UNCONVENTIONAL DEEP-WATER GPR INVESTIGATION OF DRILLING OBSTRUCTIONS

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Abstract

GPR was used at a dam rehabilitation drill site to assess the extent of a metal obstruction within limestone bedrock beneath almost 100 feet of water. The obstruction, thought to be pipe casing, was encountered during the emplacement of a concrete pile cutoff wall. The metal had been removed by excavation to a depth of 20 feet and the excavation filled with concrete, but further drilling encountered additional metal. The problem was to determine if the metal persisted at depth. The lake bottom survey was made more challenging by the constraints that the survey location was situated 5 feet behind the dam and 5 to 15 feet from metal sheet piles of unknown depth. Other constraints included spill-way releases during high water levels and power generating schedules.

The survey was designed for an underwater investigation on the lake bottom using the Tubewave-100 borehole radar antenna. Work was performed from a mini-tug, with the antenna dragged along the lake bottom. Additional investigations were conducted in the same manner to locate rebar in concrete structures.

Introduction and History

The Walter F. George Dam is the largest dam in the Chattahoochee Basin and generates 130 MW of hydroelectric power for approximately 56,000 homes. Located about one mile north of Fort Gaines, Georgia, the dam crosses state lines and sits partly in Henry County, Alabama (Figure 1).

The U.S. Army Corps of Engineers, which owns and operates the dam, constructed the facility between 1955 and 1963. The lock has a lift of 88 feet, one of the highest in the nation (Figure 2). The lake behind the Walter F. George Dam, known as Lake Eufaula in Alabama and the Walter F. George Lake in Georgia, extends 85 miles upriver and has 640 miles of shoreline. It is a popular fishing and vacation area (http://www.sam.usace.army.mil/op/rec/acf/info.htm).

The base of the Walter F. George Dam rests on jointed limestone bedrock, which has been a source of seepage problems since the dam was completed over 40 years ago. During the 1980s, the USACE attempted to stop the seepage by installing cut-off walls in front of earthen embankments east and west of the dam. This significantly reduced seepage under the embankments; however, water infiltration under the concrete structures of the dam continued. Additional grouting was conducted to plug concentrated seepage sources, particularly under the powerhouse, where peak flows measured over 30,000 gpm.

Figure 1.: Location of the Walter F. George Dam, Fort Gaines, Georgia.

Figure 2.: Looking into a lock at the Walter F. George Dam.

Unable to solve the seepage problem, the USACE decided to construct a 24-inch-thick concrete cut-off wall in front of the dam and beneath the lock guide walls. The seepage cutoff wall would be the first in history to be erected in front of an active dam. It would consist of more than 450 drilled piles, each 50 inches in diameter and spaced 33 inches from center to center and extending 300 feet into earthen embankments on either side of the dam. The underwater portion of the project covered approximately 1,270 linear feet.

The contract to install the concrete cutoff wall was awarded to Treviicos/Rodio Joint Venture, and construction began in January, 2002. The piles were installed using two casing-mounted, reverse-circulation drilling rigs. Each rig was positioned on the 54-inch-diameter casings, which had a length of 130 feet (Figure 3). When drilling was completed, the pile was checked for vertical alignment against the adjacent pile, and concrete was then placed using a tremie pipe positioned within 1 foot of the bottom of the pile (Figure 4). When placement was completed, the casing was removed.

Figure 3.: Setup for pile installation in front of the dam.

Figure 4.: Rig set up for concrete placement.

During emplacement of Pile 187 in the spring of 2002, Treviicos encountered a metal drilling obstruction in the bedrock. The obstruction was removed by excavation to a depth of 20 feet below the lake bottom and the excavation filled with concrete. Drilling resumed to a depth of 25 feet below the lake bottom, when additional metal obstructions were encountered. Treviicos wanted to determine the extent of the metal obstruction in order to decide whether or not to abandon the Pile 187 location.

Technical Approach

Treviicos contacted HGI and asked if it would be possible to locate the metal obstruction at Pile 187 and determine its extent. The physical constraints of the survey were known to be:

- Approximately 95 feet water depth;
- Concrete dam structures 5 feet south;
- Metal sheet pile of unknown depth approximately 5-15 feet north; and
- Time constraint defined by an allotted time period whereby power generation was stopped and spillways next to the survey area would be closed.

Using these parameters, HGI designed an underwater investigation of the lake bottom using a Tubewave-100 (TW-100) borehole radar antenna. The TW-100 37 mm directive borehole transducer has a center frequency of 100 MHz and can be used for sub-bottom profiling in water as well as borehole applications. The site conditions and resources available made the initial plan to troll in a boat with the antenna in tow infeasible. As a result, the survey was modified to work from a mini-tug, dragging the antenna along the lake bottom by traversing the length of the mini-tug. As noted above, for safety reasons the survey could not take place during power generation (Figure 5).

Figure 5.: Water rushing over the dam spillway during power generation, when the HGI field crew was not able to collect data.

Data Collection and Analysis

GPR data were collected along the lake bottom using the TW-100 in both mono-static and bi-static configurations, using a range of 600 ns. Data were collected in continuous mode, with the antenna pulled along a rope while traversing the mini-tug deck for approximately 20 feet in north-south and east-west directions. The GPR data were digitally recorded on the hard drive of a GSSI SIR System 2000 data collection unit. Figure 6 shows the data collection setup on the mini-tug, and Figure 7 shows the TW-100 ready to be lowered into the water.

After completion of data collection, the GPR records were downloaded to a PC for processing using GSSI's RADAN for Windows NT™. Processing included application of band-pass filtering, background removal, horizontal stacking, and averaging, deconvolution, migration, and range gains. The GPR records were then analyzed to obtain the calculated depth to the top and bottom of the presumed metal obstruction at Pile 187, as well as a presumed metal sheet pile on the lake bottom.

Unforeseen conditions encountered during the survey included:

- A sufficiently large concrete pad at the Pile 187 site that the antenna was mostly coupled with concrete and not the natural lake bottom; and
- A unique concrete composition that includes bentonite, a conductive clay derivative.

Although these conditions were not fatal to the investigation, they did attenuate signal strength, resulting in a lower signal-to-noise ratio that required a higher level of processing.

Figure 6.: GPR data collection system set up on the mini-tug.

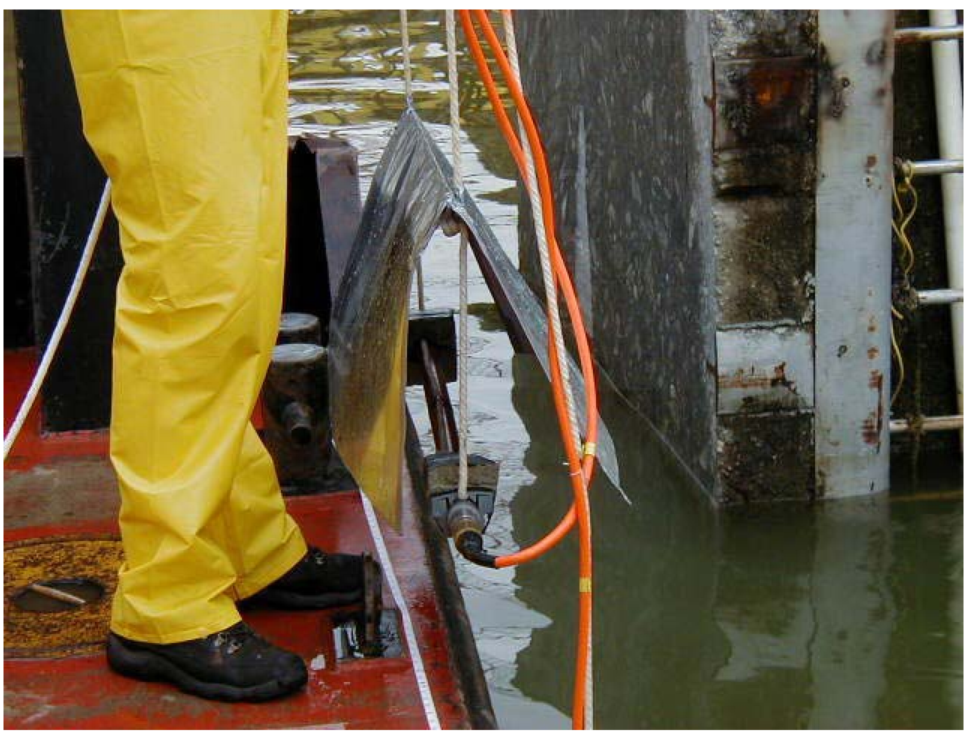

Figure 7.: TW-100 antenna ready to be lowered into the water.

Conclusions

HGI's unconventional GPR investigation using the Tubewave-100 behind the Walter F. George Dam was able to map features on the lake bottom in 95 feet of water. Figure 8 is an annotated, processed GPR record from the survey, with the locations of the metal pipe obstruction and other manmade structures indicated. Treviicos subsequently abandoned Pile 187 and extended the cutoff wall around it. HGI returned in the summer of 2002 for a follow-up GPR survey to determine whether other obstructions were present along the new alignment. No additional metal obstructions were identified.

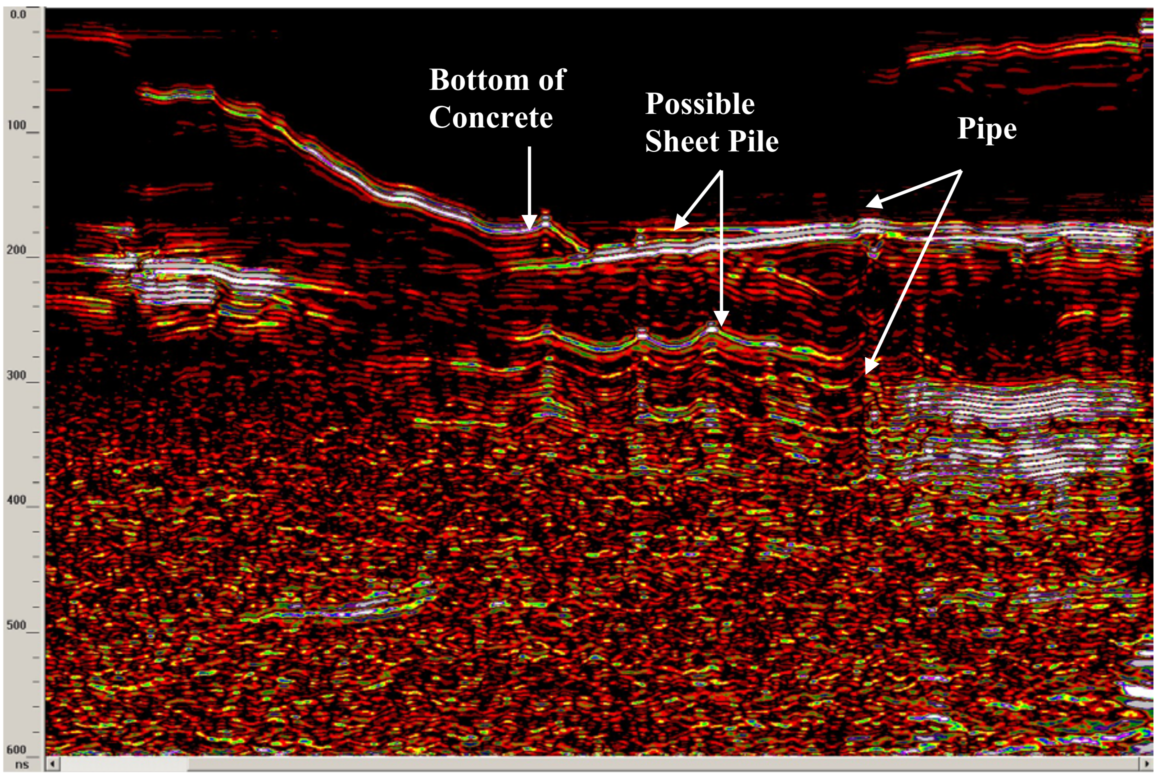

Figure 8.: Processed GPR record for data collected from an east-west run from the mini-tug. Record has been migrated.

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