

California Reservoir on Shaky Ground Highlights Aging U.S. Dams' Risks

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FREMONT, Calif.—The coastal mountains that frame this working-class city next to San Francisco Bay harbor a hidden menace: a reservoir 10 miles away that sits next to an active earthquake fault, which experts say could cause a dam break and flood thousands of homes.

The potential threat is so severe, the owner of the Calaveras Reservoir decided to build a replacement dam. But seven years after that work began, the dam is unfinished and isn't expected to be complete until 2019—four years behind schedule.

The myriad issues hampering the Calaveras Reservoir project show how difficult it can be to repair or replace an old dam, which is of growing concern nationally.

An estimated 27,380 or 30% of the 90,580 dams listed in the latest 2016 National Inventory of Dams are rated as posing a high or significant hazard. Of those, more than 2,170 are considered deficient and in need of upgrading, according to a report by the American Society of Civil Engineers. The inventory by the U.S. Army Corps of Engineers doesn't break out which ones are deficient.

But both funding and inspection staffing to deal with the problem are considered inadequate, the civil engineers' report said. An estimated \$64 billion is needed to upgrade those dams, including \$22 billion for the ones posing the highest hazard, according to the Association of State Dam Safety Officials, a nonprofit safety group in Lexington, Ky.

"It's a huge problem with limited resources," said Ivan Wong, a consulting seismologist from Walnut Creek, Calif., who works on dam projects nationally. "We can barely pay for our schoolteachers, but if a dam fails and there's a population downstream, we're talking about a disaster. We have to fix our dams, there's no doubt about it."

While no dam collapses have claimed lives in the U.S. in recent years, historically they have represented some of the nation's biggest disasters. The failure of a dam above Johnstown, Pa., in 1899 sent a wall of water into the town, killing 2,209. The near failure of an emergency spillway at California's Lake Oroville in February, following heavy rains, prompted the evacuation of nearly 200,000 people downstream.

The Anderson Reservoir near San Jose, Calif., spilled over in February, despite a state-imposed limit of holding 68% of capacity because it lies near an active fault. Hundreds of homes were flooded along Coyote Creek, in what officials of the local Santa Clara Valley Water District say could have been a much more serious disaster had the dam failed.

"There was an unprecedented level of rainfall that came in very rapidly," said Katherine Oven, deputy operating officer of the district, which plans to rebuild its dam, too.

At the Calaveras dam, California's Division of Safety of Dams in 2001 ordered the San Francisco Public Utilities Commission to keep its 31 billion-gallon capacity Calaveras Reservoir no more than 40% full.

Utility officials say the extra time is needed to make the dam—with a massive 1,200-footwide base and spillway walls up to 4 feet thick—hopefully failproof.

"It's better to plan for the worst and hope for the best," Dan Wade, who oversees the \$800 million project for the city utility, said on a tour on Wednesday as trucks moved rock and other material around freshly excavated earth. The cost is double the original \$400 million estimate.

Earthquakes pose especially big risks for dams. The seismic threat is highest along the geologically active West Coast, including Washington and Oregon, which scientists say could see rare but potentially catastrophic quakes.

The seismic risk also exists for dams in places like the Midwest where there have been infrequent, large temblors. A series of earthquakes measuring more than 7.0 magnitude jolted what is now the New Madrid, Mo., area in 1811 and 1812.

Few states face as much of an earthquake threat as California, where nearly three-fourths of the state's 1,585 dams are rated as having high or significant potential risk of failing.

Like its predecessor and many others in California, the new Calaveras dam is being constructed largely out of rock, dirt and other natural materials. Engineering experts say earthen dams, if they are of sufficient size, are designed to withstand most earthquakes. The Calaveras dam is being strengthened, in part, by having zones of compacted material, including a thicker core of impermeable clay.

One problem, experts say, is that many were built decades ago, when less was known about what a strong earthquake could do.

Engineers didn't realize then that the loose rock and soil they used to form the base of some dams could liquefy in a strong earthquake, potentially causing the top of the structure to deform and spill. As a result, state officials have ordered some dams to hold back less water until they are fortified.

About 40 miles to the north, state officials have determined the 220-foot-high Calaveras Dam poses a flooding threat because the base of the 92-year-old structure was built atop loose earth on the site of a previous failed dam. About 300,000 people live in a flood zone along Alameda Creek below.

"It would be disastrous if this thing were to fail, because you have huge urban areas downstream," said Jeff Miller, executive director of the Alameda Creek Alliance, a nonprofit environmental group.

Officials of the San Francisco Public Utilities Commission say they opted to rebuild the dam 400 yards downstream, in part they say because there was uncertainty on whether the debris from the failed dam debris could be adequately secured.

"The problem is they didn't clean up all that material," said Mr. Wade, who is the utility's program manager to rebuild Calaveras and other parts of a system that San Francisco uses to transport water from the Sierra Nevada mountains to 2.6 million people. "It wasn't understood the foundation could liquefy."

But building a new 220-foot dam has presented its own challenges. About two years into the work, workers discovered remnants of two landslides that occurred an estimated 20,000 years ago. Fearful an ancient slide could foreshadow another one, Mr. Wade said the utility spent about two years redesigning the project and taking out even more earth as a precaution.

The work now is under way in earnest at Calaveras. So far, about 7 million cubic yards of earth have been moved, with another 3 million to go—or the equivalent of 1,550 football fields buried 1 yard deep. Last year, crews finally began constructing the earthen dam itself and much of the rest of their work will be in raising it to its height of about a 22-story building.

"Right now, we're doing the glory work," Mr. Wade said, standing on an overlook to watch the bustling commotion below. "It's like painting a house: A lot of the hard work is in the preparation."