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Evaluating through-water terrestrial laser scanning under a range of flow and suspended sediment conditions

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The fine scale structure of the water-sediment boundary in fluvial environments is dynamic and complex, influencing near-bed flows, sediment transport and instream ecology. Recent advances in surveying technology have enabled the acquisition of high-resolution topographic datasets for both exposed and deeply submerged surfaces using terrestrial and bathymetric LiDAR respectively. However, there remains the challenge of accurately surveying marginally- or partially- inundated areas of river channels. Preliminary tests confirm that terrestrial laser scanning (TLS) can be performed through relatively shallow water columns, obtaining three-dimensional submerged topography at a millimetre resolution. With correction for laser refraction at the water surface and estimation of the actual point of laser emission, scanning through water using a standard green-wavelength time-of-flight terrestrial laser scanner has been shown to introduce additional errors of less than 5 mm with no effect on point precision. For partially-submerged surfaces, the sub-aerial and submerged components can be united seamlessly within a single three dimensional topographic model. However, to date, this method has only been evaluated under ideal conditions of a static, relatively shallow and clear water column.

This paper evaluates through-water TLS under variable flow and suspended sediment conditions to establish the additional error introduced. In a laboratory setting, submerged topography was acquired under variable water flow, colour and suspended sediment conditions. Decreased precision was observed with increased flow rates, while the effect of suspended sediment in the water column decreased the number of returns to the laser scanner as a function of laser path distance through the turbid water and suspended sediment concentration. The potential range of flow conditions within which through-water terrestrial laser scanning can be applied is established and additional error expected from given flow velocities and suspended sediment concentrations is presented. While many applications requiring high-resolution, high-precision data will require favourable flow conditions to achieve this, other potential applications (surveying submerged bridge structures, for example) may find the additional error introduced under normal flow conditions acceptable for the purposes of the survey. In general, while it is not proposed that through-water TLS is applicable for reach-scale surveys, it presents a rapid method for surveying marginally- or partially-submerged gravel patches that can be embedded seamlessly within larger sub-aerial surveys. It is particularly relevant for ecological applications and the evaluation of instream habitat under different flow regimes.