Summary of Storage of Floodwaters in the Watershed Report

by the Flood Management and Mitigation Measures Technical Working Group

International Lake Champlain Richelieu River Study Board

The International Lake Champlain-Richelieu River Study Board is pleased to release its Flood Water Storage report. This report is one of several undertaken by the Study Board focusing on a range of structural and non-structural solutions to flooding in the basin. The Study's efforts to develop solutions are centred around four themes: reducing high water levels in the river given extreme flood scenarios; impeding flows to the lake; improving flood response (flood forecasting and emergency preparedness) and enhancing floodplain management.

The Flood Water Storage report focuses on Theme 2 (impeding flows into Lake Champlain and the Richelieu River to reduce high water levels) through wetland and temporary farmland storage of flood waters. *Wetlands are natural landscape features within a watershed. They can help intercept floodwaters and slow their flow, reducing timing and intensity of floods downstream. Upland storage is considered a nature-based approach for flood mitigation.*

As such, study experts developed models to understand the role of existing wetlands on inflows to Lake Champlain and flows in the Richelieu River, and to assess how adding

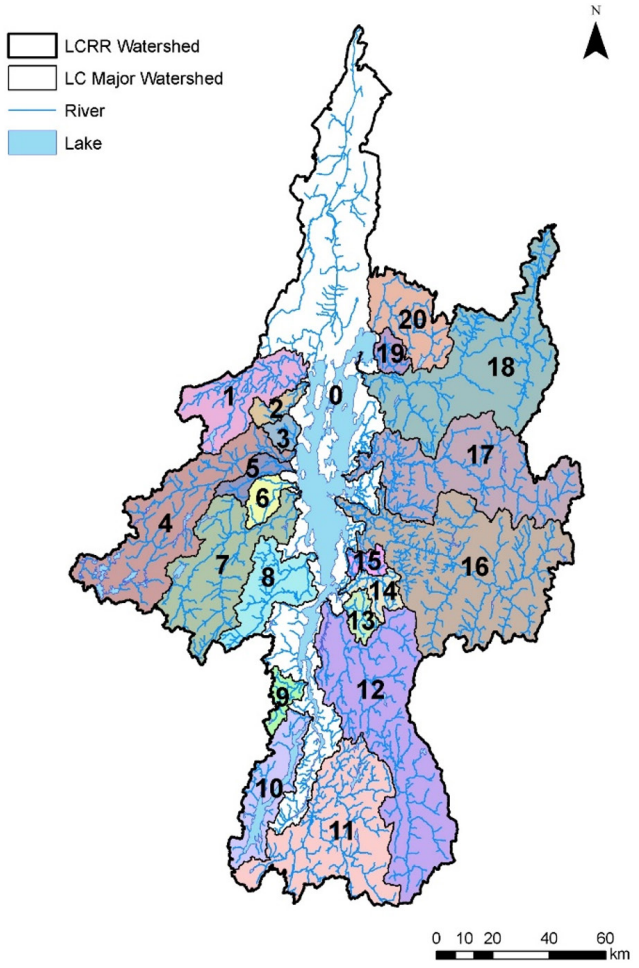

Figure 1 *Major sub-watersheds (>100km²) and tributaries in the Lake Champlain basin*

wetland area to the basin and/or temporarily flooding farmland could create additional flood mitigation benefits. Using the PHYSITEL/ HYDROTEL modelling platform and the water balance model of Lake Champlain developed by Environment and Climate Change Canada, the study has gathered a large amount of basin specific data that can be used to model and predict lake and river levels in the basin. The models have been used to answer the following key questions identified during the study:

QUESTION 1. What effects do wetlands currently have on flows and water levels in Lake Champlain and the Richelieu River, as well as on net basin supply?

For watersheds that experience recurrent floods, the natural water storage capacity of wetlands is an important asset. Study experts set out to quantify the current area of wetlands in the LCRR basin. Modelling helped quantify the flood mitigation effects of the existing 1684 km^2 (650 miles^2) of wetlands (which cover roughly 7% of the basin and drain roughly 34%). To put it into perspective, the surface area of Lake Champlain is only 1,270km^2 (490 miles^2) or about three quarters the area of wetlands in the basin.

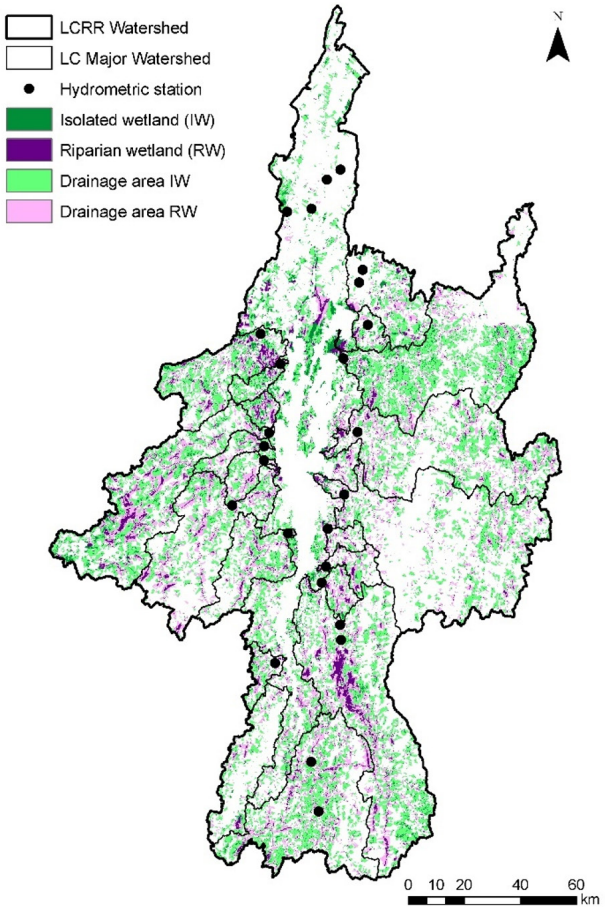

Figure 2 *Drainage area and types (isolated and riparian) of wetlands in the LCRR watershed*

Results demonstrated that existing wetlands:

- Reduce on average, the annual high flow of the 20 Lake Champlain tributaries between 9 and 52 percent
- Reduce on average Lake Champlain annual high water level by 12 cm (4.7 inches)
- Reduce on average the Richelieu River annual high water level by 9 cm (3.5 inches)
- Reduce on average the annual Richelieu River high flow by 6 percent

The reduction in flow from the more than 20 tributaries of Lake Champlain afforded by existing wetlands results in an average reduction of annual Lake Champlain net basin supply by 22 percent.

The above values, being averages, mean that from year to year, the hydrological services provided by wetlands for a tributary depend on

both the physical characteristics of wetlands, including size, location and type (i.e., isolated or riparian), the area's snowpack, and weather conditions. This makes it difficult to draw a general conclusion at the scale of the tributaries. However, for Lake Champlain, the reduction of the 2011 NBS was 14%. The effect in 2011 was somewhat smaller in comparison to the effects on lesser floods, such as in 1973 (17%), 1983 (22%), 1984 (23%) and 2013 (26%).

> **Net Basin supply (NBS) is the net volume of water entering or exiting the lake from its own basin over a specified period of time. More specifically, NBS is defined as the precipitation that falls directly onto the lake, plus the drainage basin runoff that enters the lake, minus the evaporation from the lake itself, plus or minus the direct groundwater flux.**

These results illustrate the key hydrological services provided by existing wetlands such as the reduction of peak flows, water levels and net basin supply. The results also demonstrated that without the presence of wetlands in the basin, the peak water level during the 2011 flood would have been 15 cm (6 inches) higher on Lake Champlain and 12 cm (4.7 inches) higher at Saint-Jean-sur-Richelieu.

QUESTION 2. What would be the additional effect of temporarily flooding farmlands on flow and water supply?

The first alternative evaluated during this study was the use of agricultural land close to waterways for additional water storage during floods. This scenario aimed at evaluating the additional benefits of flooding farmlands and to do so, experts treated agricultural lands as if they were "wetlands" in the model, but without explicitly converting the farmland to wetlands.

The simulation of the addition of 2256 km^2 (871 miles^2) of farmland storage resulted in:

Average reduction of annual high flow of Lake Champlain tributaries by 1-49% › **Average reduction of annual Lake Champlain NBS high flow by 15%, and high water level by 4 cm (1.6 inches)** › **Average reduction of annual Richelieu River high flow by 2%, and high water level by 3cm (1.2 inches)**

- Reducing on average annual high flow of the 20 major lake tributaries by 1 to 49 percent.
- Reducing on average annual Lake Champlain net basin supply by 15 percent and high water level by 4 cm (1.6 inches).
- Reducing on average annual Richelieu River high flow by 2 percent and high water level by 3 cm (1.2 inches).

Although this scenario demonstrated reductions to Lake Champlain net basin supplies and water levels and, to a lesser extent, the Richelieu River peak flows and water levels, it should be noted that flooding farmland for flood relief would require the use of vast surface area.

QUESTION 3. What would be the additional effect of greater wetland area in the basin on flow and water supply?

Using spatial data of the different surface types in the basin (e.g., forest, agricultural lands), study experts developed various scenarios of adding wetland area to the basin. Three watershed storage scenarios were modelled: Scenario 1 which adds 647 km^2 (250 miles^2) of wetlands (this was identified as the additional area of wetland required to reduce the 2011 peak flow at Fryers Rapids by 5%); Scenario 2 of adding 865 km^2 (334 miles^2) of wetlands (based off of a USEPA dataset showing potential additional wetland areas in the basin), and finally Scenario 3 which combines the two previous scenarios for a total of 1488 km^2 (575 miles^2) of additional wetlands.

Scenario 1 of adding 647 km^2 (250 miles^2) of wetlands reduced:

Average reduction of the annual high flow of Lake Champlain tributaries between 0.7-13% → **Average reduction of Lake Champlain NBS by 6.3% and high water level 5 cm (2 inches)** → **Average reduction of Richelieu River high flow by 2.6% and high water level by 3 cm (1.2 inches)**

Scenario 2 of adding 865 km^2 (334 miles^2) of wetlands reduced:

Average reduction of the annual high flow of Lake Champlain tributaries between 0.9-26.6% → **Average reduction of Lake Champlain NBS by 8.1% and high water level 5 cm (2 inches)** → **Average reduction of Richelieu River high flow 2.6% and high water level by 3 cm (1.2 inches)**

Scenario 3 combining Scenarios 1 and 2 for a total of 1488 km^2 (575 miles^2) of additional wetlands reduced:

Average reduction of the annual high flow of Lake Champlain tributaries between 2.6-28.1% → **Average reduction of Lake Champlain NBS by 12.7% and high water level by 8 cm (3.1 inches)** → **Average reduction of Richelieu River high flow 4.7%, high water by 6 cm (2.4 inches)**

The simulation of the combined addition of 1488 km^2 (575 miles^2) of wetland storage resulted in:

- Reduced on average annual high flow of Lake tributaries by 2.6 to 28 percent.
- Reduced on average annual Lake Champlain net basin supply by just under 13 percent and high water level by 8 cm (3.1 inches)
- Reduced on average annual Richelieu River high flow by 4.7 percent and high water level by 6 cm (2.4 inches)

These scenarios (additional wetlands) also highlighted the potential of achieving additional gains to reduce Lake Champlain net basin supplies and water levels and to a lesser extent the Richelieu River peak flows and water levels according to the combined use of PHYSITEL/ HYDROTEL and the water balance model developed by Environment and Climate Change Canada. As with the temporary flooding of farmland scenario, adding wetlands would require the use of extensive surface area in the basin. Given existing policies, programs and regulations in Canada and the United States, fostering the restoration and construction of new wetlands might provide a socially acceptable framework to build resilience over time in the basin, at least at the local sub-watershed level.

This study did not conduct an in-depth cost-benefit analysis of the various scenarios considered in this report.

Legacy of the Project

The Study's research into watershed storage in the basin resulted in the creation of hydrological models specific to the LCRR basin. Once the study is completed in 2022, the LCRR HYDROTEL modelling tool (through PHYSITEL) will continue to be available to interested parties to identify potential water storage areas and to assess multiple scenarios for each sub-watershed within the basin.

This report illustrates how various watershed storage scenarios could contribute to flood relief in the Lake Champlain-Richelieu River basin.

The full report can be found on the LCRR website: *Flood water storage using active and passive approaches - Assessing flood control attributes of wetlands and riparian agricultural land in the Lake Champlain-Richelieu River watershed.* For more information, you can also consult the technical webinar presented in November 2020 on the topic of wetland storage.