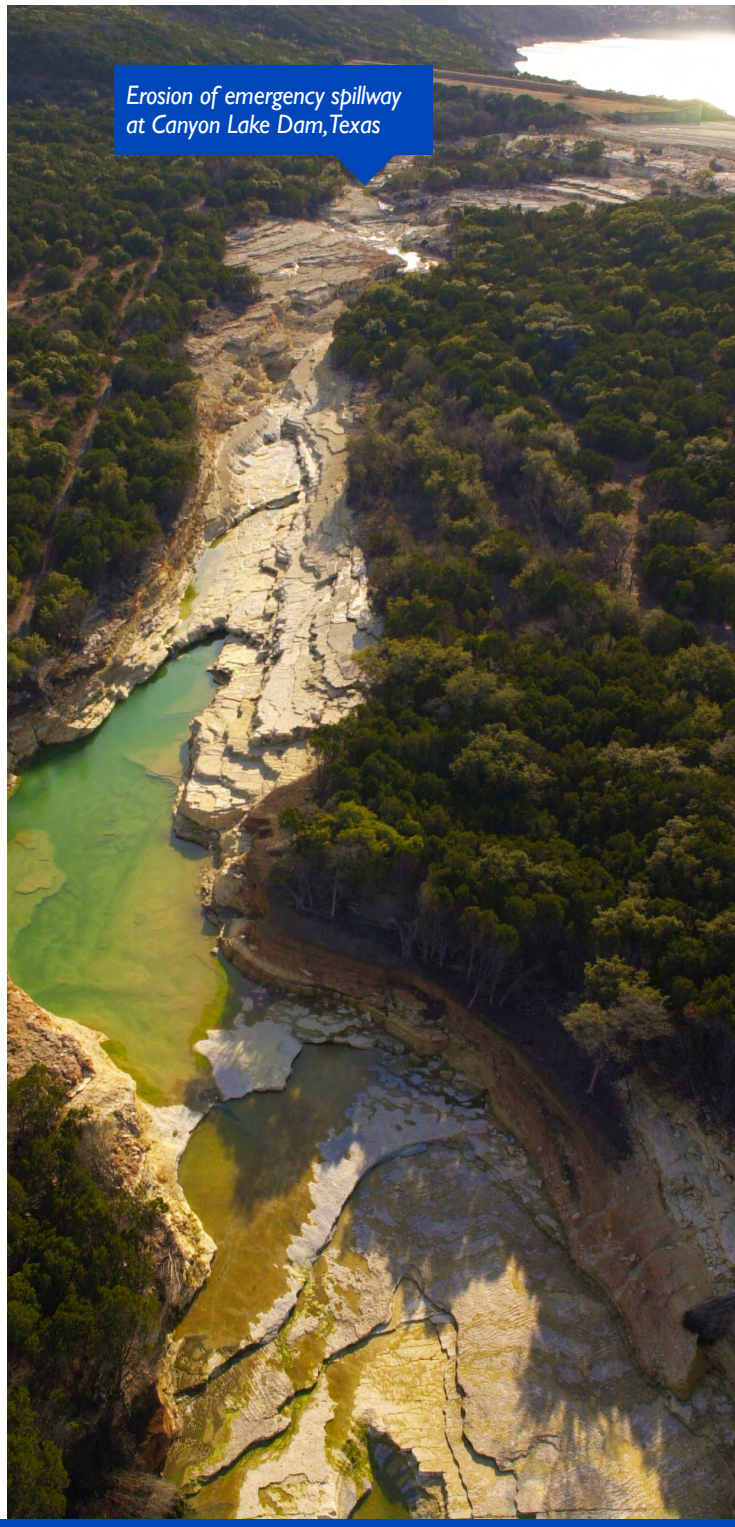
SOUTHWEST RESEARCH INSTITUTE

# Evaluating Erosion of Unlined Emergency Spillways and Chutes

During record flooding in 2002, the emergency spillway at Canyon Lake Dam in Texas was overtopped for the first time. The resulting spillway flood excavated soil and trees and significantly eroded bedrock, creating the Canyon Lake Gorge. The flood created stair-step topography in the upper reaches of the gorge. In some cases undercutting was observed, but the dominant erosion mechanism in the upper reach was block removal or plucking.

Southwest Research Institute® (SwRI®) has developed a coupled computational fluid dynamics (CFD) and distinct element method simulation framework to model the Canyon Lake spillway erosion.



*Erosion of emergency spillway at Canyon Lake Dam, Texas*

## Methodology

- The erosive capacity of water was represented by transient water pressures and shear stresses on the spillway boundary.
- Resistive capacity of the rock was simulated by dynamic discontinuum modeling of jointed rock subjected to hydrodynamic forces obtained from the flow analysis.
- The 2-D discontinuum code UDEC explicitly incorporated horizontal bedding planes and sub-vertical joint sets to capture the geology.
- The flood was analyzed using ANSYS Fluent. The fluctuation pressure from CFD was applied as pore pressure in the horizontal and vertical joints, assuming the open joints were saturated and water pressure was instantaneously transmitted.

## Solution

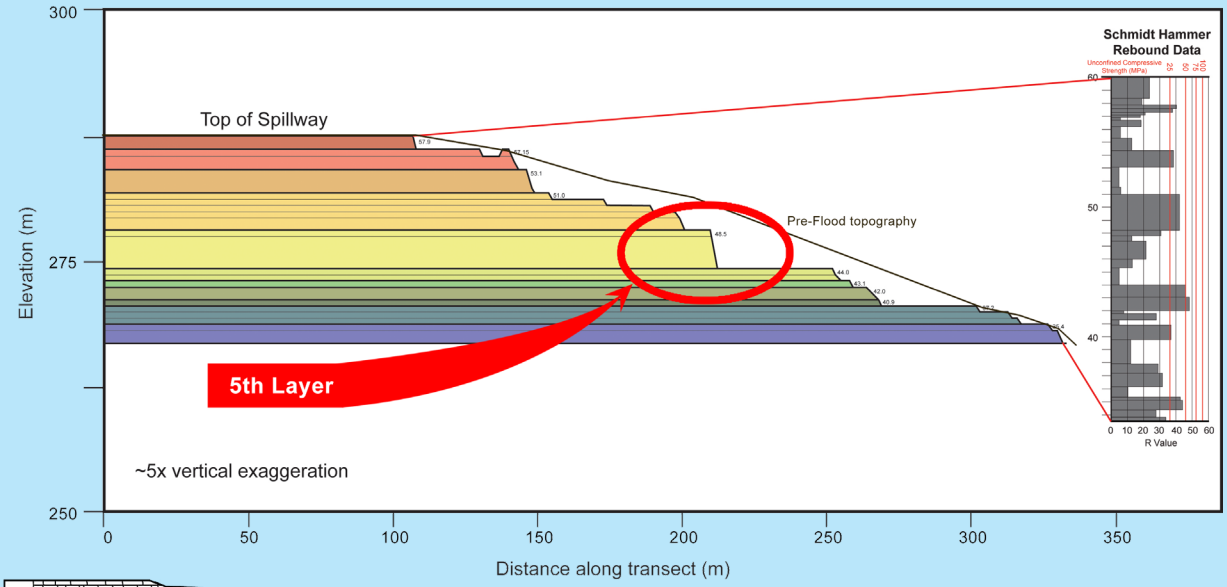
Hydromechanical interaction modeling reproduced the essential elements of the observed spillway erosion at Canyon Lake Gorge.

- CFD modeling simulated the flood discharge over the spillway.
- Discontinuum modeling simulated the rock erosion.
- The kinematics of block displacement corresponding to the 5th layer at EL 275 demonstrates that the block separation and removal or plucking failure modes are similar to the field observation.

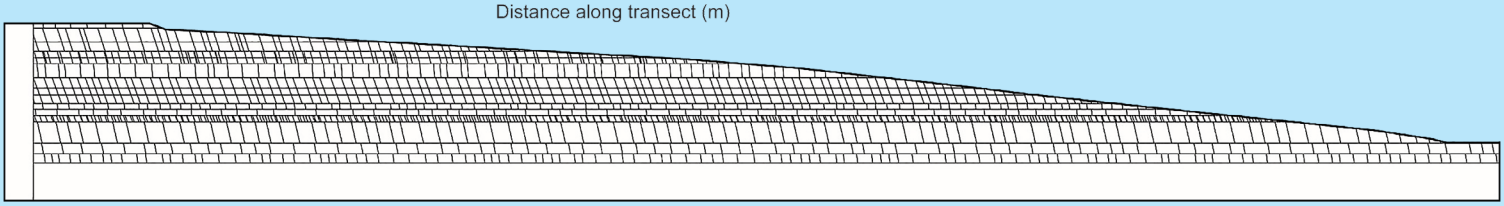
## Applications

The SwRI-developed coupled computational approach to simulate erosion in spillways can be used to:

- Simulate full-scale flow and conduct geomechanical analyses.
- Evaluate the potential effects of flood hazards.
- Evaluate mitigation performance by increasing resistive capacity and/or modifying hydraulic design.

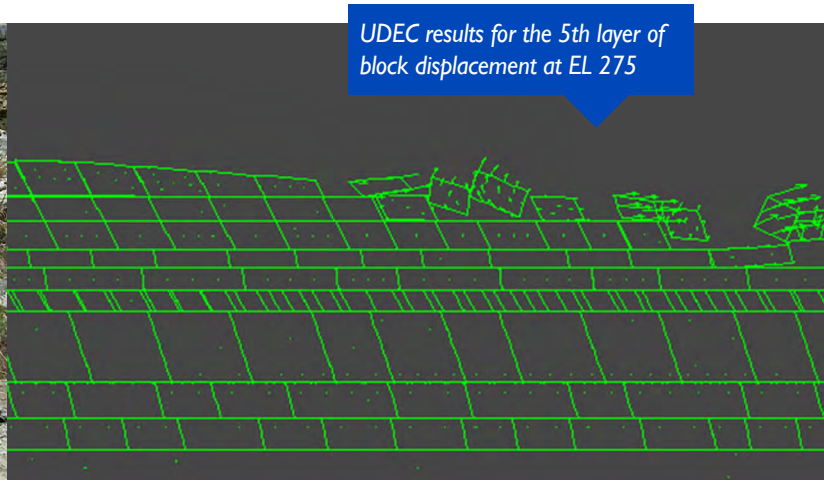



*Geologic cross-section, pre- and post-flood topography*



*UDEC 2-D jointed rock model*

*Block peeling at Canyon Lake Gorge*



*UDEC results for the 5th layer of block displacement at EL 275*

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Dasgupta, B. et al., *"Computational Approach to Predict Rock Erosion in Unlined Spillways,"* International Commission on Large Dams (ICOLD) Congress, Kyoto, Japan, June 2012.

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