



## **Evidence of an emerging levee failure mechanism causing disastrous floods in Italy**

Stefano Orlandini (1), Giovanni Moretti (1), and John Albertson (2)

(1) Dipartimento di Ingegneria Enzo Ferrari, Università degli Studi di Modena e Reggio Emilia, Modena, Italy, (2) School of Civil and Environmental Engineering, Cornell University, Ithaca, NY, USA

A levee failure occurred along the Secchia River, Northern Italy, on January 19, 2014, resulting in flood damage in excess of \$500 Million. In response to this failure, immediate surveillance of other levees in the region led to the identification of a second breach developing on the neighboring Panaro River, where rapid mitigation efforts were successful in averting a full levee failure. The paired breach events that occurred along the Secchia and Panaro Rivers provided an excellent window on an emerging levee failure mechanism. In the Secchia River, by combining the information content of photographs taken from helicopters in the early stage of breach development and 10-cm resolution aerial photographs taken in 2010 and 2012, animal burrows were found to exist in the precise levee location where the breach originated. In the Panaro River, internal erosion was observed to occur at a location where a crested porcupine den was known to exist and this erosion led to the collapse of the levee top. This paper uses detailed numerical modeling of rainfall, river flow, and variably saturated flow in the levee to explore the hydraulic and geotechnical mechanisms that were triggered along the Secchia and Panaro Rivers by activities of burrowing animals leading to levee failures. As habitats become more fragmented and constrained along river corridors it is possible that this failure mechanism could become more prevalent and, therefore, will demand greater attention in both the design and maintenance of earthen hydraulic structures as well as in wildlife management.