We present a case study on using electromagnetic and time-lapse micro-gravity methods to monitor an aquifer storage recovery (ASR) project. An abandoned coal mine has been developed into an underground water reservoir in Leyden, Colorado. Excess water from surface sources is injected into the reservoir during winter and then retrieved for use in the summer. Understanding the storage-recovery process requires knowledge of water concentration and movement within the mine workings, associated rubble zones above, and the host geologic units. Because significant changes in both electrical conductivity and mass density are associated with the ASR process, electromagnetic and micro-gravity methods are ideal for monitoring and characterizing this process. Three time-lapse micro-gravity surveys and a 3D time-domain electromagnetic (TEM) survey were carried out during and after the water injection. Strong and well-defined time-lapse gravity anomalies associated with the injected water distributed at depth up to 300 m were observed. A 3D TEM survey was performed using a fixed-loop configuration. The survey was designed both to target the observed gravity anomalies due to the injected water and to characterize the geo-electrical structure of the host geology. TEM data indicate the presence of a conductive zone coinciding with the water-saturated rubble zones that were detected by the gravity surveys.

The focus of this presentation is twofold. First, we will discuss aspects of applying time-domain EM methods to the characterization of spatial variability and dynamics of aquifers used in ASR process. In particular, we present numerical modeling, survey design, field data acquisition, and data interpretation of the TEM survey. Secondly, we present the joint interpretation of TEM data with time-lapse gravity for characterizing the hydrogeophysical properties of the aquifer. The independent and complementary information regarding the porosity and saturation obtained from gravity and TEM data allows us to predict hydrologic properties of the rubble zones that constitute the primary storage space in the aquifer. The ASR project at Leyden, CO provides an ideal test site for hydro-geophysics research. The lessons learned at this site have broad implications on using geophysics, especially micro-gravity and EM methods, in monitoring the dynamics of natural and artificial aquifers.