Using Multiple geophysical methods to evaluate a distressed earthen dam

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An earthen dam located in an undisclosed location has a history of seepage and material slumping along the dam crest and downstream slope. The original dam was constructed in the 1960s, was raised in the mid-1980s and again in the early 2000s. The raise in the 1980s was completed by adding embankment material and increasing the size of the clay core. In the early 2000s, the dam was raised again by adding additional material to the dam crest along with driving a sheet-pile wall through the dam and into the core. In 2012, several areas of seepage and surface sloughing were observed that were attributed to flow through near surface fractured rock in the right abutment. To cut off this seepage, a grouting program was completed in 2013. The slumping that is currently ongoing along the dam crest and embankment was first observed two years later, possibly due to seepage creating a new preferred pathway, this time underneath the main part of the dam.

A geophysical survey was conducted to help determine the cause or causes of the observed slumping. At the start of the geophysical investigation, there were two major target theories to investigate. The first was that seepage through the embankment material is causing saturation and washout of fine-grained materials. The second theory is that it is due to potential karst-related subsidence. While no karst is known to exist at the site, it has been mapped nearby within the same geologic setting.

To better understand the current condition of the dam and to help narrow down the theories of slumping, multiple geophysical methods were deployed. First, about 8 acres of Frequency Domain Electromagnetics (FDEM) data were collected along the dam and abutments to map soil saturation variations that could be indicative of seepage. The FDEM showed areas of both increased and decreased bulk conductivity. These areas were targeted for further investigation using Electrical Resistivity Imaging (ERI) and two seismic methods, Seismic Refraction Tomography (SRT) and Multi-channel Analysis of Surface Waves (MASW). In total, 7 seismic lines and 5 ERI lines were collected.

The ERI, SRT and MASW results, when correlated to the structure of the dam and the two raises that have occurred, show two significant possible issues within and beneath the dam that could be related to the observed subsidence issues. One of these is geologic in nature and the other is related to the 1980s era dam raise. The ERI results even offer a possible explanation for a site mystery: Where does the seepage from elevated pore water pressures observed in piezometers along the crest of the dam go? There is no observable seepage downstream that might correlate to the elevated pore water pressures at the crest. Based on the ERI results, it is possible that this water is draining into fractured or karstic rock that underlies the toe of the dam.