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Detection of Zone of Seepage Beneath Earthfill Dam

by

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A University Transportation Center Program at Missouri University of Science & Technology

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16. Abstract

MST proposes to acquire resistivity and self-potential data at the Lake Sherwood earth fill dam site. These geophysical data will be processed, analyzed and interpreted with the objective of locating and mapping seepage pathways that might compromise the integrity of the earth fill dam. The main project deliverable will be a map showing the location and estimated depth of any seepage pathways at the site.

17. Key Words

Non-destructive imaging, non-invasive imaging, seepage, self-potential, SP, resistivity, technology transfer, education.

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Detection of Zone of Seepage Beneath Earthfill Dam

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EXECUTIVE SUMMARY

Electrical resistivity and self potential (SP) data were acquired across selected segments of the Lake Sherwood earth-fill dam and in designated areas immediately adjacent to the dam.

The 2-D electrical resistivity profile data were acquired with the objectives of imaging the subsurface to depths on the order of 100 ft and identifying possible seepage conduits. The SP data were acquired with the objective of identifying active seepage/flow pathways in the subsurface.

A zone of anomalously high resistivity was imaged on the acquired electrical resistivity profiles. This zone of anomalously high resistivity is attributed to the grout presence of within soil and bedrock at depths in excess of 30 ft. Non-grouted soil is characterized by low resistivities; non-grouted bedrock is characterized by intermediate resistivities. Unfortunately, the resistivity tool did not provide sufficient resolution to image active fracture conduits in the subsurface.

Anomalously high SP readings (negative values) were recorded at observation locations along the abutment several hundred feet from the upstream face of the dam. This zone is thought to represent an inlet point for the higher temperature waters that exit the downstream face of the dam at the site denoted as the “waterfall”.

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The 2-D electrical resistivity profile data were acquired with the objectives of imaging the subsurface to depths on the order of 100 ft and identifying possible seepage conduits. The SP data were acquired with the objective of identifying active seepage/flow pathways in the subsurface.

2. ELECTRICAL RESISTIVITY DATA

A total of six electrical resistivity profiles were acquired at the Lake Sherwood dam site. Four profiles (1-4) were acquired June 29th; two additional profiles (5-6) were acquired on August 10th.

The four electrical resistivity profiles (1-4) acquired on June 29th were recorded using a SuperSting R8 resistivity unit equipped with 40 electrodes centered on borehole location #10, a Wenner array configuration, and an electrode spacing of 6 feet (Figures 1 and 2). These survey parameters provided for depths of investigation on the order of 35 to 40 ft. Note that station 0 is on the shoreward end of the resistivity profiles; Station 240 is on the dam (Figures 1 and 2).

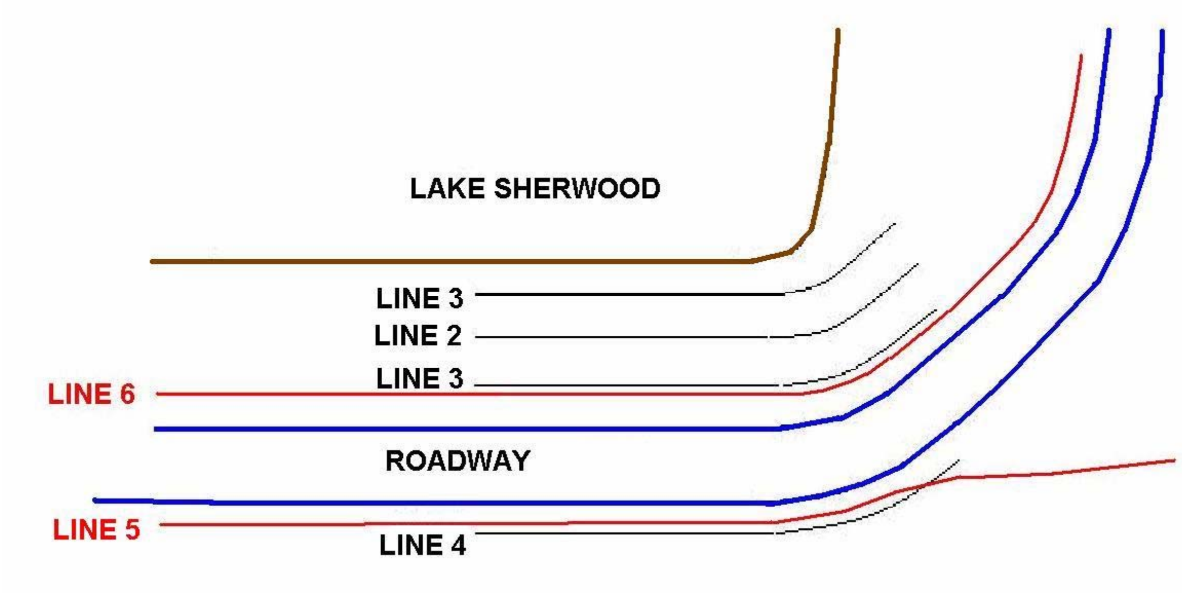


Figure 1: Location of electrical resistivity profiles 1-6.

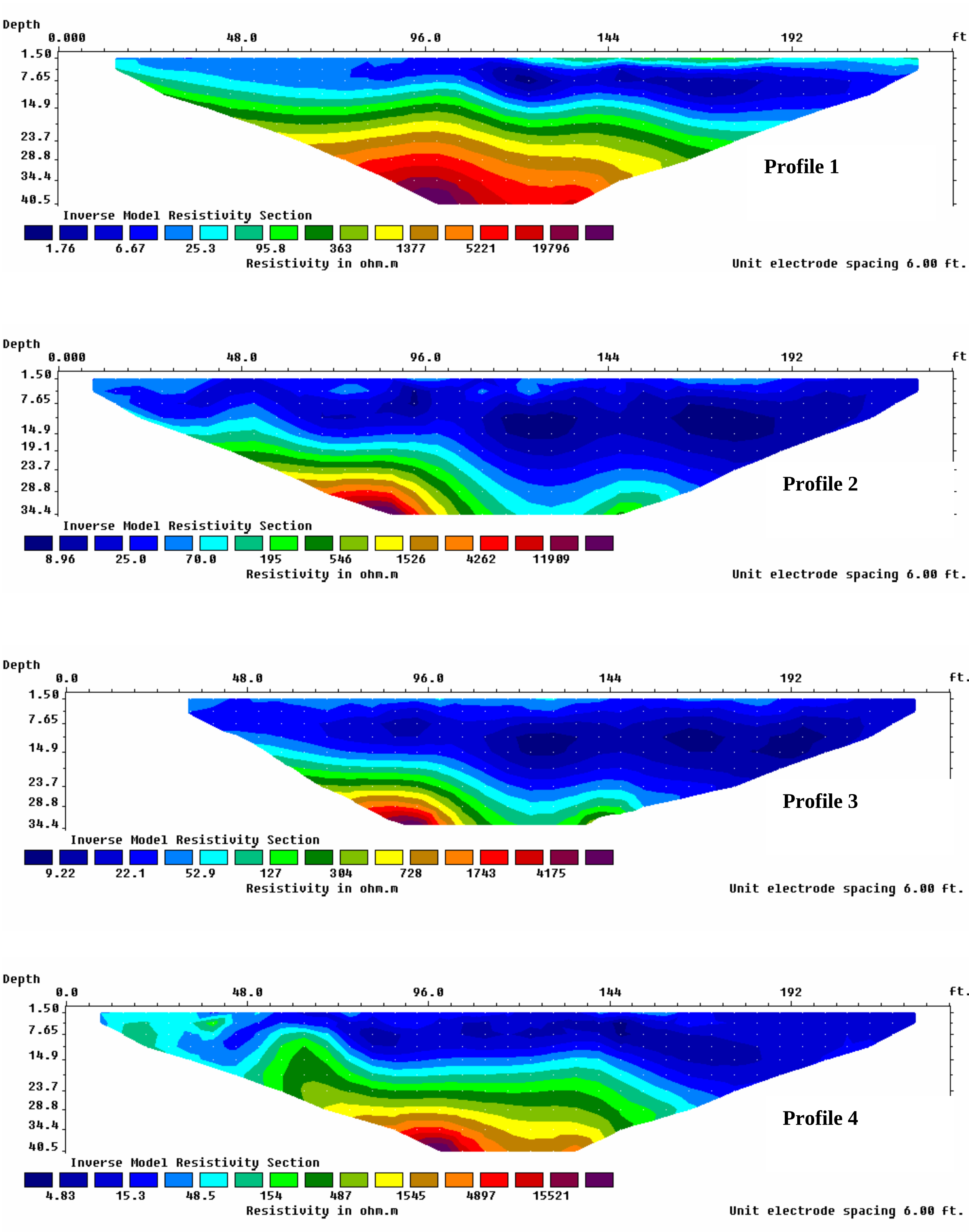


Figure 2: Electrical resistivity profiles 1-4 (Figure 1).

The most significant feature on resistivity profiles 1-4 is the zone of anomalously high resistivity centered between 24and 36 ft to the landward side of the borehole location #10 (center of each resistivity profile). This zone of anomalously high resistivities (>6,000 ohm-m) is interpreted as grouted soil. Non-grouted soil is characterized by low resistivities; non-grouted bedrock is characterized by intermediate resistivities. Unfortunately, the resistivity tool did not provide sufficient resolution to image active fracture conduits in the subsurface.

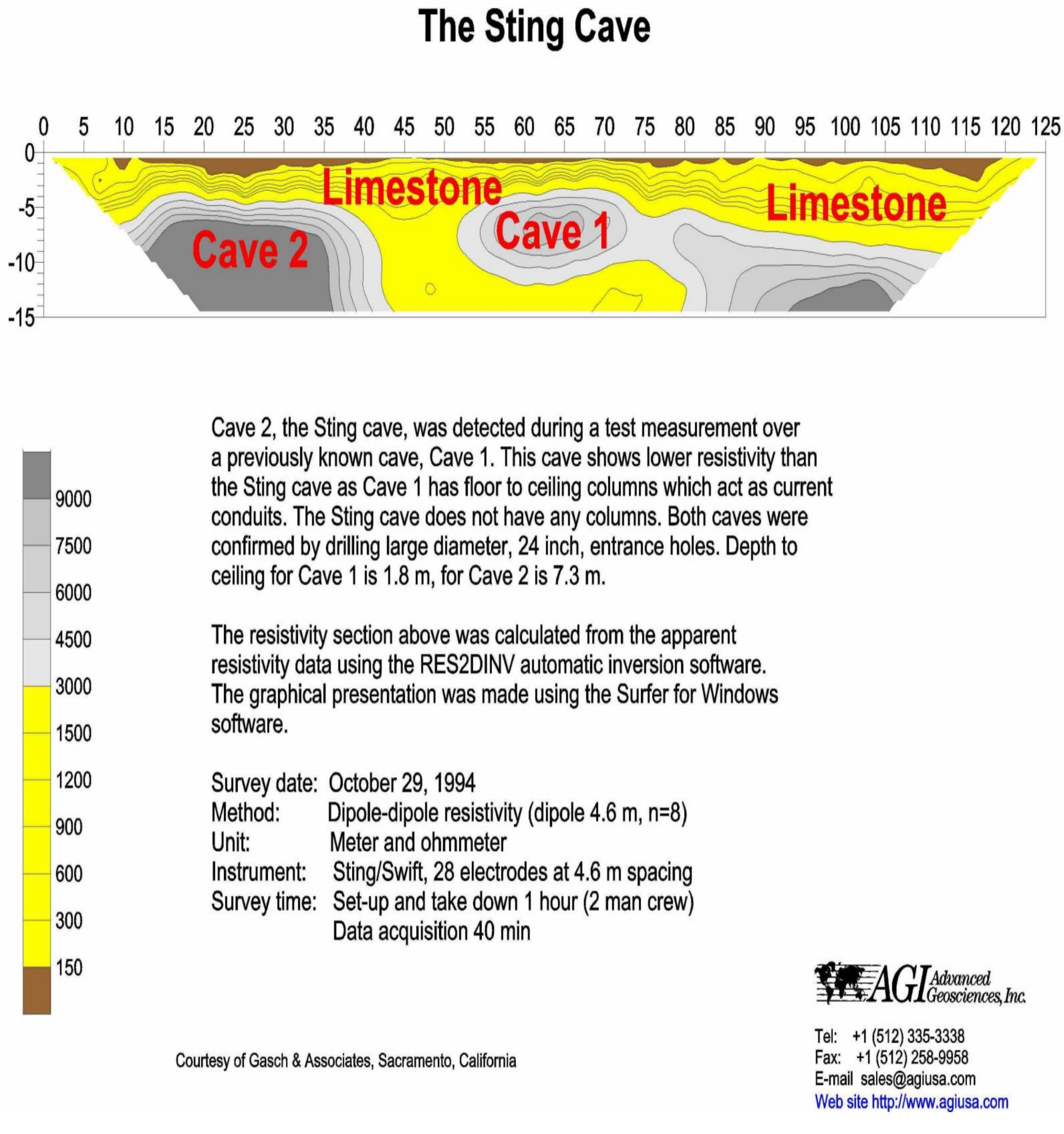
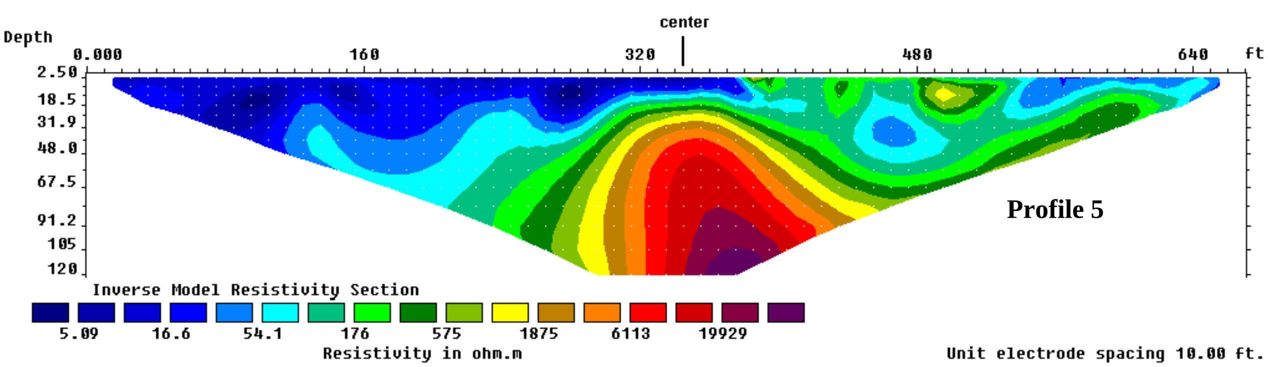


Figure 3: Example electrical resistivity profile across known caves. The electrode spacing was 2.5 ft. Note that the air-filled cavities are characterized by resistivities in excess of 6000 ohm-m (FHWA, 2005).

The two electrical resistivity profiles (5 and 6) acquired on August 10th were recorded using a SuperSting R8 resistivity unit equipped with 68 electrodes centered on borehole location #10, a Wenner array configuration, and an electrode spacing of 10 feet (Figure 4). These survey parameters provided for maximum depths of investigation on the order of 120 ft. Profile #5 was acquired on the downstream side of the dam roadway; profile #6 was acquired on the upstream side of the dam roadway. Note that station 680 is on the shoreward end of the resistivity profiles; Station 0 is on the dam (Figures 1 and 2). (This is reversed relative to profiles 1-4; Figures 1 and 2).



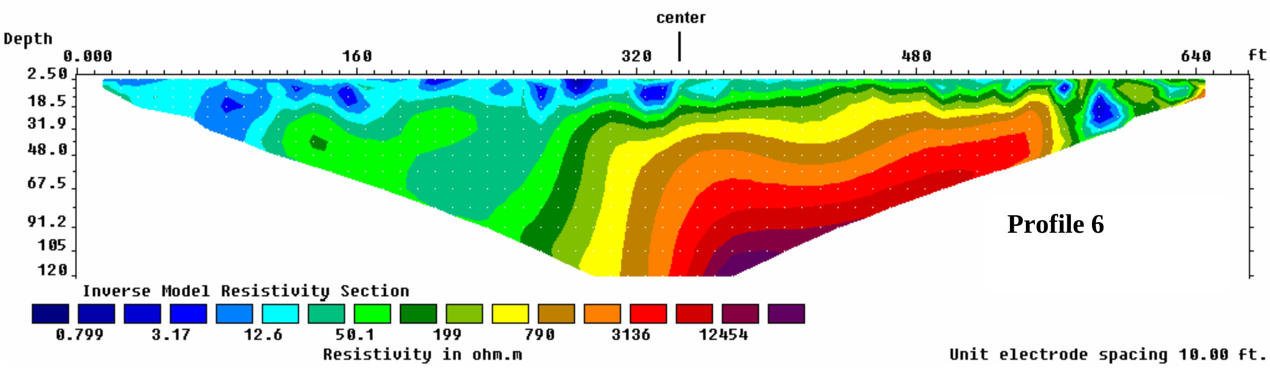


Figure 4: Electrical resistivity profiles 5 and 6. Station 0 is on the shoreward end of the resistivity profiles; Station 680 is on the dam

The most significant feature on resistivity profiles 5 and 6 is the zone of anomalously high resistivity centered between 20and 30 ft to the landward side of the borehole location #10 (center of each resistivity profile). This zone of anomalously high resistivities (>6,000 ohm-m) is interpreted as grouted soil and/or bedrock. Non-grouted soil is characterized by low resistivities; non-grouted bedrock is characterized by intermediate resistivities. Unfortunately, the resistivity tool did not provide sufficient resolution to image active fracture conduits in the subsurface.

3. SELF POTENTIAL (SP) DATA

Self potential (SP) data were acquired at multiple test locations on and immediately adjacent to the Lake Sherwood dam. The trailing electrode was coupled to the base station; located more than 100 ft from the water's edge; the lead electrode was coupled to the ground at each test location (Figure 5).

Figure 5: Non-polarizable Model #920 023 SP electrodes.

The SP tool is unique because it is the only geophysical method that responds directly to the presence of flowing/seeping water (into the subsurface). Locations where water is flowing/seeping into the ground are typically characterized by prominent negative anomalies; locations where water is flowing/seeping out of the ground are normally characterized by prominent positive anomalies (FHWA, 2005). Figure 6 shows two example parallel SP profiles (D-1 and D-2) that were acquired at a study site in northern Kentucky. A prominent negative anomaly is observed on this profile near the center of the profile, at a location where run-off is known to flow into the subsurface along a “losing” stream.

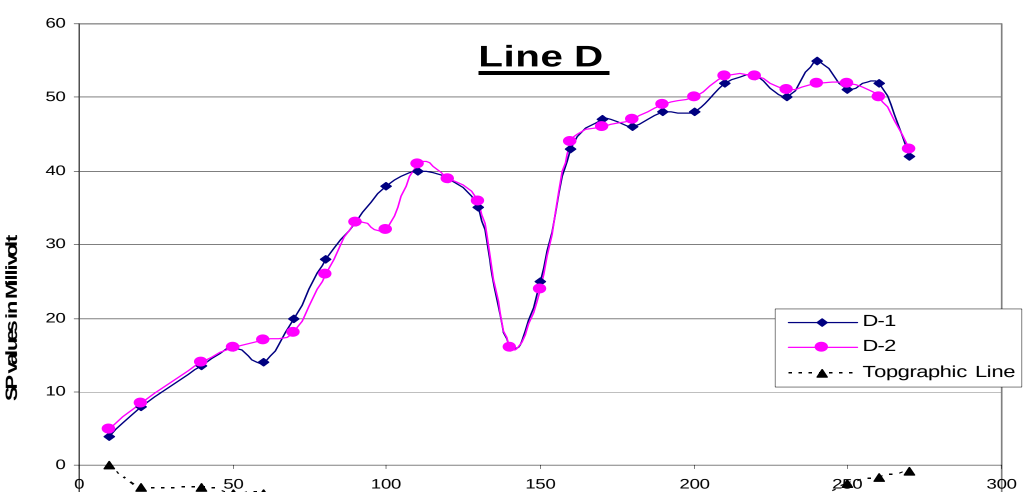


Figure 6: Prominent negative anomaly is observed on example SP profile D-1 and D-2 (Kentucky test site). The prominent negative anomaly is attributed to the flow of water into bedrock at the test location.

The SP data acquired at the Lake Sherwood dam site are presented as Figure 7. Two prominent negative anomalies are observed on this plan view map. The first anomaly, designated as "**A**" on Figure 7, is located on the crest of the dam. This anomaly is thought to be caused by seepage through the face of the dam at this location and at depths of less than 40 ft. However, the anomaly could also be caused by the presence of undetected metal casing, if such casing straddles the water table and is undergoing active corrosion. The second prominent anomaly, designated by the letter "B" on Figure 7, is located at what is thought to be an inlet point for the higher temperature waters that exit the downstream face of the dam at the site denoted as the "waterfall".

4. RECOMMENDATIONS

In our opinion, the zone of anomalously high resistivity adjacent to borehole #10 (landward side) is most probably caused by the presence of grout that has effectively sealed the soil making it impervious. Non-grouted soil is characterized by low resistivities; non-grouted bedrock is characterized by intermediate resistivities. Unfortunately, the resistivity tool did not provide sufficient resolution to image active fracture conduits in the subsurface. Unfortunately, the resistivity tool did not provide sufficient resolution to image active fracture conduits in the subsurface.

In our opinion, the zone of anomalously low (negative) SP readings represents the most probably inlet point for the higher temperature waters that exit the downstream face of the dam at the site denoted as the "waterfall". This interpretation should be considered by any geotechnical engineers involved in ongoing mitigation efforts.

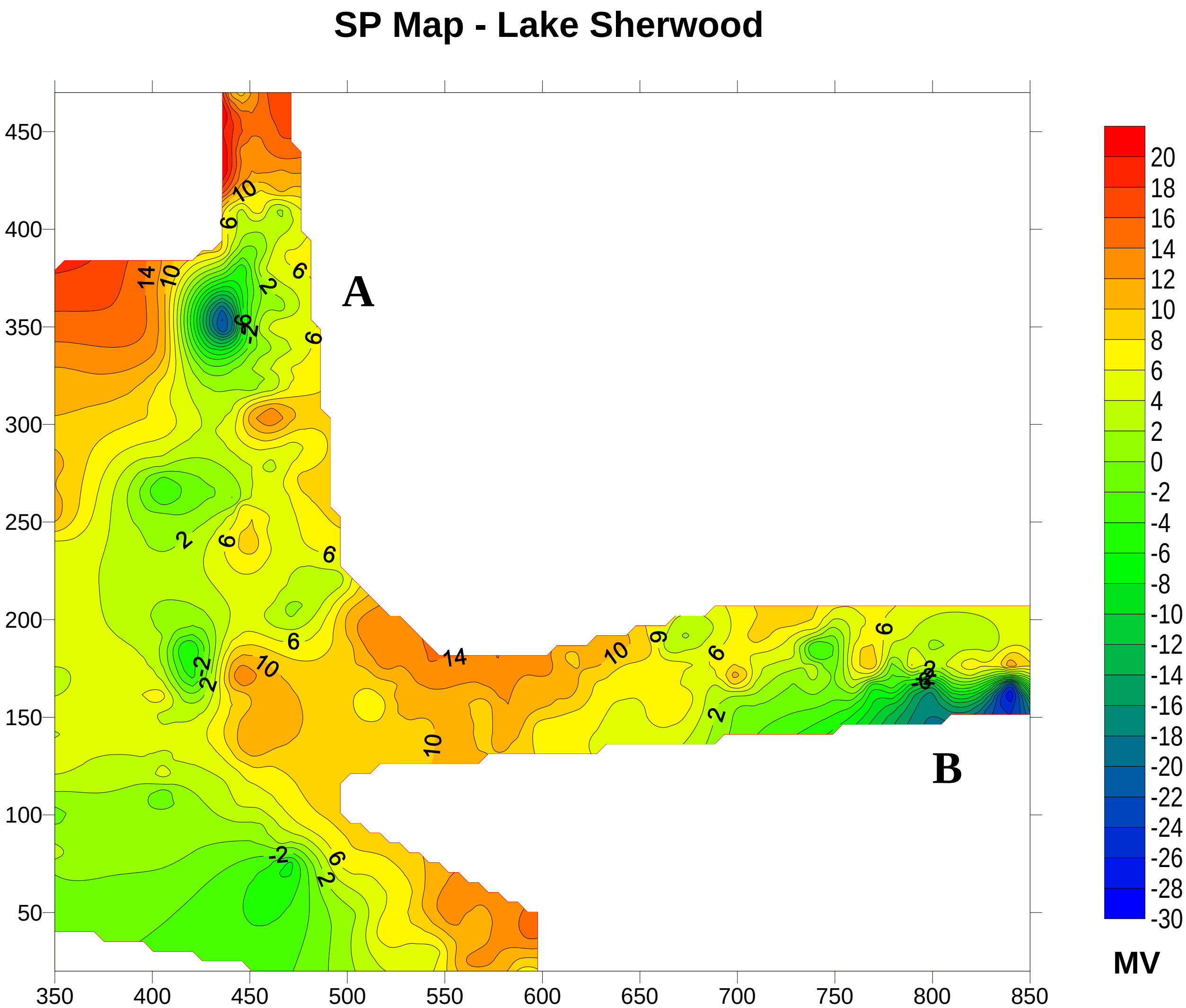


Figure 7: Lake Sherwood dam SP data.

5. REFERENCES

FHWA, 2005, Application of Geophysical Methods to Highway Related Problems: http://www.cflhd.gov/agm/index.htm