Could Monticello Dam fail?

By Margaret Burns
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This thought probably is running through the heads of everyone living in Yolo County, following the 6.0-magnitude earthquake that devastated Napa on Aug. 24, 2014.

The simple answer is yes, because anything is possible. But is it probable? Not very.

Monticello Dam is a high concrete arch dam, completed in 1957 and filled to capacity in 1963, and owned by the federal Bureau of Reclamation. Daily operation of the dam is done by the Solano County Water Agency, contracted by the Solano Irrigation District.

The dam is 100 feet thick at the base and tapers to 12 feet at the crest, which has an elevation of 449 feet above sea level. It is filled by runoff from a 566-square-mile watershed, which amounts, in average years, to about 400,000 acre-feet of water. An acre-foot is enough water to flood one acre one foot in depth. Maximum capacity of the dam is 1.6 million acre-feet.

Dams fail due to several distinct causes. The most common is overtopping of the dam capacity, usually due to unexpectedly heavy rainfall in the watershed. This may be exacerbated by accidental blockage of the spillway or inadequate spillway design.

The second most common cause is defects in the foundation of the dam. These may be due to substandard construction methods or poor maintenance. The third most common cause is failure due to piping and seepage from internal erosion and cracks in the dam structure.

Problems with conduits and valves caused by the entry of embankment material into conduits are another source of dam failure. All of these reasons combined constitute an explanation for 94 percent of all dam failures, according to the 2011 Roseville Multi-Hazard Mitigation Plan.
That leaves approximately 6 percent for other causes of dam failure, of which earthquakes could be one.

Dam failure has the potential to cause more death and destruction than the failure of other man-made structures because of the force of rapid release of water. For this reason, there has been increasing regulatory oversight by federal and state governments to ensure the safety of dams.

Using the destructive force of dam failure as a deliberate offensive tactic, the Allies bombed the Eder and Möhne dams in Germany's Ruhr Valley in 1943. A listing of major dam failures and their causes can be found on the "Dam Failure" site of Wikipedia. Not one dam failure due to earthquakes is cited in that listing.

Most often used as an example of an earthquake-induced dam failure is the near-failure of the Lower Van Norman Dam in the 6.7-magnitude San Fernando earthquake in 1971. Severe damage to the dam lowered the crest about 30 feet. Residents in a 6-mile-long area down the valley were evacuated. The retained water was not at its maximum height, so the water did not overtop the dam, which had been constructed between 1912 and 1915.

The water behind the dam was further lowered over three days to protect the population, according to John Rundle, director of the UC Davis Computational Science and Engineering Center, and the U.S. Geological Service website on earthquake hazards.

The older dam was an earthen dam, known to be much less able to withstand shaking than Monticello Dam, a concrete arch dam. The more modern replacement dam built in San Fernando in 1975-76 withstood the Northridge earthquake (magnitude 6.7) in 1994 with little damage.

Dam monitoring

The Bureau of Reclamation has a systematic four-step program that continuously monitors the status of its dams. There is a review and inspection every four years, which involves looking at seismic, hydrologic and static parameters, says Drew Lessard, area manager of the Central California Area of the Bureau of Reclamation.

“Our headquarters in Denver and our area office take turns being in charge of these inspections, which are exhaustive,” Lessard said. “It is visual, looking for anomalies like seepage in the internal galleries that house some of the sensing equipment we rely on for data. But we also evaluate how much loading the horizontal joints are bearing and other structural parameters, evaluate seismic data.

“If anything is out of kilter, we will do more studies to analyze those potential weaknesses. If unwanted changes are found, we make plans for corrective actions and do it then. “We routinely take cores of concrete from various points in our dams and test them for compressibility — how much load can they stand before giving way. In our experience, overloading of dams from seismic events is less frequent than static loads from the water being held in check.”

Thomas Pate, principal water sources engineer of the Solano Water District, relates an experience he had while at the Denver headquarters of the Bureau of Reclamation some years ago. “There was a two-story-tall machine designed to test the compressibility of the concrete cylinders that are removed to evaluate the structural integrity of a dam,” Pate said. “I looked at one pile of boxes and it was labeled Monticello Dam. ‘That’s my dam on the floor,’ I thought. The engineer in charge told me that ‘Monticello is one of the better dams we’ve built.’ I found that reassuring.

“Locally, we have daily visual inspections of the entire dam site, looking for any potential signs of change that could have consequences. Once every few years, the Bureau of Reclamation comes and they have people crawling all over the dam, checking every aspect of its stability.”
According to Lessard, after any event in an area that could affect a dam, the dam is immediately inspected. He said that nothing unusual was seen at Monticello Dam after the Napa quake last month.

Earthquake probability

What is the probability of an earthquake at Monticello Dam? There is historic evidence that a serious earthquake can occur in this area, as it did in 1892 with a magnitude-6.4 quake that leveled downtown Winters. However, it took 100 years for J.R. Unruh and Eldridge Moores, geologists at UC Davis, to establish the reason for the quake.

“It was difficult to establish until we had appropriate instrumentation because this is a concealed fault, a blind thrust as the Coast Ranges move up and into the Central Valley,” Moores said. That specific fault line extends north of Winters along the eastern edge of the Coast Range. Fault maps also show a fault line running more or less linearly adjacent to the western edge of Lake Berryessa — the Hunting Creek-Berryessa Fault Line. The Great Valley fault line running north of Vacaville is close to the site of the Monticello Dam.

“The direct effect of the Napa earthquake on the Monticello Dam would have been very small,” Rundle said, “therefore not a concern. However, there are several faults in the area of the dam.
“Earthquakes on a fault are known to affect other faults,” Rundle added. “This is called ‘fault interaction.’ It is due to the transfer of stresses or forces on one fault to another close by. A concern might be that these nearby faults in Northern California might together start to be active.

“What would happen if the Great Valley fault, which basically runs under the dam, were to fail in an event such as the magnitude-6.4 Vacaville-Winters earthquake, which was located somewhere in that area? Very probably, this will not happen. But I can’t and won’t say that it absolutely won’t happen.”

Quake forecasts

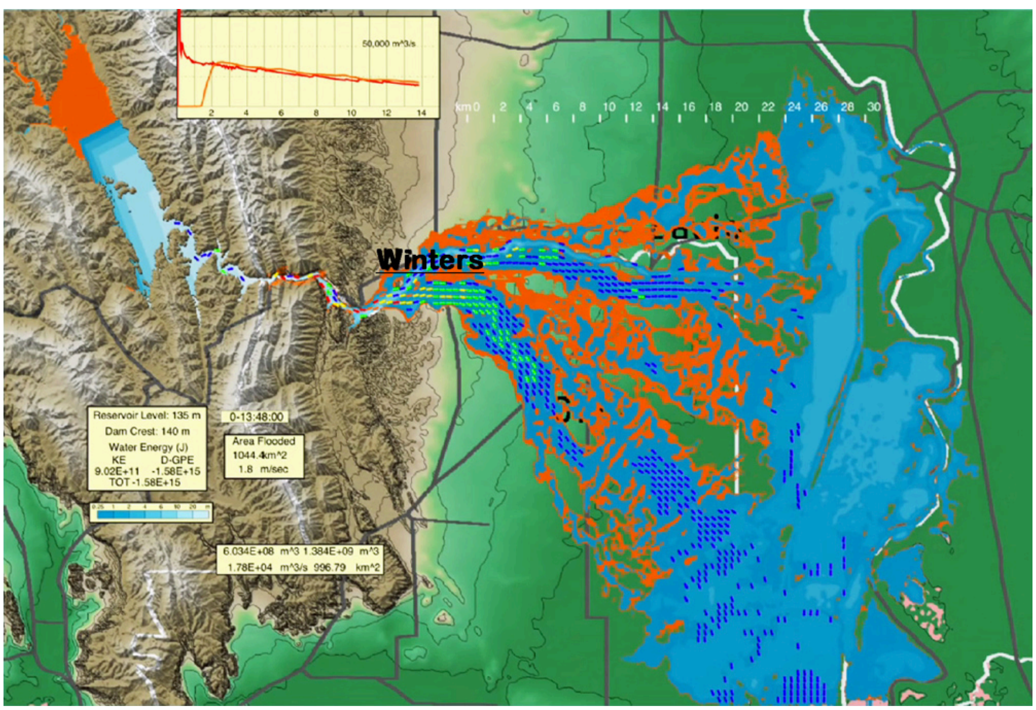
The Open Hazards website (www.openhazards.com), on which Rundle blogs, offers an earthquake forecast within a 50-mile radius. The probability of a greater than 7 magnitude earthquake within 50 miles of Winters is 5.27 percent in the next three years.

However, that 50-mile radius includes portions of the Bay Area with the active Hayward-Rodgers fault line, so it is not known exactly what the probability for Winters is specifically, because it is located in a less active area of the 100-mile-diameter circle.

Another blogger for the OpenHazards site is Steven Ward, a research geophysicist at the Institute of Geophysics and Planetary Physics at UC Santa Cruz. He has created a "computer simulation of the first 16 hours of flooding that might be expected from the failure of Monticello Dam. This worst-case scenario envisions a nearly instantaneous breakdown of the structure and a reservoir filled to capacity.

Steven Ward, a research geophysicist at the Institute of Geophysics and Planetary Physics at UC Santa Cruz has created a computer simulation of the first 16 hours of flooding that might be expected from the failure of Monticello Dam from a possible earthquake. This worst-case scenario envisions a nearly instantaneous breakdown of the structure and a reservoir filled to capacity. This is unlikely but informative. There are approximately 800,00 acre-feet of water in Lake Berryessa as of December, 2015, which has a normal capacity of about 1.6 million acre-feet.

The simulation can be accessed at http://es.ucsc.edu/~ward/berryessa-dam.mov. It shows water reaching Winters in roughly 30 to 40 minutes after a dam break.



However, the simulation is the worst-case scenario. Ward writes, "Rather than flush-and-gone, a dam break here is akin to opening a valve to a hose that will spray at a nearly constant rate for hours and hours. Second, just downstream is California's Central Valley, a very flat and nearly unchannelled place. Don't expect the flood to follow a well-defined river track as you might elsewhere. "The simulation suggests that about 1,000 square kilometers will be affected. Most areas would see water less than one or two meters deep, but the outburst would last a day or more."

The Glory Hole spillway is at 440 feet above mean sea level (msl). The height of the dam is 450 feet msl. Highway 128 is designed to be the initial spillway if water rises that high - watch out Winters. The water level has never been above 446.7 feet msl and has only been at or above Glory Hole (440' msl) 24 times in its 57 year history.

https://www.davisenterprise.com/local-news/could-monticello-dam-fail/