Multi-phase surface and crosshole geophysical investigations, including time-domain dipole-dipole resistivity and frequency domain Mise-a-la-Masse (MALM) surveys, were conducted on the Captain Jack Project, an EPA Superfund remediation site, located near the town of Ward, Colorado. The Project area consists of an abandoned gold mine comprised of the Big Five Tunnel, the Dew Drop Tunnel, and the Niwot Crosscut. Access into the mine workings is from the Big Five Portal, but extends only approximately 900 feet before a collapse prevents further exploration into the tunnels. Historic data suggests that the Big Five tunnel follows the NE-SW mineralized trend for more than 2000 feet, before intersecting the Niwot crosscut which connects the Big Five to the Columbia vein to the North. The Dew Drop Tunnel is updip of the Big Five, following the same mineralized structure.

The objectives of the first phase of the geophysical program (June 2011) was to characterize the geology of the host rock and the mineralized fault zone, as well as to determine the location of the tunnel system, if possible. Time-domain resistivity results indicated a high resistivity background with lower resistivity fluid conduits, but were unable to image deep enough to detect the mine tunnel. The MALM was used as a reconnaissance survey, with large distances between the lines covering the overall trend of the Big Five and Dew Drop tunnels. However, MALM data showed potential to optimize the placement of drill holes meant to intersect the geologic structure associated with the mine, or intersect the tunnel itself.

The second phase of the surface geophysics (August 2011) consisted of more MALM acquisition on the western end of the project, filling in gaps and areas of interest from the previous work. By combining data from both phases an interpretation of the location of the Big Five tunnel and Niwot intersection was made. This interpretation correlates well with historical renderings. Using the mine tunnel as a transmitting electrode it appears the MALM survey technique was able to image its approximate position 2000 ft into the mountain side, at depths of up to 500 ft. The effectiveness of using the tunnels as electrical transmitters may be dependent on seasonal variations in water levels. Given good seasonal conditions and continuity of cultural features (e.g., rails) and water, the MALM 'in-tunnel electrode' techniques can be used as a tool for tunnel location.

Multiple drill locations were chosen based off of the MALM results. The first two holes were less than 30 ft apart and failed to intersect the tunnel; thus, crosshole ERT was acquired between the borings. Based on the crosshole ERT results, a third boring was drilled on the ERT anomaly and intersected the tunnel. It was determined the initial borehole missed the tunnel by less than 5 feet laterally.

A second location was drilled further along the fault trend. The tunnel was expected to be at a depth of approximately 450 ft. During drilling a large void was encountered at approximately 350 feet, and extended several hundred feet downward. This boring was likely drilled into a previously unknown shaft or winze system.