Mactaquac Aquatic Ecosystem Study
Report Series 2015-003

METHODS PAPER: Reservoir Sediment Sampling

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February 10, 2015

Canadian Rivers Institute

UNB

Correct citation for this publication:

Chateauvert, A., B. Wallace, and G. Yamazaki. 2015. METHODS PAPER: Reservoir Sediment Sampling. Mactaquac Aquatic Ecosystem Study Report Series 2015-003. Canadian Rivers Institute, University of New Brunswick 6 p.

DISCLAIMER

Intended use and technical limitations of the report, "METHODS PAPER: Reservoir Sediment Sampling". This report describes the methods employed to establish baseline data on surface sediment composition and contaminants in the headpond and downstream along the river. The CRI doesn't assume liability for any use of the included data outside the stated scope.

Introduction

NSERC CRD Project 1B.1.3 - Reservoir sediment composition, chemistry, and potential for downstream displacement.

Dam reservoirs are sediment sinks and consequently, downstream sediment transport and deposition occurs with dam removals (e.g., DeGraff and Evans 2013). Sediment suspension, transport, and deposition can be modelled in a dam removal scenario (e.g., Draut and Ritchie 2013), including the establishment of the new river channel depending on the geomorphic conditions of the reservoir, e.g., sediment accumulations (Pizzuto 2002).

The methods described herein are being used to establish baseline data on sediment composition and contaminants. The sediment thickness maps will inform sampling locations where grab samples (post-dam deposits) and deeper core samples (time series/depositional histories) are required. The goal is to understand the spatial variability and magnitude of contaminant and nutrient concentrations. Surface sediments will also be sampled downstream and similarly characterized, allowing us to test predictions of transport and deposition should the dam be removed (MAES, Phase 2).

Methods

Study Design

Using the sediment thickness maps produced in Projects 1.B.1.1 and 1.B.1.2, the MAES Sediment Team established a map of 24 sampling sites that covered needs for the hydrodynamic modellers, e.g., upstream of main reservoir/headpond (upstream of Nackawic), the main reservoir (onshore/offshore), deeper sediment zones, the Mactaquac Arm, and the contaminant/biological requirements, e.g., the Nackawic/AV Nackawic area. Sites were prioritized including the immediate 2014 needs (Table 1). Depending on the 2014 results and various team needs, additional sites will be added in subsequent years.

For 2014, samples were collected at 18 sites within Mactaquac Headpond including three (3) sites in the lotic environment upstream of Nackawic, and two (2) sites in the Saint John River downstream of Mactaquac Dam (Table 1 and Figure 1). At Nackawic (Site 8) and in the original river channel (Site 15), five (5) replicate samples were collected to obtain a preliminary assessment of sediment chemistry and grain size variability for power analyses.

Sample Collection

Grab Samples: Surface sediment samples were collected using a 15 cm × 15 cm Ekman grab modified with an extra 12lbs weight (purchased as a supplement from the manufacturer). The synthetic rope was 45 m long. For most locations, the final site was selected at the deepest point in the area of interest, i.e., the potential area of greatest sediment deposition. In some cases, proximity to a point of interest, e.g., the Nackawic/AV Nackawic area, was the selection criteria.

Figure 1. Sediment sampling sites for the Mactaquac Aquatic Ecosystem Study (see Table 1).

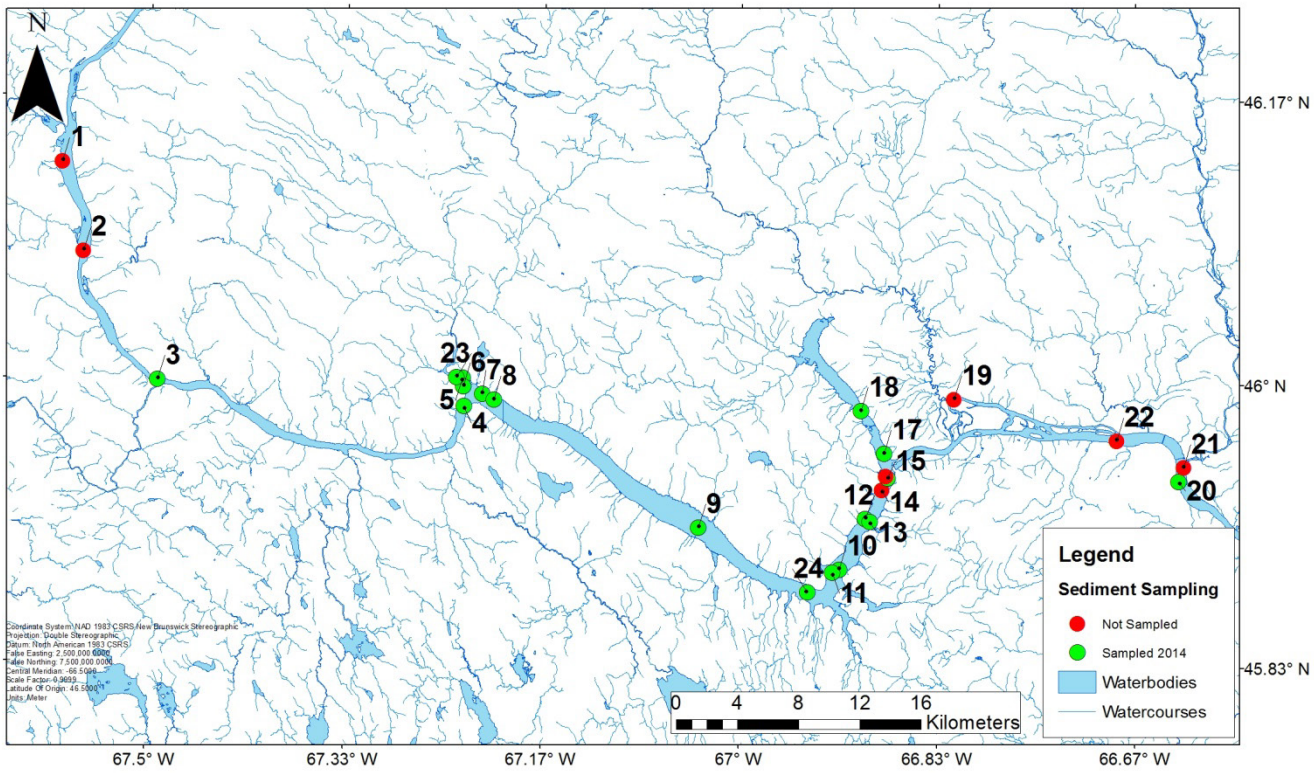

Table 1. Sediment sampling sites for the Mactaquac Aquatic Ecosystem Study. Sites are located in the mainstem of the Saint John River. Sites sampled in 2014 are identified.

			Coordinates	
Site ID	**Site Location**	**Type of sample collected**	**Latitude**	**Longitude**
Site 1	Meduxnekaeg River	NC*	46.12752	-67.57461
Site 2	Bulls Creek	NC	46.07499	-67.55592
Site 3	Meductic/Eel River	Chemical and Grain Size	45.99993	-67.49225
Site 4	Nackawic (upstream)	Chemical and Grain Size	45.98568	-67.23307
Site 5	Nackawic (Trickling Filter)	Chemical and Grain Size	46.00231	-67.23470
Site 6	Nackawic (Downstream – Waste Water Treatment Plant - DS WWTP)	Chemical and Grain Size	45.99733	-67.23373
Site 7	AV Nackawic (Outfall)	Chemical and Grain Size	45.99313	-67.21799
Site 8	Village of Nackawic (downstream)	Chemical and Grain Size	45.98961	-67.20819
Site 9	Bear Island	Chemical and Grain Size	45.91534	-67.03460
Site 10	Kellys Creek bend (cut bank)	Chemical and Grain Size	45.89090	-66.91596
Site 11	Kellys Creek bend (inside bank)	Grain Size	45.88911	-66.92162
Site 12	Jewett's Creek (cut bank)	Grain Size	45.92096	-66.89418
Site 13	Jewett's Creek (inside bank)	Grain Size	45.91917	-66.89022
Site 14	Snowshoe Island	NC	45.93786	-66.88025
Site 15	Mactaquac Original River Channel 1	Chemical and Grain Size	45.94473	-66.87512
Site 16	Mactaquac Original River Channel 2	NC	45.94621	-66.876742
Site 17	Mactaquac Blue Hole	Chemical and Grain Size	45.95923	-66.87854
Site 18	Mactaquac Arm	Chemical and Grain Size	45.98433	-66.89819
Site 19	Keswick River	NC	45.99158	-66.81935
Site 20	Fredericton Sewage Outfall	Chemical and Grain Size	45.94332	-66.62968
Site 21	Nashwaak River	NC	45.95156	-66.62563
Site 22	Fredericton Marina	NC	45.96728	-66.68223
Site 23	DS Nackawic Bridge	Grain Size	46.00282	-67.23993
Site 24	Kings Landing	Chemical and Grain Size	45.87749	-66.94261

**NC - indicates samples were not collected in 2014.*

The Ekman was deployed and retrieved. The sample was inspected in the Ekman and an acceptable sample was defined as relatively undisturbed sediment to a depth of 5 cm (Figure 2).

Figure 2. Sediment inside the Ekman Grab (Mactaquac Reservoir 2014).

Sampling was repeated until an undisturbed sample was achieved (this ranged from 1 to 5 tries per site). A clean (2.5% nitric acid washed), 5 cm diameter, polycarbonate tube was used to sample the top 5 cm of sediment (Figure 3). It was inserted into the sediment, extracted, and poured into a laboratory certified clean, pre-labelled amber glass jar for metals and polycyclic aromatic hydrocarbons (PAHs) analysis (Environment Canada 1994), a clear glass jar for nutrient analysis (Environment Canada 1994), and a 200mL Whirl-Pack bag for particle size analysis. Each sample was stored on ice until returned to the laboratory. The visual appearance of each sample was documented in photos, both in the Ekman grab and in the sampling tube. Sediment samples were either stored at 4˚C (particle size and nutrient analyses) or frozen within 6 hrs until analysis.

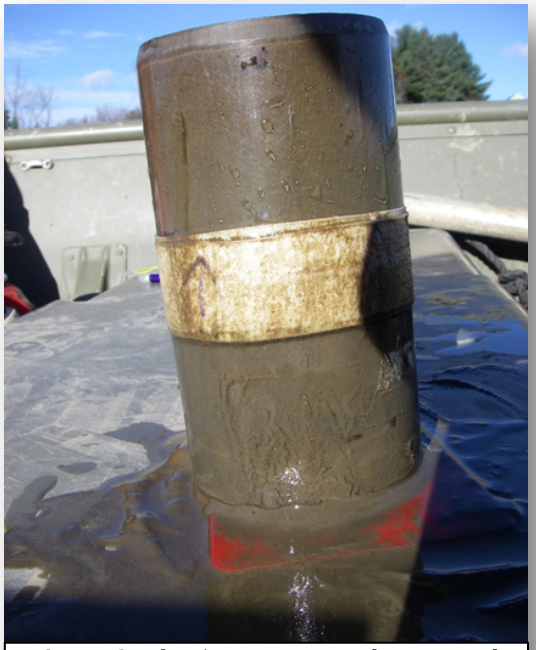

Figure 3. The 5 cm core sample removed.

Core Sampling: The core sampling to understand the depositional story including the pre-dam sediment composition is still in a planning stage as of this report's publication.

Laboratory Analysis

Sediment samples were analyzed for nutrients at RPC Laboratories (Fredericton, NB; http://www.rpc.ca), metals and PAHs at CRI's Environmental Chemistry Laboratory (UNB Saint John; http://canadianriversinstitute.com/services/environmental-chemistry-lab), particle size analyses were conducted at Civil Engineering, UNB Fredericton The RPC and CRI laboratory methodologies are described in the documentation for each of the facilities.

Particle Size

Grain sizes were analyzed using a Mastersizer 2000 laser diffraction particle size analyzer (Malvern Instruments Inc.; www.malvern.com). The Mastersizer 2000 uses laser diffraction to measure the size distribution of the particles in the sample by measuring the scattering of light as a laser is passed through the sample (Malvern Instruments Inc., 2007). The sediment samples were measured wet using the Hydro 2000S dispersant unit, which contains a stirrer and pump that circulates the sample (solute) and a dispersant (solvent - in this case distilled water) through a cell consisting of 2 panes of glass. When fitted into the optical bench of the Mastersizer, the laser passes through the cell to measure

the light scattering pattern of the solution. This pattern is compared to an electronic background measured before the sample is added to the dispersant and a final particle size distribution of the sample is predicted.

Sediment samples preserved in the 200mL plastic bags in a refrigerator were removed from the fridge and mixed in the bag to ensure an even distribution of particle sizes using a spatula and by squeezing the bag. During this time, the Mastersizer completed background measurements with only the distilled water to be compared to the measurements of the sample later. A 5-10ml sub-sample was removed from the grain size analysis sample bag and placed in a clean 100mL glass beaker using a spatula. The sample was then mixed with ~40mL of distilled water and kept well mixed in this solution using a Pasteur pipette by repeatedly squeezing and releasing the pipette bulb. The Mastersizer is able to measure samples over a range of obscurations (i.e., the amount of light lost through scattering and absorbtion); a volume of the sample (~5ml of the sediment mixed with distilled water) was injected into the Mastersizer dispersant unit with the Pasteur pipette, ensuring the obscuration was in the acceptable range (10-20% is considered ideal). During the measurement process, the unit measures 20,000 individual scattering patterns (snaps) and averages these into a single measurement. The unit records 3 sets of these measurements and averages these to produce a single average particle size distribution for each sample. Following the measurement of each sample the unit was drained and refilled with distilled water a minimum of 2 times. The unit was considered clean when the laser obscuration of the distilled water was <0.5%. Three separate subsamples from each particle size sample collected were measured in the above fashion in random order. The D10, D50 and D90 were recorded; cumulative fraction of sample ≤10%, ≤50% and ≤90%, respectively. The average of the three subsamples is reported. Grain size class was characterized using the Wentworth scale (Wentworth 1922).

REFERENCES

DeGraff, J.V. and J.E. Evans (Eds.) (2013). The Challenges of Dam Removal and River Restoration. Reviews in Engineering Geology Volume 21. Geological Society of America. 203 p.

Draut, A.E., J.B. Logan, and M.C. Mastin (2011). Channel evolution on the dammed Elwha River, Washington, USA. Geomorphology. 127(1-2): 71–87.

Pizzuto, J. (2002). Effects of dam removal on river form and process. BioScience. 52(8): 683–691.

Wentworth, C. K. 1922. A scale of grade and class terms for clastic sediments. The Journal of Geology. 30(5): 377-392.

Malvern Instruments Inc. 2007. Mastersizer 2000 User Manual. MAN0384 Issue 1.0 March 2007. 154p