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Characterization of Water-Bottom and Bedrock GPR and CHIRPceiver Sub-bottom Profiling

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Summary

A geophysical investigation was performed to characterize the near surface geology in the waterways upstream of a dam. The objective was to map the water-bottom and delineate depth to bedrock and expand upon a previous survey conducted in 2021. The investigation employed the use of both GPR and marine sub-bottom seismic acquisition to obtain the necessary results. The equipment used:

Instrument	Specifications	Method	Area
Mala EasyLocator Pro HD	80 – 950 MHz	GPR	Sandbar, head pond
Mala GroundExplorer GX80 HDR Antenna		GPR	River
GSSI 10Mhz Bistatic Antenna	10 MHz Bistatic	GPR	River
Falmouth HMS-622 CHIRPceiver	1-10 KHz – Single Frequency	Marine Seismic (SBP)	River

This investigation highlights the strengths and weaknesses of both methodologies and demonstrates how the combination of methods can accurately characterize the subsurface geology in very shallow aquatic environments or on land. In the water, the GPR systems were able to characterize water-bottom but due to attenuation and lack of signal penetration failed to identify bedrock surface, see Figure 1 below for penetration depths. The marine sub-bottom profiler system was able to map sediment thickness providing both water-bottom and bedrock surface but was limited to areas of water depths greater than 1 meter (Figure 3). In

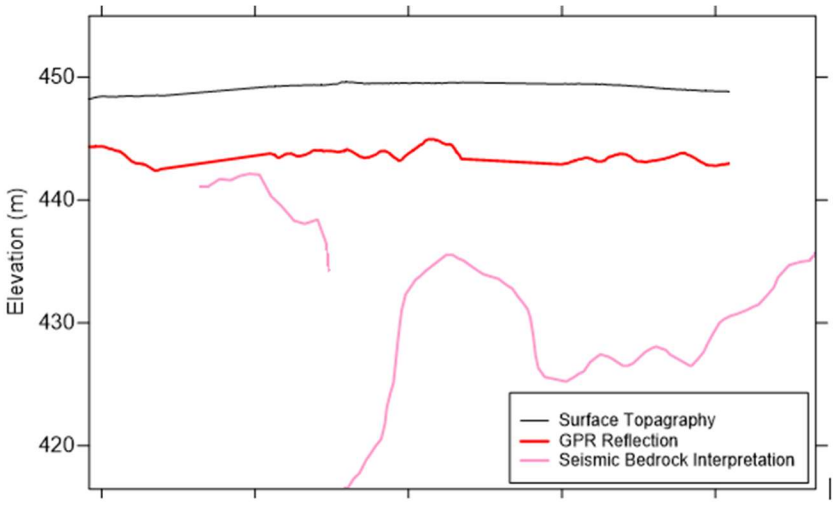

Figure 1: Comparison of Seismic versus GPR in the river. GPR only provided bathymetry in the water.

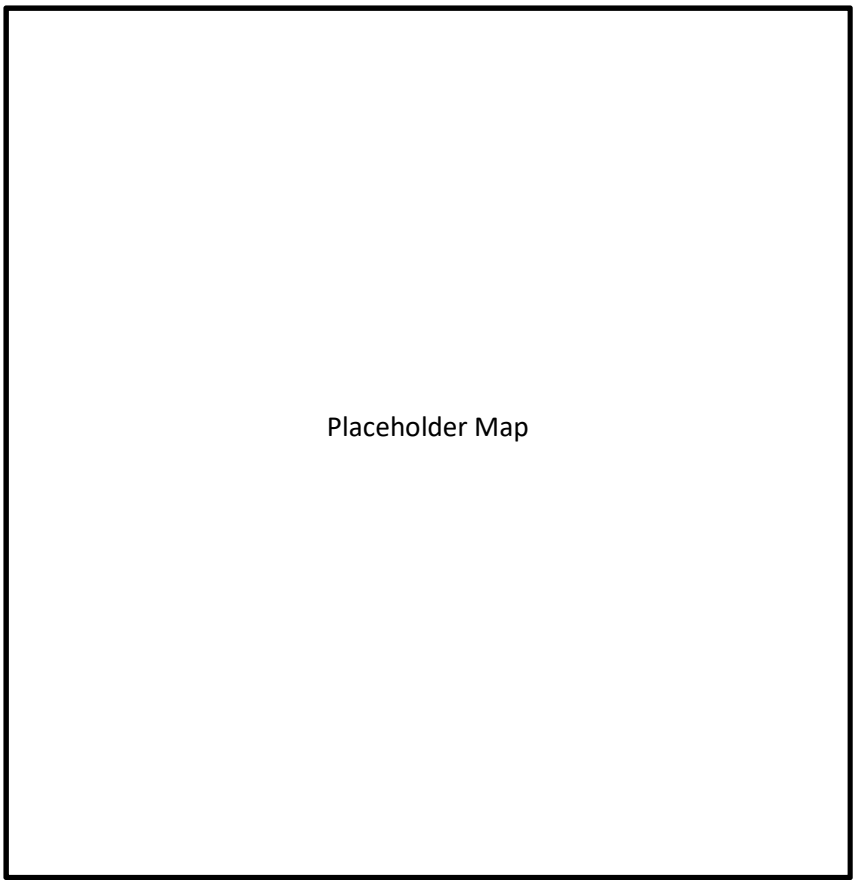

Figure 2: Interpreted Sediment and Bedrock Thickness along the river channel.

Methods

The sub-bottom profiler is a subset of seismic acquisition. This method involves transmitting acoustic signals and recording the echoes that bounce back. A reflection occurs when there is a contrast in the acoustic impedance. Acoustic impedance for a single layer can be represented by:

$$Z = \rho V_p$$

Where ρ is the density in kg/m^3 and V_p is the p-wave velocity in m/s.

The collected signals (arrival times) are then processed and displayed as a record from which reflectors can be picked. The prominent reflectors being the water-bottom and bedrock. The CHIRPceiver system utilizes a frequency sweep in its operation and emits pulses through its transducers, the system is towed behind the boat as shown in Figure 3 and data is collected through a single hydrophone. Boat operation can be essential to data quality as keeping the source and hydrophone aligned can be difficult through river currents, passes are made with the current to reduce noise.

Figure 3: CHIRPceiver system being towed along the river, Geode GNS system (yellow) collecting GPS coordinates.

GPR uses electromagnetic waves to image the subsurface. It sends a radio waves into the ground and detects the reflected signals from subsurface structures. GPR is sensitive to changes in the electrical properties of the ground. Subsurface structures such as moisture content, material composition, and the presence of voids or objects will change these properties. The selected frequency used for GPR allows for optimization of the survey, penetration and resolution are often mutually exclusive with lower frequency increasing depth of investigation and higher frequencies increasing resolution.

Conclusions

The survey makes use of both GPR and sub-bottom profiler. This investigation highlights a niche approach in geophysical surveys, particularly in complex environments such as fluvial systems. While each method has its strengths and weaknesses, their combined application allows for a more comprehensive understanding of subsurface conditions. The GPR systems' efficacy in shallow and terrestrial environments complements the marine seismic system's ability to explore deeper aquatic settings. This ensures that a full profile of the sediment deposits, from the riverbed to the deeper sediment layers, is accurately characterized. Initial planning is crucial and referencing of any ground-truth information available will allow for better survey design and selecting the correct geophysical method to apply.

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References

1. Wang Rui et al 2018 IOP Conf. Ser.: Earth Environ. Sci. **128** 012113
2. LeBlanc L.R., Mayer L., Rufino M., Schock S.G., King J., Marine sediment classification using the chirp sonar, The Journal of the Acoustical Society of America, 91(1), **107** – 115)