. The Nevada Emergency Assistance Fund reimbursed most of the documented costs of the water breaks, however, because they occurred during the emergency response.

The following summer there were an unusually large number of water breaks around houses in Wells that were likely initiated in some way by the earthquake.

Figures 12, 13, and 14. Water tank has shifted and developed a bulge at its base (“elephant’s foot”) on one side (lower left). The shifted base is shown on the lower right with a baseball cap for scale.

EARTHQUAKE COSTS OF UTILITY DAMAGE

Utility damage costs were principally to the water system, with lesser but significant costs for service and repairs to the propane gas and the electrical systems. Many costs are not reported, so the total estimate is a minimum value. The insured costs of the water system damage and the assistance in repairing it were in excess of $111,000. Wells Propane documented costs of $70,000, including inspections, pipe repairs, and nonstructural office damage. Wells Rural Electric estimated a loss of about $30,000 in nonstructural damage in their main office, not including labor and loss of revenue from 6 hours of work to reset the transformer. The sewer system has not been fully inspected but no losses are known to have occurred because of the earthquake.

Total damages to utilities as a result of the Wells earthquake are estimated to exceed $211,000 (table 1), and are likely to be about $250,000.

Table 1. Estimated Utility Damage Costs.

Water system	>$111,000
Propane gas system	$70,000
Electrical system	>$30,000
Sewer system	unknown
Total	>$211,000

Lessons Learned about Utility Systems and Earthquakes

- Use flexible piping connections (standard practice) at tank, at building entry, and for appliances to allow some pipe movement during ground motion and prevent gas piping from breaking.
- Propane tanks, even temporary tanks, should be placed properly by propane technicians and not moved away from these placements and put in improper settings (such as on an inclined bank or a snow bank). A properly placed propane tank likely would not have sustained any damage during the Wells earthquake. However, the liquid propane leak that did occur illustrates the potentially serious danger of propane tank failure. Leaking liquid propane expands 270 times as it changes into a gas. A propane tank failure, particularly a liquid propane leak, may result in a very dangerous propane cloud and explosion hazard, and may further require an evacuation of the area. Propane tanks should be installed to survive lateral movement and remain upright through earthquake shaking.
- It is especially important for manufactured home owners to know how to turn off their gas. Two manufactured houses sustained internal gas pipe breaks due to the earthquake. It is possible that the gas piping in these homes was not designed and/or constructed to accommodate lateral shear stress in the structure, and thus was vulnerable to earthquake shaking. Although many manufactured houses survived the earthquake without gas leaks, this propane leak vulnerability may exist in other manufactured houses throughout the state. In the case of Wells, the residents turned off their gas before this could progress into an explosion or fire.
- Residents of Wells are taught not to fear propane gas, but to understand and respect it. Homeowners in Nevada need to be trained on how and when to turn off the gas service to help limit gas leaks caused by earthquakes and help prevent explosions and fires following an earthquake.
- Anchoring heavy and critical equipment properly is important in earthquake country. Large, heavy pieces of equipment, such as transformers, may seem stable at rest, but earthquake shaking can cause such equipment to shift on their foundation. If movement is enough to break connections or otherwise create a hazard, systems may have to be shut down for a period of time. Loss of such equipment can cause power outages that can be days in length.

ACKNOWLEDGMENTS

Special thanks to Eric Hubbard, Jim Reagan, and D.D. LaPointe for reviewing and editing the manuscript. Thanks also to Wells Rural Electric Company for information about the impacts of the earthquake on the electric system and to the City of Wells for information on the damaged water system.