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Hydrogeologic Investigation of Subsurface Stratigraphy using Ground Penetrating Radar in Southwestern Shelby County, Tennessee

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INTRODUCTION

An MMRI collaboration with Dr. Daniel Larson and Rizwanal Hasan from the University of Memphis is investigating the effectiveness of ground penetrating radar (GPR) for imaging the subsurface below the Mississippi River floodplain in Shelby, County, Tennessee. GPR is a non-invasive, near-surface geophysical tool that transmits radar signals into the ground and creates a radargram image based on the signal that is reflected off of subsurface layers. The goal of the research is to identify the extent of known and potential breaches in the upper Claiborne confining unit at President's Island and Ensley Bottoms (Figure 1). The presence of breaches in the upper Claiborne confining unit beneath the Mississippi River Valley alluvial aquifer (MRVA) was identified in previous studies using borehole drilling, but the lateral extent of the breaches is unknown. The downward movement of poorer quality groundwater, through these breaches threatens the water quality of the deeper Memphis aquifer. This research will be incorporated into Rizwanal Hasans M.S. thesis.

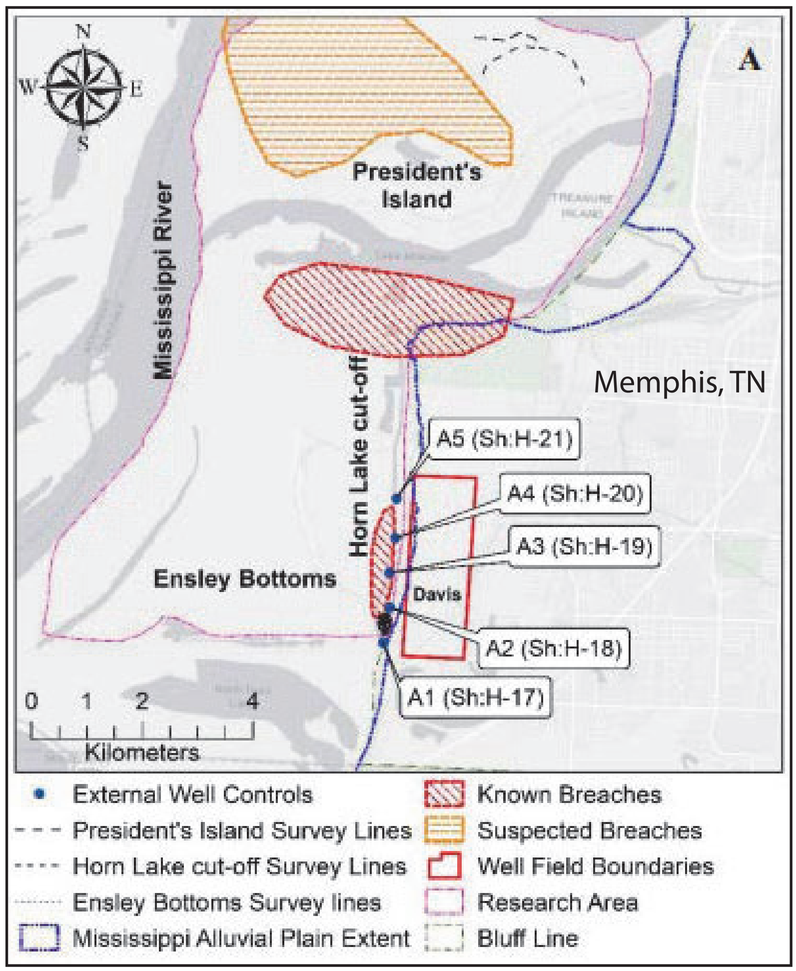

Figure 1. Map of the study areas of GPR survey transects and ground water wells used to ground truth the GPR data.

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IMAGING THE SUBSURFACE

The city of Memphis and Shelby County, Tennessee draws the majority of its municipal, industrial and agricultural water supply from the Memphis aquifer, and to a lesser degree, from the underlying Fort Pillow aquifer, at a rate of over 9.69×10^{05} cubic meters per day (256 million gallons per day). The estimated reserve of groundwater in the Memphis aquifer is about 2.16×10^{14} cubic meters (57 trillion gallons) beneath Shelby County. Historical and current pumping has created a composite cone of depression in the potentiometric surface of the Memphis aquifer around well fields, increasing the potential for a downward hydrologic gradient from the shallow aquifer system to the underlying, semi-confined Memphis aquifer. This downward hydraulic gradient between vertically stacked aquifers may allow water to readily pass through discontinuities within the fine-grained confining unit, or aquitard, to reach a deeper aquifer. These localized discontinuities in an aquitard are termed as breaches and are challenging to identify without extensive subsurface investigation.

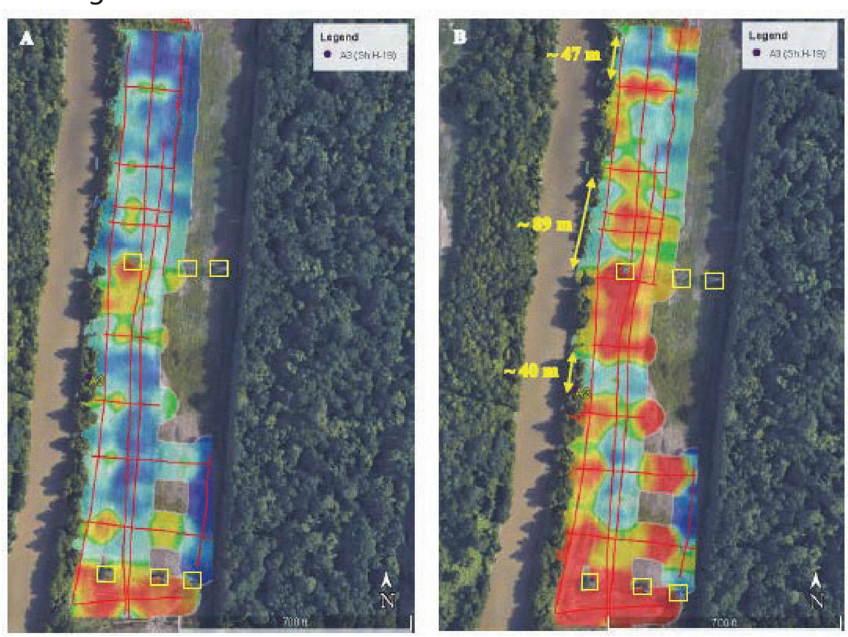
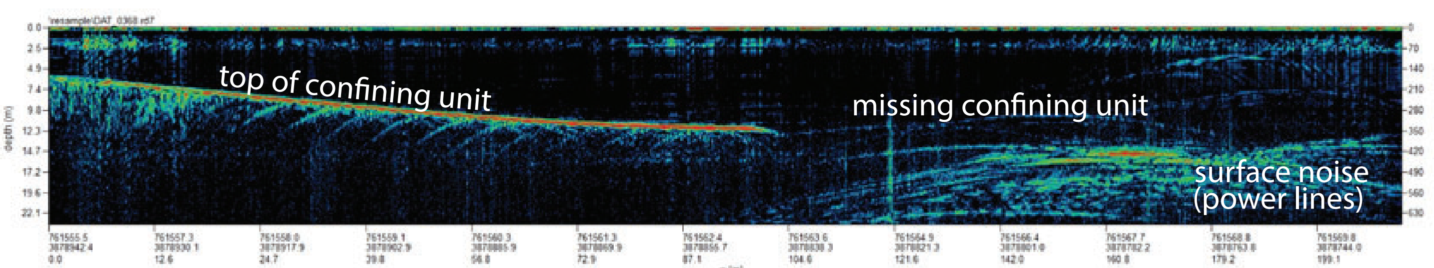


Figure 2. Aerial photograph of the study area near a well used for ground truthing showing depth slices of the GPR data. Red lines are the surveyed profiles. (A) Depth slice at 25.4 m, blue area is aquitard, and (B) Depth slice at 31.5 m, below the aquitard.

A total of 91 transects totaling 21.7 km of radar data were acquired for this project. The GPR radargrams for the east side of the well field and parallel to the valley margin show a well-defined, concave upward surface at 12.75 m at its shallowest and 26 m at its deepest. Geologic data from a borehole 400 m to the south of the profile suggest the surface is likely the top of the aquitard. The radargram resolution is high enough to reveal small, approximately 1 m wide discontinuities as well as a large discontinuity that is over 30 m long. However, the ~30m wide discontinuity appears to show where the aquitard is missing. This is consistent with geologic log data from other boreholes in the area that show the aquitard is missing.



Future Work

Future work will include more GPR surveys with the 160 MHz system to test its sensitivity and with a 50 MHz GPR system to image deeper variations in the subsurface stratigraphy where the aquitard is thin or absent. Furthermore, additional GPR data needs to be collected at the Davis well field where some of the GPR data show vertical displacements in horizontal reflectors that appears to be from a fault that may displace the base of Quaternary alluvium. This could be part of the Meeman-Shelby fault system, which is over 50 km long, and recent research has shown it has a long slip history with the most recent occurring in the mid-Holocene.