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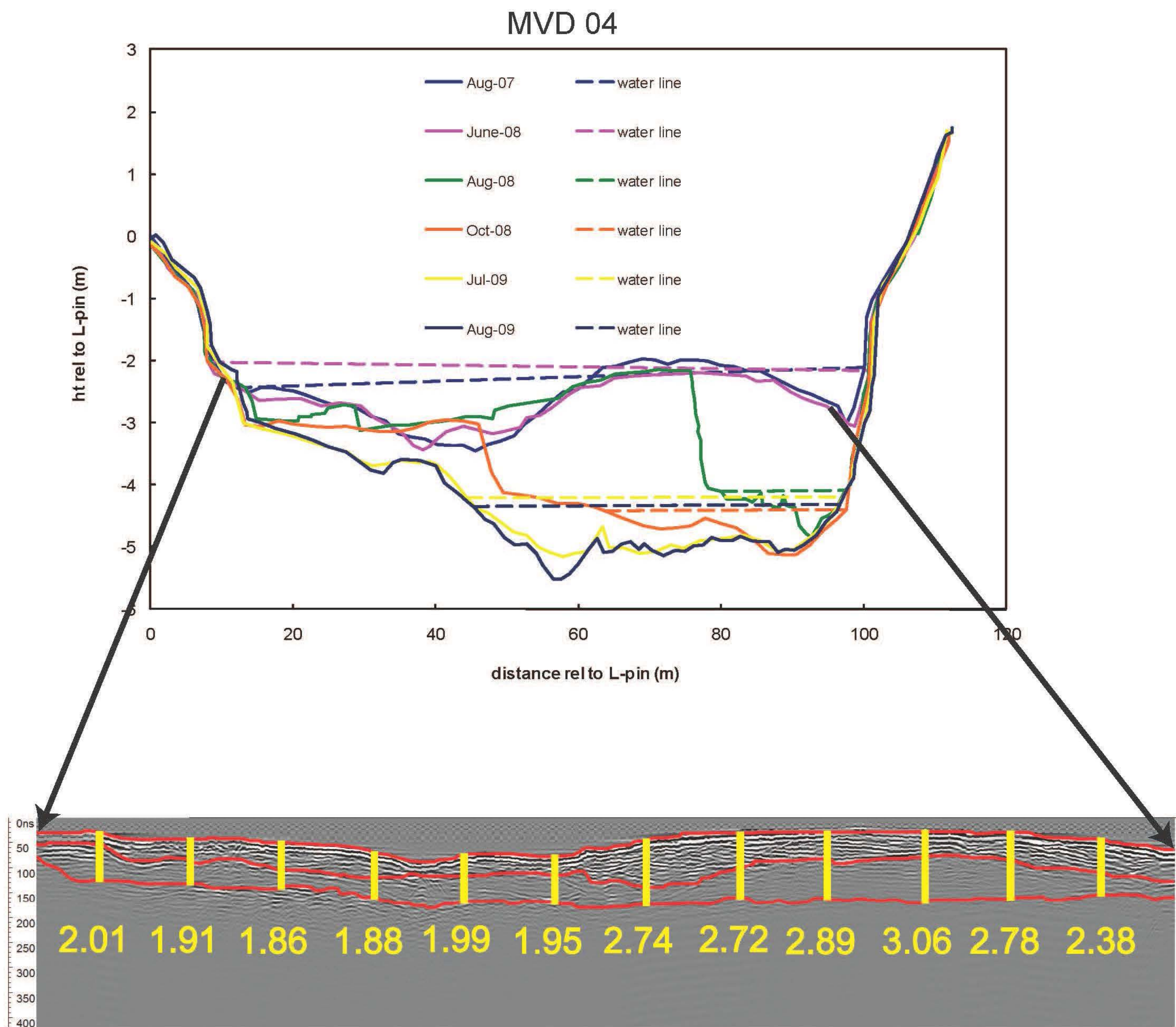
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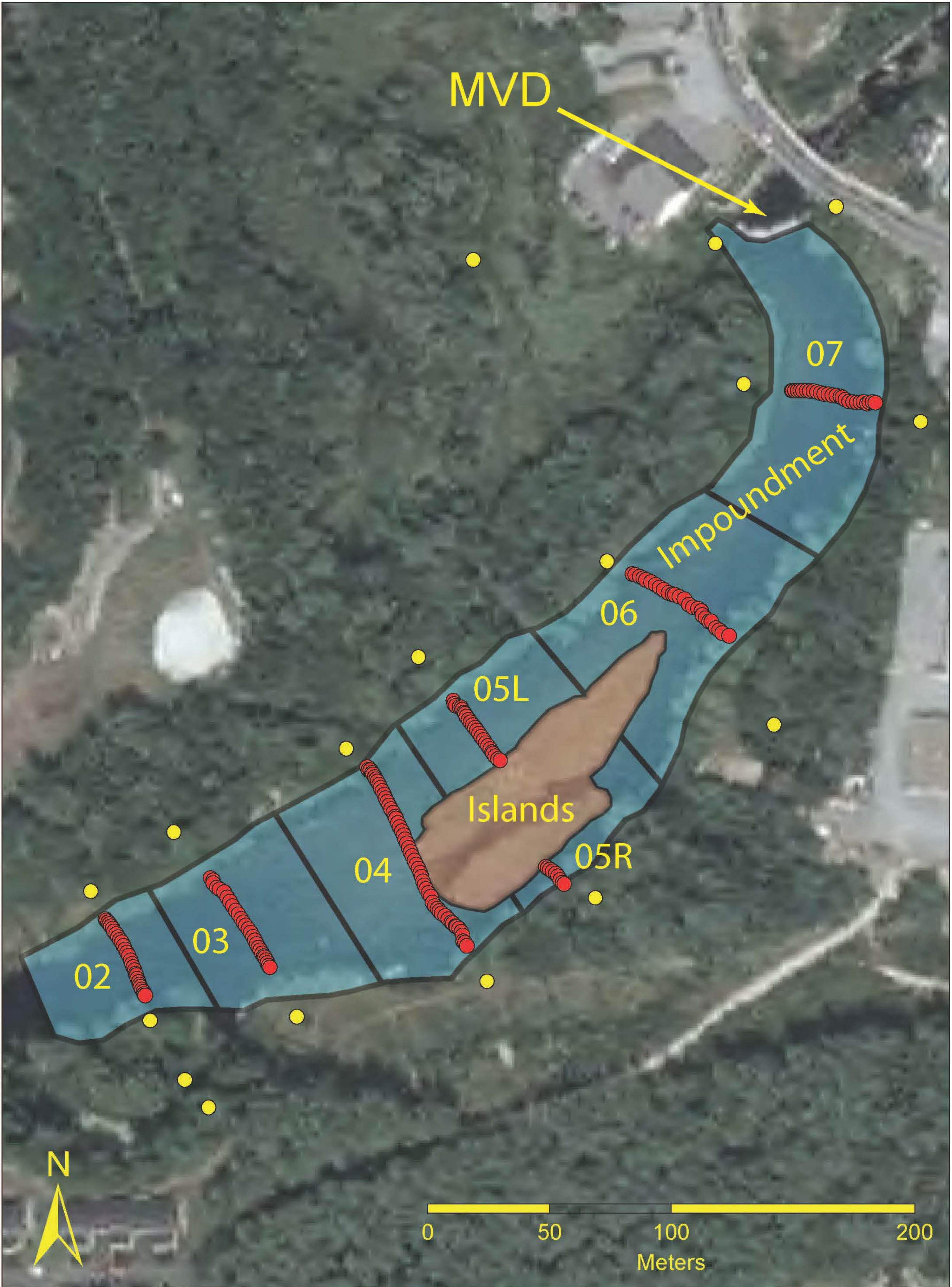
Estimating the Quantity of Sediment Stored Behind the Merrimack Village Dam

David Santaniello & Noah Snyder

We investigate the viability of ground penetrating radar (GPR) as a method to estimate the quantity of sediment stored behind the Merrimack Village Dam (MVD) on the Souhegan River in southeastern New Hampshire. If the pre-dam riverbed can be imaged, the thickness and volume of the reservoir deposit can be calculated without physically sampling the material. Such estimates are necessary to plan sediment management after dam deconstruction. In May 2008, seven cross sections were surveyed with a Mala Geosciences ProEx 100 MHz GPR unit. The instrument was deployed in a canoe and paddled across the reservoir, while a GPS unit placed on top of the GPR device recorded the location. We choose the MVD as the field site for this study for several reasons. First, the dam was removed in August 2008, allowing the GPR interpretations to be ground-truthed as the river incised into the reservoir deposit. Second, the sediment was known to be almost exclusively sand overlying a pre-dam riverbed of gravel, cobbles, and boulders, and this difference in material creates a strong reflection of electromagnetic (EM) waves capable of being imaged by GPR. Also, the deposit included few ferromagnetic materials, so magnetic permeability will not affect the imaging, and the conductivity of fresh water is low, so the EM wave attenuation is low enough to survey several meters into the subsurface. Finally, the reservoir deposit could be at most ~6 m thick, the height of the dam, guaranteeing the pre-dam riverbed would be visible on the GPR image. In a related study by MS candidate Adam Pearson, topographic and bathymetric surveys were conducted in 2007, 2008, and 2009 to monitor the sediment flux associated with the removal. By 2009, these surveys measured the pre-dam riverbed in the uppermost cross sections from the dam. We compare these surveys to the interpreted GPR images to calculate a calibrated velocity of the EM waves traveling through the impounded sand of 0.043 m/ns. Using this velocity, the average thickness of the sediment above the interpreted pre-dam riverbed calculated for each of the six cross sections varies between 0.81 m and 3.11 m. In order to calculate the total area of the impoundment, ArcGIS was used to trace the area of the impoundment on a digital ortho-photo quadrangle downloaded from NH GRANIT, the statewide GIS provider of New Hampshire. The total area was then divided into eight individual areas, one per GPR cross section with an addition area for the islands where no GPR data was recorded. Each representative area was defined as the area beginning at its cross section and spanning halfway to the adjacent upstream and downstream cross sections, or to the beginning or end of the impoundment for the upper and lower-most cross sections. The areas were calculated in ArcGIS and were multiplied by the average thickness interpreted on their corresponding GPR image, giving individual volume estimates. The average thickness of the island area was calculated by averaging the thicknesses calculated at the endpoints on either side of the islands. The total volume estimate of sediment stored behind the MVD prior to removal is 67,000 m³, compared to an estimate of 62,000 m³ calculated by Gomez & Sullivan, an environmental consulting firm, by physically probing the deposit across seven transects with a steel rod until it could no longer be hammered into the sediment.



GPR profile of MVD 04. The interpreted (red) lines show the bottom of the impoundment in June 08 and the internal stratigraphy. The yellow lines show measurements to the interpreted pre-dam riverbed and are recorded in meters. The greatest single spot of erosion seen on the topographic survey from June 08 to Aug 09 is 2.92 m thick at the 72 m mark. The interpreted pre-dam riverbed for this area is 2.89 m. The Aug 09 survey most likely shows the pre-dam riverbed from the 59 - 85 m marks.



Map of the MVD study site. The GPR instrument was canoed across the impoundment at each cross section (left and right pins shown as yellow dots) while the GPR tracklog (red dots) recorded its position. The total impoundment area (blue) is divided into seven numbered representative areas with a GPR record and the island area (orange) where the pre-dam riverbed thickness is interpreted from the GPR data of cross sections 05L and 05R.