Reservoir siltation and Quaternary stratigraphy beneath the Mactaquac headpond, New Brunswick, Canada, as revealed by acoustic and ground penetrating radar sub-bottom imaging

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The 660 MW Mactaquac Hydroelectric Generating Station is located on the Saint John River approximately 20 km upriver of Fredericton, New Brunswick, Canada. As part of an aquatic ecosystem study designed to support a decision on the future of the station, sediment in the headpond, extending 80 km upriver, is being examined. The focus of this sub-study lies in (1) mapping the thickness of sediments that have accumulated since inundation in 1968, and (2) imaging the deeper glacial and post-glacial stratigraphy.

Acoustic sub-bottom profiling surveys were completed during 2014 and 2015. An initial 3.5 kHz chirp sonar survey proved ineffective, lacking in both resolution and depth of penetration. A follow-up survey employing a boomer-based “Seistec” sediment profiler provided better results, resolving sediment layers as thin as 12 cm, and yielding coherent reflections from the deeper Quaternary sediments.

Post-inundation sediments in the lowermost 25 km of the headpond, between the dam and Bear Island, are interpreted to average 26 cm in thickness with the thickest deposits (up to 65 cm) in deep water areas overlying the preinundation riverbed adjacent to Snowshoe and Bear islands (both now submerged). A recent coring program confirmed the presence of silty sediment and showed good correlation with Seistec thickness estimates. In the ~15 km stretch upriver of Bear Island to Nackawic, the presence of gas in the uppermost sediments prevented sub-bottom penetration and acoustic estimates of sediment thicknesses. Profiles acquired in the uppermost ~40 km reach of the headpond, extending to Woodstock, showed a strong, positive water bottom reflection and little to no sub-bottom penetration, indicating the absence of soft post-inundation sediment.

Deeper reflections observed within 5 km of the dam revealed a buried channel cut into glacial till, extending up to 20 m below the water bottom. Channel fill includes a finely laminated unit interpreted to be glaciolacustrine clay-silt covering a possible esker – similar to stratigraphy downriver at Fredericton.

A waterborne GPR survey, using 100 MHz antennas, was conducted near Nackawic in August, 2016 to evaluate its suitability as an alternative to acoustic profiling in areas of gas-charged sediment. This proved to be an effective solution to the “acoustic blanking” problem, revealing bottom sediment layers with estimated thicknesses of less than 1 m. This approach was limited to water depths of ~15 m due to signal absorption, as a consequence of the moderate electrical conductivity (~120 uS/cm) of the water.

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