Linking Foundation Conditions to Operational Risk: A Case Study on Youghiogheny Dam Spillway

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Partial spillway failures at Oroville and Guajataca Dams in 2017 resulted in large-scale evacuations, caused over $1 billion in damages, and prompted congressional mandates for federal agencies to assess spillway vulnerabilities. In response, the U.S. Army Corps of Engineers (USACE) initiated portfolio-wide screenings of concrete-lined chute spillways to identify structures susceptible to operational damage and inform risk-based safety improvements. This case study highlights the need for targeted spillway analyses and establishes a technical foundation for long-term risk-informed asset management. In 2023, USACE Risk Management Center's (RMC) screening of lined spillways identified critical deficiencies in the Youghiogheny Dam spillway in Confluence, Pennsylvania. The concrete-lined spillway was constructed under two contracts; the original construction, which consisted of the upper channel lining and ogee weir monoliths, was completed in 1943, and the second contract for the lower portion of the chute was completed in 1946-1947. The spillway has never been activated. The RMC screening and a subsequent spillway-focused semi-quantitative risk assessment (SQRA) identified the absence of critical defensive measures such as dowels, joint reinforcement, water stops, slab turndown keys, and inconsistent anchoring. The foundation beneath the spillway slabs is composed of Pennsylvanian-epoch Glenshaw Formation rocks: a series of nearly horizontal cyclic sedimentary units - sandstone, siltstone, shale, limestone and indurated clay - which have variable strength and resistance to erosion. The indurated clay layer is prone to slaking and may be present between the sandstone and siltstone units that support much of the spillway weir structure. Where slab anchoring is present, foundation preparation was conducted using pneumatic drilling methods that may have exacerbated fractures within weak foundation materials. The hillslope above the right spillway channel exposes these weak materials, where shallow sloughing and surficial slides are common. These sloughs and slides accumulate at the base of the spillway channel and block the downstream outlets of the drainage galleries, reducing their effectiveness in dissipating pressures beneath spillway slabs during a flow event. Erodibility estimates conducted with RMC toolboxes show that the probability of erosion of the sandstone beneath the spillway weir is risk-neutral to unlikely if exposed to flow. However, moderate erosion of the underlying carbonaceous silt-shale and silt and clay shale is also likely. While life-safety-based investments were not warranted, the team recognized the potential for significant damage if spillway flow occurs. As part of this risk assessment, the team evaluated operational potential failure modes associated with spillway activation that could result in major structural repair costs, spillway outage, and possible impacts on hydropower generation.