THE UNIVERSITY OF MEMPHIS
Center for Applied Earth Science and Engineering Research

MLGW Aquitard Study; Contract 12064
PROJECT 1-4 EXECUTIVE SUMMARY

Project 1-4: *Map potential aquitard breaches in Ensley Bottoms near the Davis well field, TVA, and proximal to the Allen well field using geophysical techniques.*

Objectives

(1) To investigate the depth of penetration of 30-35 m required to image the Mississippi River Valley Alluvial (MRVA) and the Upper Claiborne confining unit (UCCU) with ground-penetrating radar (GPR).

(2) To image the significant change in the electromagnetic properties at the contact of the MRVA and UCCU.

(3) To image potential structures that might allow groundwater movement from the MRVA to the Memphis aquifer.

Summary

- Thinning or localized absence of an aquitard (referred to as breaches) warrants concern as this limits the protection of an aquitard to an underlying water supply aquifers. Previous studies found breaches near the Davis well field, Horn Lake cut-off, and also suspected the presence of breach on President's Island (Criner et al., 1964; Graham and Parks, 1986; Parks, 1990; Parks et al., 1995; Carmichael et al., 2018). Koban et al. (2011) suggest the potential for contamination of the Memphis aquifer through the breaches present in the study area.
- Waldron et al. (2009) and Schoefernacker (2018) used geophysical methods (Seismic reflection and electric resistivity, respectively) to identify breaches in near the Shelby County landfill at Shelby Farms.
- This research used two different GPR systems to perform high-resolution mapping of subsurface features, including the (1) MALÅ GX (160 MHz antenna), and (2) PulseEKKO Pro (50 MHz antenna).
- A total of 91 survey lines (21.6 km in length) were collected in three areas: President's Island (PI), Horn Lake cut-off (HLC), and near the Ensley Bottom pump station (EBPS) (Figure 1, and Table 1).
- The 160 MHz antenna was used to collect data in PI and EBPS, and the 50 MHz antenna was to collect data in HLC.

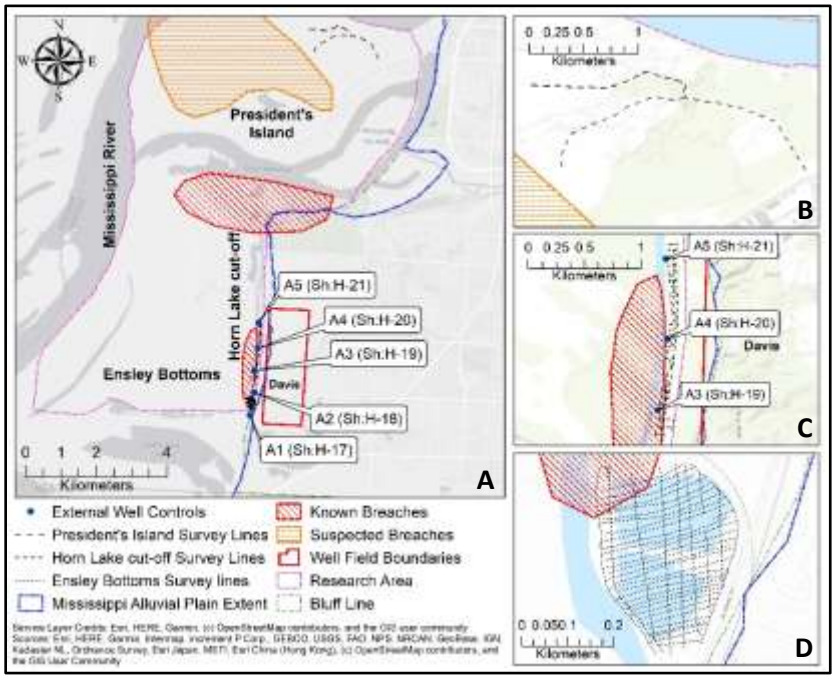

Figure 1: (A) Map showing all survey lines along which GPR data were collected. (B) Location of the survey lines in the President's Island, (C) Location of survey lines in the Horn Lake cut-off, and (D) Location of survey lines near the Ensley Bottoms pump station

Table 1: Number of survey lines with the length of the total survey in each area

Study Area	Number of survey lines	Length (Km)
President's Island	03	5.3
Horn Lake cut-off	47	7.1
Ensley Bottoms pump station	41	9.2
Total	91	21.6

- All data were collected during the summer of 2019 and 2020. GPR data from PI and EBPS were collected after three weeks of rainy weather. Wet conditions prevailed during the collection of data from HLC.
- Geologic well logs of wells A1(Sh: H-17), A2(Sh: H-18), A3(Sh: H-19), A4(Sh: H-20), and A5(Sh: H-21) near EBPS and HLC (Figure 1) were used as an external control to confirm the depth of penetration and stratigraphic variations, where A1, A2, A4, and A5 provide well control for the top of the UCCU. Well A3 indicates and absence of the UCCUin an identified breach (Parks et al., 1995).
- GPR data were processed and interpreted using GPR-SLICE v7.MT to make 2D/3D subsurface images that apply exclusive processes of resampling/binning to recreate GPR data as radargrams using predefined algorithms.

- Findings
  - The GPR achieved the depth of penetration but failed to image the top of the UCCU due to the high attenuation of the signal in overlying strata caused by fine-grained sediments in the MRVA confining unit (MRVA CU) overlying the MRVA aquifer (MRVA AQ) (Figure 2) and the wet condition of the soil. GPR is a poor geophysical method to choose when attempting deep surface mapping.
  - Other issues with objects such as trees and transmission towers caused interference in the radargram, which hinders interpretation. Transmission towers are present in the HLC and EBPS.
  - The interpreted data from PI, HLC, and EBPS show that GPR data can be used to interpret shallow subsurface stratigraphy and deformation to a depth of penetration of about 20 m (Figure 2, and Figure 3).
  - Micro-faults/faults and/or fractures are evident in radargrams from HLC and EBPS (Figure 3B and Figure 3C). Fractures in unconsolidated sand and gravel sediments likely increase vertical hydraulic conductivity, locally.
  - A concave upward reflection at EBPS immediately west of the bluff line is interpreted to be an N-S trending fault zone dipping toward the west (Figure 2, and Figure 3C). Depending on the structure of the fault zone, this may present a pathway for vertical water migration from the MRVA to the Memphis aquifer. The presence of faults in the study area is also supported by the research of Martin and Van Arsdale (2017).

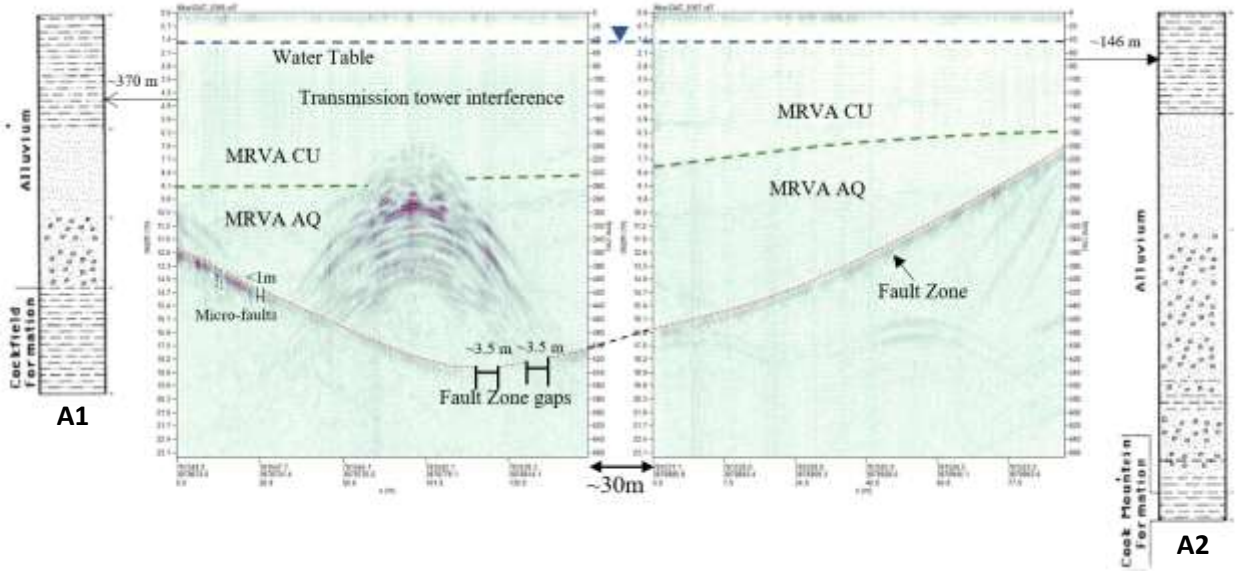

Figure 2: Interpreted fault zone near the EBPS (red dashed line). The hyperbola indicates interference from the nearby transmission tower. The green dashed line indicates boundary between MRVA CU and MRVA AQ, and the water table is shown by blue dashed line.

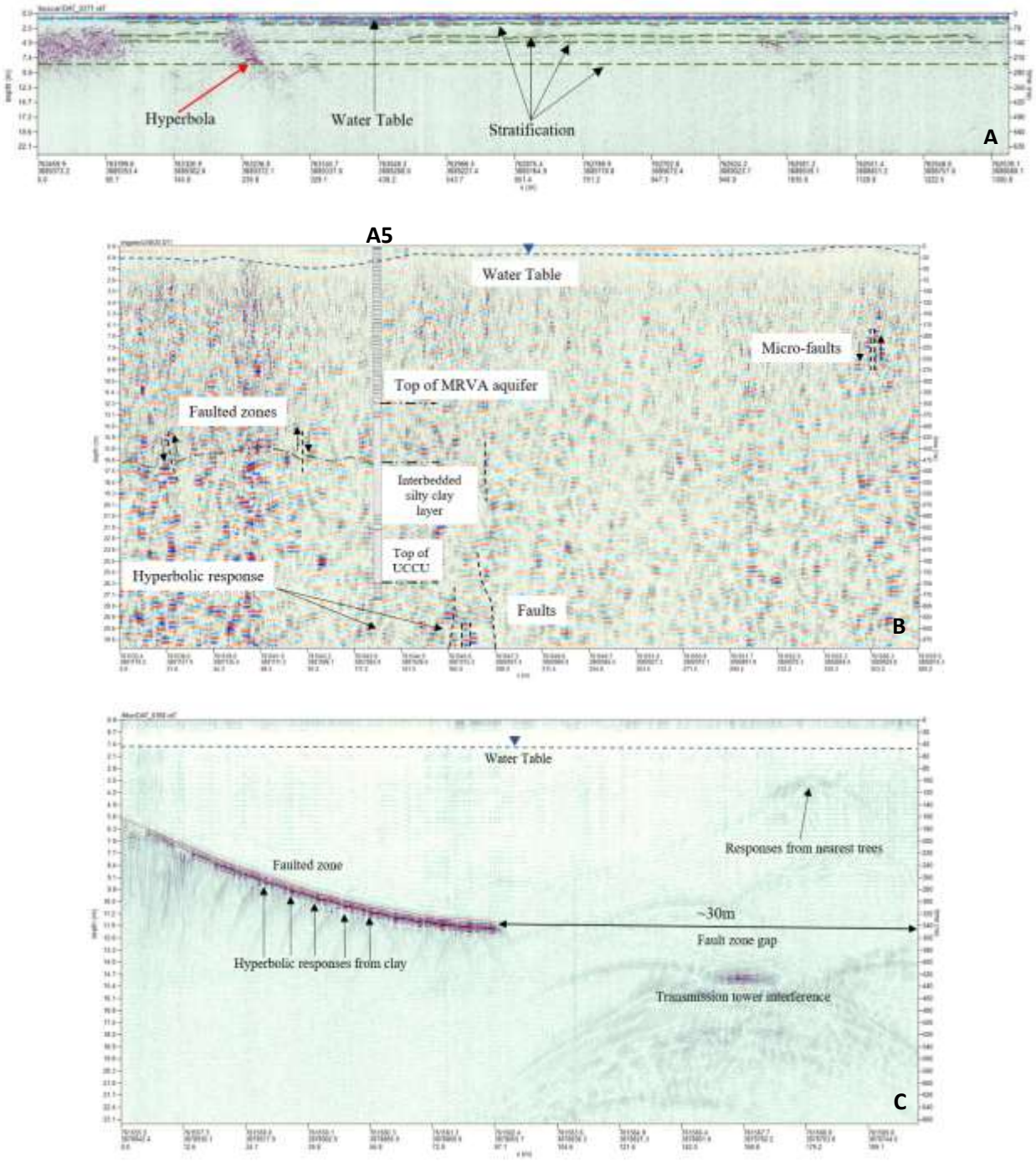

Figure 3: (A) Radargram at PI shows stratifications (green dashed lines) due to changes in the electromagnetic properties of the soil. (B) Radargram at HLC overlaid by the geologic well log of A5 shows faulted zones in the UCCU (top is speculated from the log). (C) Radargram at EBPS showing faulted zone with hyperbolic responses from clay. The blue dashed lines represent the water table in respective areas.

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