Delta Levee Break Heightens System Vulnerability

Aerial view of the flood scene shortly after the levee break. Photo from DWR.

On June 3, 2004, a 300-foot section of a levee in California's Sacramento-San Joaquin River Delta failed, flooding Jones Tract, a 12,000-acre island, and threatening a significant portion of the state's water supply. No clear cause was apparent. The flooding not only destroyed crops and displaced about 300 residents, but reduced the river flow that forms a barrier to saltwater intrusion into the lower delta. The U.S. Bureau of Reclamation was forced to increase releases of fresh water from Shasta Dam to help control salinity, and the California Department of Water Resources (DWR) had to reduce pumping from their export pumps to reduce the intrusion of seawater. Residents of many islands were evacuated, and estimated crop losses from flooding on Jones Tract were $10 million. Crop loss from seepage on other islands was also expected to reach several million dollars, and total damage estimates, including repairing the breach, approached $100 million. Crews from government agencies at all levels, the California Conservation Corps, inmate crews from the California Department of Forestry and Fire Protection, private quarry firms, and others worked around the clock to fill the break. On June 30, the gap was finally closed with more than 200,000 tons of rock.

According to the U.S. Geological Survey (2000), until the late 1800s the delta was a tidal freshwater marsh covered by peat and peaty alluvium. Then levees were built along the stream channels, and farming began on the newly protected land. Now a rich agricultural area, the delta is also an important source of fresh water for 22 million Californians. The delta lies in the center of an extensive water transfer system, and much of the water from the delta is pumped southward to the San Joaquin Valley and central and southern California. The tracts and islands maintained by the levees help protect water-export facilities in the southern delta from saltwater intrusion by displacing water and maintaining favorable freshwater gradients.

The levee break called attention to a situation that many people have been worrying about for some time: encroaching development into the flood plains and a dire need for levee maintenance. On June 16, *The Sacramento Bee* reported on comments made by Col. Michael Conrad, district commander for the U.S. Army Corps of Engineers, in an address to the Central Valley Flood Control Association. He observed that communities continue to develop in poor locations such as flood plains where land is cheap, and when crises such as levee breaks occur, they turn to federal and state resources for help. According to *The Bee*, Conrad has become increasingly vocal about the need for a "big-picture policy to reduce flood damage." Further, he said flood-control agencies can't blame environmental requirements for delays in maintaining levees, and acknowledged that his own agency needs to work harder to facilitate levee repair.

The *Tri-Valley Herald* said the situation could have been worse. Had the cause of failure been big waves or an earthquake, a chain of failures could have been triggered across 1,100 miles of levees in the region. According to the article, the levees are currently in disrepair for a variety of reasons: most are privately owned and not part of a government-run flood control project, and conflicts between delta water leaders and Southern California water users have prevented regional collaboration on maintenance responsibilities.

On July 1, President Bush declared the area a federal disaster, freeing money from the Federal Emergency Management Agency for 75 percent of the costs to repair or replace damaged public facilities, remove debris, fund emergency expenses, and also for projects to prevent future disasters. State and local agencies will cover the balance.

Pumping of Jones Tract, which was covered by 10 to 18 feet of water, began in July and is expected to continue into October. DWR awarded a $3.8 million contract to a Lodi construction company for the dewatering work.

Additional Information

California Department of Water Resources delta levee break information page, calwater.ca.gov/Levee_Break/DeltaLeveeBreakInfo.shtml.

U.S. Geological Survey, 2000. Delta subsidence in California. Fact Sheet FS-005-00, available at ca.water.usgs.gov/archive/reports/fs00500/fs00500.pdf.

Technologies Evaluated for Treating Acid Mine Drainage

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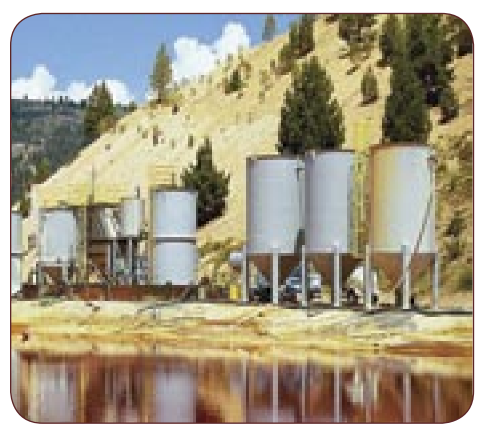
Intermittent extraction of copper sulfate, copper, and sulfur minerals from the abandoned Leviathan Mine in Alpine County, California, has resulted in extensive acid mine drainage (AMD) and acid rock drainage (ARD). Oxygen and water that contact the excavated waste rock and mineralized rock in the mine workings oxidize sulfur and sulfide minerals, leading to the generation of sulfuric acid. The acid dissolves toxic levels of metals, including aluminum, arsenic, copper, iron, and nickel. Releases of acidic waters and toxic metals have resulted in historic fish and insect kills in local creeks and the east fork of the Carson River. Actions taken by the state of California have significantly reduced the quantity of metals and acidity discharged from the Leviathan Mine. These actions included adding storm water controls, separating Leviathan Creek from the waste rock to reduce ARD, constructing five ponds to prevent discharge of AMD, and treating captured AMD.

The compost-free bioreactor at the Leviathan Mine treats up to 30 gallon per minute ARD flow year round before releasing it to Aspen Creek.

Over the past three years, the U.S. Environmental Protection Agency National Risk Management Research Laboratory (NRMRL), in cooperation with EPA Region IX, the state of California, and Atlantic Richfield Company, has evaluated three technologies for treating AMD and ARD at the site: active biphasic lime treatment, semi-passive settling in an alkaline treatment lagoon, and passive compost-free bioreactors. Conventional methods of treating AMD and ARD involve the capture, storage, and batch or continuous treatment of water using lime addition, which neutralizes acidity and precipitates metals. The biphasic treatment and alkaline treatment lagoon technologies are simply improvements to conventional lime treatment technology. The compost-free bioreactor technology nurtures sulfate-reducing bacteria, generating sulfides, which scavenge dissolved metals to form metal sulfide precipitates. Typical influent and effluent concentrations, removal efficiencies, and discharge standards for each technology are provided in the table at right.

The biphasic lime treatment system employs two-step lime addition to



The biphasic lime system treats an AMD volume of 3.5 million gallons each summer before releasing it to Leviathan Creek.

neutralize acidity and precipitate dissolved metals from the AMD at flow rates ranging from 50 to 185 gallons per minute (gpm). During the first phase, the pH is raised slightly from 2.8 to 3.2 by mixing lime slurry with AMD to precipitate iron as ferric hydroxide. During this first precipitation step, the arsenic "co-precipitates" or is adsorbed to the ferric hydroxide to form a small volume of arsenic-rich hazardous sludge. Precipitate from the first phase is shipped off-site for disposal. The pH of the partially treated AMD is then raised to between 8.0 and 8.4, and the remaining metals precipitate to form a larger quantity of nonhazardous sludge.

The alkaline (lime) treatment lagoon, a simplified version of the biphasic treatment system, is used to treat a low flow (12 to 30 gpm) ARD source. Single-step lime addition in combination with vigorous aeration is employed to neutralize acidity from pH 4.5 to pH 8 and precipitate metals. A series of bag filters captures large floc particles, while a multicell settling lagoon allows extended lime contact and fine particle settling prior to discharge.

Compost-free bioreactor technology, developed and operated by Glenn Miller and Tim Tsukamoto of the University of Nevada-Reno, relies on biologically mediated sulfate-to-sulfide reduction, attributed primarily to *Desulfovibrio* species, to neutralize acidity and precipitate metal sulfides from ARD (pH of 3.1) at flow rates ranging from 8 to 30 gpm on a year-round basis. Unlike compost bioreactors, this technology uses liquid alcohol as a carbon source fed continuously into the influent, and a rock matrix rather than a compost or wood chip matrix, which is consumed by bacteria and collapses over time. The benefits include better control of biological activity and improved hydraulic conductivity and precipitate flushing. The solids generated by this technology are nonhazardous.

NRMRL field studies found that all

	Aluminum (mg/L)	Arsenic (mg/L)	Copper (mg/L)	Iron (mg/L)	Nickel (mg/L)
Biphasic System					
Influent	486	4.05	2.99	653	8.77
Effluent	1.09	0.0101	0.0101	0.0038	0.0389
Removal Efficiency	99.78%	99.75%	99.66%	99.99%	99.56%
Alkaline Lagoon					
Influent	31.6	0.533	0.0161	378	1.61
Effluent	0.21	0.0032	0.0041	0.32	0.0204
Removal Efficiency	99.34%	99.40%	74.53%	99.92%	98.73%
Bioreactor					
Influent	39.9	<0.005	0.765	120	0.484
Effluent	0.0258	<0.005	0.0065	0.105	0.0417
Removal Efficiency	99.94%	Not Calculated	99.15%	99.91%	91.38%
Discharge Standard	**2.0**	**0.15**	**0.016**	**1.0**	**0.094**

Performance data for the three AMD/ARD treatment technologies.

three technologies effectively promote AMD and ARD neutralization and metal precipitation, and consistently meet site discharge standards. Active biphasic lime treatment appears to be applicable in situations where flow rates are high and the treatment season is short, while the semi-passive alkaline treatment lagoon favors a lower flow rate and extended treatment season. However, the innovative passive compost-free bioreactor is not constrained by seasonal conditions and can be scaled to treat low to moderate flows, which are typical of AMD and ARD sites.

Additional information, including costs, benefits, and limitations of the lime-based technologies were presented in an innovative technology evaluation report (ITER), technology capsule, and demonstration bulletin in the summer of 2004. Documentation of the bioreactor evaluation will be available in the summer of 2005.

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