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Sedimentation a building problem in the West's reservoirs

by Matt Weiser

Gary Esslinger, manager of Elephant Butte Irrigation District in southern New Mexico, spends as much time moving silt as he does water. Elephant Butte Reservoir, built in 1915, is fed by the naturally muddy Rio Grande, which drains 28,000 square miles of easily eroded desert in two states. Sediment has claimed 600,000 acre-feet of its 2.6 million acre-foot capacity. "If I could create a bumper sticker," Esslinger says wryly, "it would say, 'Silt Happens.'"

The sediment clogs canals, pipelines and farm fields. It has filled 33 small flood control dams below Elephant Butte, effectively rendering them useless. The district -- which supplies some 7,900 farmers -- maintains a fleet of excavators, dozers and dumptrucks, but Esslinger is running out of places to move dirt. He encourages developers to haul it away for fill, but demand remains low. "It's just going to become a bigger and bigger problem as these (dams) get older," he says.

It's a global conundrum: Dams slow the natural run of water, and slow water drops sediment to the bottom of reservoirs -- eventually filling them. Yet the problem has received precious little attention over the years, and as a result, it's not well understood.

A *High Country News* analysis of U.S. Bureau of Reclamation data -- which offers the most recent, publicly accessible surveys for eight of 11 Western states -- reveals that 35 reservoirs have lost some 4.6 million acre-feet of storage capacity to sedimentation. That's about 8 percent of their total storage, or enough water to serve at least 9 million households.

The actual amount of storage lost is certainly greater. The surveys examined by *HCN* cover less than 10 percent of the dams managed by BuRec. Thousands more are overseen by other agencies, from small irrigation reservoirs to giant multipurpose reservoirs owned by state agencies. And many of BuRec's surveys are already two decades old.

"(This) will be, in the next 20 to 50 years, an extremely important topic," says Robert Baskin, a hydrologist at the U.S. Geological Survey's Utah Water Science Center. "The economic impact ... could be dramatic."

Engineers have been aware of the problem for centuries. A dam built in Spain in 1394 is still operating because it was built with a gate at its base so sediment can be flushed out. Some modern dams, including the giant Three Gorges Dam in China, incorporate similar systems. But American engineers, while ingenious at storing and moving water, essentially ignored sediment. They generally set aside a certain percentage of each reservoir's volume, usually below its outlet gates or hydroelectric works, for sediment storage -- a space often dubbed the reservoir's "dead pool." Once that space filled, the dam's life was over.

Utah is one of the few Western states that have even attempted to assess sedimentation. In a March 2010 report, the state's Department of Water Resources estimated that in 40 years, Utah's total storage capacity will have declined 25 percent. Its reservoirs lose about 12,340 acre-feet a year to sedimentation, yet the state needs about double that amount annually in additional supply to keep up with population growth. The reservoirs "cannot be considered renewable resources unless sedimentation is adequately addressed," the report states.

But Utah was able to find data for only 18 of its 133 reservoirs larger than 1,000 acre-feet. Nationally, the state of knowledge is equally poor. John Gray, a hydrologist at the U.S. Geological Survey in Reston, Va., manages the nation's only large database on reservoir sedimentation, which includes surveys of 1,824 large and small reservoirs across the country compiled by the Soil Conservation Service, now the Natural Resources Conservation Service.

Most of the surveys are much older than BuRec's and haven't been updated in at least two decades; many were completed using crude techniques -- measuring reservoir depth with weighted rope, or noting how much piano wire sank to the bottom from a boat crossing a known transect. As a result, it's hard to know for sure how rapidly the nation's reservoirs are filling, or how full they are. "We're just not even the tip of the iceberg here," Gray says. "We should be ... getting a lot more data on this, and where there are problems, start alerting those locations. There's time to address this."

The U.S. Army Corps of Engineers provided funding last year to help move the data to a more modern software platform. The data are available for public download, but are not searchable online. Gray hopes to obtain $1 million over four years to fix that, and to allow new surveys to be easily uploaded. But it's unclear where the money will come from, given the current budget crisis.

Meanwhile, BuRec has been plodding away making new surveys, says Ronald Ferrari, a Denver-based BuRec hydraulic engineer who oversees the agency's sediment survey program, though many have not been added to the USGS database. Ferrari spends two to three months every year visiting reservoirs with a specially equipped boat, using GPS, multibeam sonar and lidar to render detailed profiles of their bottoms. It once took a team of six people five or six months to survey a massive reservoir like Lake Powell, on the Colorado River. Now, two people can do it in two or three weeks, and they get far better data. Even so, the agency tackles just four or five a year. "We'd like to have more of them completed," Ferrari says, "but it's definitely dictated by the allowable budgets."

Southwestern reservoirs are generally surveyed more often because of known higher sedimentation rates in that region. The last full survey at Powell, however, was in 1986. No new survey is planned, Ferrari says, because its sedimentation rate is considered low and because of budget constraints.

How quickly reservoirs fill, and where, varies widely, but all are shrinking every day. Soil type and local geography and land use all play roles. And unexpected events, such as wildfire in the watershed, can have huge consequences.

Elephant Butte in New Mexico is an extreme example, with a 23 percent decline in capacity. Most others surveyed by *HCN* are filling more slowly; McKay Reservoir near Pendleton, Ore., for example, has lost 2.6 percent of its capacity over 90 years. Yet even at slow rates, problems can emerge early, especially when exacerbated by drought or other factors.

Southern Montana's Bighorn Lake has lost 3.9 percent of its capacity over 50 years. The long, narrow reservoir stretches across the state line into Wyoming. For half of every year, cliffs and plateaus of sediment maroon a popular boat launch and marina in Lovell, Wyo. "We no longer have a lake," says Bob Croft, president of Friends of Bighorn Lake. "We have a river channel that has 18-foot mud walls on it when it goes empty."

The problem is aggravated by water releases at Yellow Tail Dam -- 30 miles north -- which serve a trout fishery below the dam. This creates dramatic water-level changes around Lovell, which in turn cause sediment to settle out of the water there, rather than dispersing widely on the reservoir floor.

Most large reservoirs have centuries to go, but small ones may have only decades, and many have already filled completely. On the Stanford University campus in California, sediment has reached the brim of Searsville Dam. Meanwhile, the Matilija Dam on California's Ventura River, which was built in 1948 for water supply and flood control, now provides neither. A single storm in 1969 filled 27 percent of the reservoir with sand and mud; it's currently 90 percent filled with sediment. There is agreement to remove the dam, but finding a place to move the accumulated muck remains an obstacle.

"Every reservoir is headed towards that condition, just at different rates," says Baskin. A variety of solutions are possible; none are cheap. Sedimentation can be reduced by improved land management upstream to minimize erosion. Mechanical fixes are also available, from dredging to adding diversion structures upstream to separate and transport sediment elsewhere. Dams can also be retrofitted with new gates so sediment can be flushed out. At small reservoirs, dams are often raised, recovering lost capacity, but only for a short time.

At Otter Creek Reservoir on Utah's Sevier River, officials are attempting a multifaceted fix. Built in 1897, the reservoir had lost about 22 percent of capacity after a century. In 1999, the state helped Otter Creek Reservoir Company pay for $4 million in dam improvements, including new spillway gates to raise the water elevation 2 feet to compensate for lost capacity. At the same time, state and federal agencies are working to restore the watershed, which was degraded by livestock grazing. A 2005 fire, followed by rainstorms, delivered a fresh shot of sediment that may have reversed some gains. But the effort continues.

"We've been trying to get people to realize there may be things they could do now to prevent a major issue later down the road," says Ferrari. "Eventually, somebody's going to have to deal with it."

Matt Weiser writes about water and the environment for the Sacramento Bee.

Sedimentation is relatively higher in reservoirs than in other water bodies because reservoirs impound a large volume relative to the area of their watershed. Sediment accumulation is accelerated by inadequate land-use practices that liberate soils, by the conversion of land into urban and suburban development that hastens runoff, or both.Â Sedimentation also can result in the loss of habitat for fish, and sediment can carry pollutants including nutrients, which may act as catalysts for eutrophication. Reservoir sedimentation can change physical, chemical, and biological components of the ecosystem, which results in the degradation of beneficial uses such as drinking water supplies, navigation, electricity production, flood control, and recreation (Figure 3.1). The West's reservoirs are waging a constant battle against rising levels of sediment.Â Engineers have been aware of the problem for centuries. A dam built in Spain in 1394 is still operating because it was built with a gate at its base so sediment can be flushed out. Some modern dams, including the giant Three Gorges Dam in China, incorporate similar systems. But American engineers, while ingenious at storing and moving water, essentially ignored sediment. They generally set aside a certain percentage of each reservoir's volume, usually below its outlet gates or hydroelectric works, for sediment storage -- a space often dubbed the reservoir's "dead pool." Once that space filled, the dam's life was over. The rate of sedimentation has been a serious problem for reservoir operation and water management worldwide including in Zimbabweâ€™s semi-arid regions [16] [17]. In semi-arid areas natural conditions and anthropogenic activities affect the sedimentation processes [18]. The most notable is the inappropriate land uses and human induced land cover changes; these have serious implications to future water supply [19].Â The decreasing trend in sediment concentration from December to April is a result of loose soil in the catchment due to animal trampling in the dry summer. Sedimentation is a big problem as it reduces the life of the reservoir considerably. Therefore, it is essential to know the sedimentation process in the reservoirs to evolve some strategy to tackle the problem. 22.1 Distribution of Sediments in Reservoirs.Â Sediment-reservoir Volume Ratio: If the inflow volume of water and sediment is large compared to the reservoir volume, water cannot be retained in the reservoir for a longer period. In that case deposition of the percentage of inflow sediment will be much less as the retention period is low.Â There are a large number of reservoirs in the world which have been built for different purposes like water supply, irrigation, and flood control or for controlling downstream water quality.