Application Note

Monitoring greenhouse gas emissions from hydro-electric reservoirs in northern Quebec, Canada

Surface waters of natural freshwater bodies are capable of releasing far more carbon into the atmosphere than they absorb (Cole et al. 1994). Artificial reservoirs are also known to have environmental impacts which include greenhouse gas (GHG) emissions (Rosenberg et al. 1997, Fearnside et al. 2004, Tremblay et al. 2005). Therefore the inclusion of hydroelectric facilities as part of an overall strategy to produce clean energy requires quantification of GHGs associated with their construction. Vegetation submerged by impoundment of reservoirs ceases to function as a sink for atmospheric CO_2 and undergoes microbial decomposition, releasing both CO_2 and methane (CH_4). Reservoirs above flooded peatlands in boreal regions may release more GHGs through decomposition than reservoirs created where upland boreal forests once stood (St. Louis et al. 2000), but other factors such as climate, reservoir age, and roughness of surface waters influence emissions as well.

A Canadian research team from Environnement Illimité, Inc., Université du Québec à Montréal (UQAM), McGill University, and Hydro- Québec are attempting to answer these and other important questions in northern Québec Province as part of the Eastmain Reservoir (EM-1) Project (Fig. 1). The reservoir under study encompasses 603 km^2, 14% of which is now submerged peatland. Due to the difficulty of obtaining accurate measurements in aquatic environments, researchers are relying on two separate methods to compare results (Duchemin et al. 1999).

Figure 1. EM-1 Project study area.

One method employed floating static chambers (Fig. 2) that are sampled directly using the **CIRAS-SC** (Fig. 3) to determine changes in CO_2 concentrations at the air-water interface, monitored over 7 minute periods. The slope of the concentration over time represents the GHG flux. "Direct" fluxes are compared to theoretical CO_2 fluxes between the surface water and atmosphere calculated by the thin boundary layer (TBL) method, for which the researchers used the **EGM-4** (Fig. 4) to quantify the partial pressure of dissolved CO_2 (pCO_2). Essentially, TBL CO_2 flux is the difference between CO_2 concentration of water and the atmosphere, as influenced by air and water temperatures and wind speed over the water's surface.

Results of the study show that CO_2 flux to the atmosphere increased significantly for the first year following impoundment of Eastmain-1 Reservoir (Bastien et al. 2007). By the second year the effect was still in evidence, although it had declined significantly. Methane production followed a similar although less dramatic pattern. Early indications are that as

reservoirs age their annual GHG emissions return to levels similar to those of natural aquatic systems (Fig. 5).

New and comparative methods like those described above are being used to estimate GHG emissions as part of a broad effort to understand the role of natural phenomena and human activity in the global carbon budget. The **EGM-4** (using non-dispersive, infrared gas analysis coupled with microprocessor based signal processing) is an ideal instrument for applications that demand specificity to and a high standard of accuracy for CO_2 measurements.

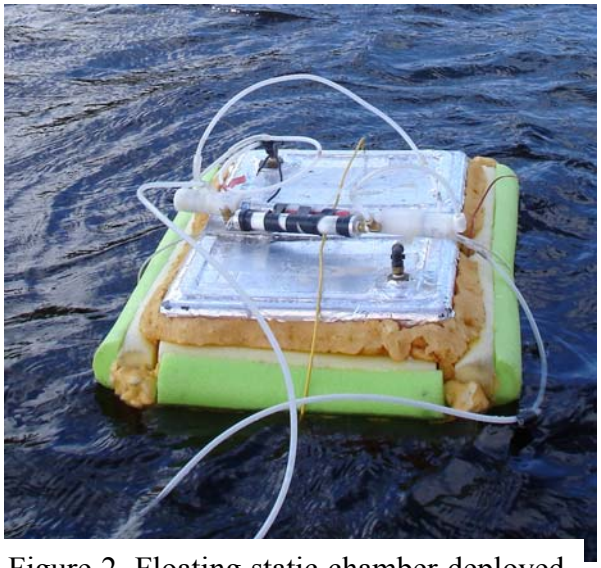

Figure 2. Floating static chamber deployed on water surface.

Figure 3. Suite of research instrumentation including the CIRAS-SC used to determine near-surface GHG fluxes in combination with the floating chamber.

Figure 4. Thin boundary layer estimates of CO_2 flux determined from data captured by the EGM-4 gas analyzer.

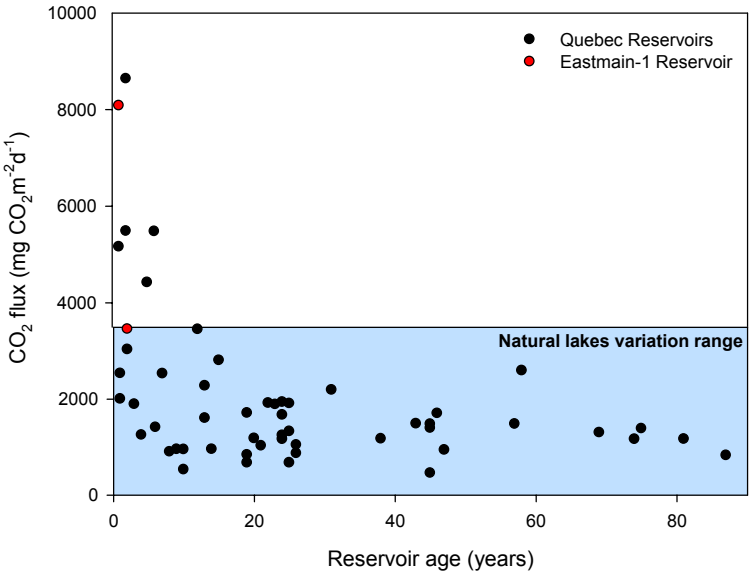

Figure 5. CO_2 flux from the newly constructed Eastmain-1 Reservoir over time as compared to flux rates of reservoirs in Québec Province.

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