REVISED WORK PLAN

FOR

THE IDENTIFICATION OF MEASURES TO MITIGATE FLOODING AND ITS IMPACTS ALONG LAKE CHAMPLAIN AND THE RICHELIEU RIVER

Submitted by the

International Lake Champlain and Richelieu River Study Board

to the International Joint Commission

August 9, 2019

Preamble

On April 10th 2019, the International Joint Commission (IJC) requested from the Lake Champlain Richelieu River (LCRR) Study Board to produce a revised work plan until the completion of the study, that would serve the purpose of providing the required direction and resources available to the various working groups and to identify, if need be, whether further directions, or clarifications are needed from the Commission in order to achieve the success the Commission and Study are seeking. The IJC also requested an update on Independent Review Group needs and plans. The work plan is to include revised timeline and budget details for the various Technical Working Groups (TWGs).

Executive Summary

In spring of 2011, the Lake Champlain-Richelieu River basin experienced record flooding. In 2014-2015, at the request of the U.S. and Canadian governments, the IJC carried out preliminary technical work on the flooding issue. In September 2016, the U.S. and Canadian governments provided the IJC with a reference under the Boundary Waters Treaty to conduct an in-depth study to investigate the causes and impacts of flooding in the Lake Champlain-Richelieu River watershed, with emphasis on the record 2011 flooding, and make an evaluation of possible flood mitigation solutions. The governments asked the IJC to carry out a five-year study at a cost of approximately US$11.4 million (CA$15.4 million), with costs being approximately equivalent in each country. The IJC established the International Lake Champlain-Richelieu River Study Board in December 2016, and the Study Board submitted its initial work plan in May 2017.

Considerable progress has been achieved in the implementation of this work plan, which is now undergoing a “mid-point” revision. Furthermore, as a result of a number of circumstances beyond the Board’s control, it is not able to complete its work within the timeline specified in the governments’ reference and has received by IJC a one year extension of the Study. The revised workplan accounts for this extension. Overall, this revised work plan describes accomplishments to date, what was learned and how the Study Board is redirecting activities and resources to better meet the IJC Directive and address challenges it has identified to date.

This revised work plan builds on the accomplishments produced by the Study over the last two and a half years. Midway through its mandate, the Study Board has enough information to present a more targeted approach that will ensure production ofits deliverables in a timely manner. Rather than a list of individual TWG tasks, the updated plan highlights the interrelations and timeliness amongst the tasks identified in the initial work plan in an integrated manner. The elaboration of a Gantt chart (timeline) with the development of a critical path now allows the Study to prioritize the tasks necessary to define a suite of recommendations to mitigate flood damages along the Lake Champlain and Richelieu River.

Accomplishments

The major milestones realized so far in the Study are:

- A flood mitigation framework that provides a clear logical path for the study to follow to assess various mitigation strategies that will lead to reduced flood impacts and better preparation to face flooding events. In this framework, structural and non-structural solutions are strategically presented under four themes: instream structures that can lower flood levels by accelerating the discharge of water out of Lake Champlain (Theme 1), slowing-down the inflows into Lake Champlain and the Richelieu River (Theme 2) and non-structural approaches such as developing better response plans taking advantage of state-of-the-art flood forecasting and real-time inundation mapping systems (Theme 3) and more effective floodplain management (Theme 4);
- An improved understanding of the physics of the system through the development of modeling and management tools such as a precise digital terrain model, three hydrologic models, 2-D and 3-D hydraulic models and a water balance model (WBM). Those tools provide robust simulated inflows and outflows and flood plain delineation including inundation depths;
- A high resolution 2-D hydraulic model of the Saint-Jean shoal area that generates stage discharge relations and can identify flood level reductions associated with the structural mitigation measures (Theme 1) being considered;
- A strategy for assessing climate change risks that will support the Study Board's flood mitigation recommendations. It is based on the IJC climate change guidance framework and includes a decision-scaling approach starting from the anticipated impacts and their plausibility of occurrence, trend analysis including definition of the Maximum Probable Flood (MPF), stochastic modelling techniques, and the downscaling of Global Change Models (GCM). Together, these tools offer the diversity of analyses and robustness to support sound recommendations in a climate change context;
- An Integrated Social-Economical-Environmental (ISEE) modelling platform to facilitate the evaluation of flood mitigation measures through a suite of calibrated performance indicators that are responsive to the various measures pertaining to the four themes, allowing for a scientifically sound assessment of their effectiveness;
- The initial development of the Collaborative Decision Support Tool (CDST) which will be used n the analysis and communication of the benefits and impacts associated with mitigation measures being assessed through an iterative process with ISEE, which will guide further discussion by the Board,
- Creation of interim flood inundation maps for the entire Lake Champlain shoreline and much of the Richelieu River that will assist local emergency managers and the public until a real-time flood inundation mapping system is completed,
- A series of public and targeted stakeholder meetings to convey study plans and results to date, and
- The initiation of an in-depth analysis of stakeholder's current social and political perception of proposed structural and non-structural measures in order to map the level of desirability of those solutions. This analysis relies on the assessment of vulnerability, resilience and how flood risk is perceived and the acceptability of mitigation approaches in local communities, by stakeholders and government officials.

Priorities

Thus far, the generation of tools and knowledge has enabled the elaboration of a suite of comprehensive mitigation measures in all four themes of the strategic framework that will be submitted for discussion with governments, stakeholders and the public to weigh the political and social acceptability of the proposed measures which can be summarized as:

Theme 1: Explore the effectiveness of removing structural artifacts from the Saint-Jean shoal portion controlling the flow, using the upper portion of the Chambly Canal below lock No 9 to enhance the conveyance of water in the system, moving the control section upstream of Saint-Jean-sur-Richelieu, and combinations of those actions.

Theme 2: Examine the flood reduction capacities offered by restoring floodplains and wetlands in the basin

Theme 3: Collaborate with first responders to help them improve and optimize their decision scheme when a flood may and is occurring by integrating forecasts on a timely manner. This is based on the development and associated recommendations of the implementation of a binational flood forecasting and real-time inundation mapping system.

Theme 4: Enhancing floodplain management strategies and regulations by providing information on flood plain management best practices from local and national perspectives, consulting governments on flood risk reduction measures, and participate in inter-departmental committees

The Study Board also prioritized assessing the political acceptability of its proposed flood mitigation measures and understanding potential impacts on First Nation and Native American Tribes' sites of significance. Hence, work in Canada and discussion in the US, was initiated with the Waban Aki, Abenaki and Mohawk Nations to gather evidence on the extent of the use of the territory as well as the identification of sacred sites and cultural resources that could be impacted by the flood mitigation measures.

Challenges and the Study Board response

The Study has experienced delays due to personnel turnover, late and unpredictable appropriations in funding US study activities, and the U.S. government shutdown in late December, 2018 through January, 2019. The Study Board is thankful of the IJC's decision to grant a one-year extension of the Study, with March 31, 2022 as the new date for submitting its recommendations. It is aware that the decision is contingent on governments' approval. To ensure tight control of its activities and budgets the Study management has adopted a Gantt chart project management approach to understand the dependencies among the 300 or so tasks, their timeliness and level of importance, and to help with the tracking of all activities and funds.

The Study Board has revised some activities planned in its initial work plan and updated them so that they align with its flood mitigation framework. In addition, non-essential activities have been reduced and/or removed and additional key activities have been endorsed to ensure the successful delivery of its recommendations. Critical activities include assessing the potential of upland and flood plains water storage in the basin, implementing the IJC climate change

framework and a decision-scaling approach, and initiated a consultation and participation process with all stakeholders including the First Nation and Native Americans on the LCRR basin.

The Study Board agrees that more study products resulting from the work to date needs to be made available to those interested in the study – from both a technical and general information standpoint. This has also been heard during our public meetings. The Board will ensure that study products receive appropriate reviews and distribution to specialists and the public at large moving forward.

Finances

At this mid-term review, discussions were held with each of the TWGs regarding the level of advancement of their assigned tasks, progress towards task completion and budgets. Because of the lessons learned and subsequent reprioritization of some of the work, budgets needed to be reallocated accordingly with each of the TWGs. Other administrative functions were also scrutinized. The Study Board has been managing the study bi-nationally but from a financial perspective, the situation is different in each country.

In Canada, the ability to carry over annual surplus has allowed to present a balanced budget including a reallocation of funds over the entire duration of the Study. The expenditures of the Study as of March 31, 2019 were under the initial planned amount, with only 26% spent. Because resources are secured and allocated yearly according to need, from the Canadian perspective, Study management is confident that this revised work plan will use up the allocated resources in the three remaining years until 2022 and allow for continuous adjustment of efforts to address any upcoming issue.

In the United States, funding is allocated on a year-to year basis with the final amount as well as allocation date unknown from year to year. In fiscal year 2019 (October 1, 2018 – September 30, 2019), the US will receive its funding in the fourth quarter of the fiscal year. By the end of fiscal year 2019 (September 30, 2019), the US expenditures on the study will be slightly ahead of initial projections with approximately 60% of total projected study funding spent. The Study Board is aware of the expected deficit in the US budget and will use risk management and other measures to ensure the most critical study work tasks are completed in coordination between the US and Canada. Other project management approaches to ensure adequate work is completed with available funding, such as tight activity and budget controls, will be used.

Timeline

Timelines for study tasks are outlined in the newly created LCRR study Critical Path Method (CPM) spreadsheet which, in conjunction with an MS Project based Gantt chart, outlines in excess of 270 LCRR study tasks from inception to completion. These documents are living documents which will be utilized to report study progress and will be periodically updated and be made available to study members upon request.

Study Products

The Study Board will submit its final recommendations to the IJC on March 31, 2022. Over 15 reports will be produced over the next three years and will be subjected to different internal and external review processes. Some key reports expected over the next three years are:

- Final Report on the Causes and Impacts of past floods in LCRR, Fall 2019
- White paper on the flood prediction, real-time flood inundation mapping system, Winter 2020
- LCRR Climate Change Strategy Spring 2021
- Potential Structural Flood Mitigation Measures for the LCRR Basin, Summer 2021
- Social and Political Acceptability of proposed mitigation measures, Winter 2022
- Final LCRR Study report to the IJC Spring 2022

Linkages with Governments and Opportunities

Throughout the remaining project period, the Study Board will maintain regular and structured communications with several Canadian and U.S. governmental organizations at the federal and provincial / state levels and less formally with regional governments (MRCs, counties) and municipalities to inform them on the progress of the study and get their feedback on the suite of mitigation measures that we are developing. Of particular interest, the Study has established cooperation with the Quebec Steering Committee in charge of updating the Politique de protection des rives, du littoral et des plaines inondables (PPRLPI; Policy for the protection of shorelines and floodplains). This constitutes an opportunity to benefit from synergies between these efforts. In the US, the study routinely updates the Lake Champlain Federal Partners and the New York and Vermont Silver Jackets groups on study progress and plans.

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List of Acronyms

BMP: Best Management Practices

CDST: Collaborative Decision Support Tool

CPM: Critical Path Method

DEM: Digital Elevation Model

ECCC: Environment and Climate Change Canada

FEMA: Federal Emergency Management Agency

FVCOM: Finite Volume Coastal Ocean Model

FMMM-TWG: Flood Management and Mitigation Measures Technical Working Group

HHM-TWG: Hydrology, Hydraulics and Mapping Technical Working Group

HRU: Hydrologic Response Units

IRG: Independent Review Group

ISEE: Social-Economical-Environmental

LCRR: Lake Champlain and Richelieu River

MELCC: Ministère de l'environnement et de la Lutte aux Changements Climatiques

MOU: Memorandum of Understanding

MRC: Municipalité régionale de comté (County Regional Municipality)

NBS: Net Basin Supplies

NOAA: National Oceanographic and Atmospheric Organization

PAG: Public Advisory Group

PI: Performance Indicators

PMF: Probable Maximum Flood

PPRLPI : Politique de protection des rives, du littoral et des plaines inondables (Policy for the protection of shorelines and floodplains)

RHHU: Relatively Homogeneous Hydrological Unit

RR-TWG: Resource Response Technical Working Group

SPE-AG: Social Political and Economic Analysis Group

SVS: Soil Vegetation Snow

TWG: Technical Working Group

WBM: Water Balance Model

1 Introduction

During spring 2019, midway through its mandate, the Lake Champlain Richelieu River (LCRR) Study Board conducted the assessment of all activities initially planned, and identified opportunities for enhancements. All study team members took part in this exercise; all activities were assessed for their value in supporting the development of recommendations to mitigate flooding and its impacts, and were modified when needed, and a few additional critical activities were included in the remaining 2.5 years of the study. This revised work plan for the Lake Champlain Richelieu River study conveys the results from this exercise.

Although it is a forward-looking document, this revised work plan first provides a quick snapshot of the Study's status in terms of tasks completion (chapter 2). It then follows the vision of the Study Board moving forward, and includes a description of the strategic framework to develop its flood mitigation measures in a structured manner (chapter 3), the various tools it has developed and techniques it is using to support its recommendations (chapter 4), and the study timeline and management tools it put in place to track and control its activities until study completion (chapter 5).

The revised work plan also addresses the financial aspects of the study (chapter 6), offers an outline of some of its important components and documents that could be reviewed by the Independent Review Group (IRG) established by the IJC (chapter 7), and identifies its linkages with current government efforts (chapter 8), outreach activities (chapter 9) and challenges faced by the study (chapter 10).

2 Status of the study

2.1 Status and accomplishments

Following the work plan approval by the IJC on October 2, 2017, the Study board has accomplished several milestones over the last two and a half years to meet the objectives of the 2016 government reference. But before addressing these accomplishments, a broad overview of the task advancements as initially planned is necessary.

Annex 1 provides a portrait of task status with regards to the work plan for each of the four technical working groups (TWG). In short, the tasks allocated to the Hydrology, Hydraulics and Mapping (HHM) as well as Flood Management and Mitigation Measures (FMMM) TWGs are for the most part on schedule and a few have been realigned and simplified to meet resource constraints. The Resource Response (RR) TWG has met with some delays in completing some tasks (among others, the Cause and Impacts of Past Floods report) but the team is now progressing at a faster pace even with being allocated additional tasks (Water Storage Analysis and development of performance indicators for indigenous people). The Social Political and Economic Analysis Group (SPE-AG) has been faced with the most important changes to reflect the increased need to inform the Board on acceptable mitigation measures. SPE has completed key chapters for the Causes and Impacts Report (amongst others: historical analysis of flooding from a social perspective) and an effective Outreach plan. Vulnerability and resilience

assessment of communities, risk perception as well as cost-benefit analyses are progressing in spite of some delays. A task has been dropped (Development of a multi-agent governance model) and been replaced with a social and political acceptability analysis of proposed mitigation scenarios). The Governance analysis has been re-thought by SPE, to possibly take advantage of social network analysis that will provide insights into the interactions of key governance stakeholders in the watershed.

Overall, the Study is progressing well, in spite of some significant delays, and has accomplished major milestones. These are summarized below.

First and foremost, the flood mitigation framework provided a clear analytical path for the study to identify and analyze potential mitigation assessments and for stakeholders tounderstand the process the study will be using to assess mitigation measures.. Structural and non-structural solutions are grouped under four themes: instream structures that can lower flood levels (Theme 1), the ability to store water on the landscape and thereby reducing the extent of flooding and the timing of flood peaks (Theme 2); non-structural approaches such as better response plans, better flood forecasting system and emergency preparedness (Theme 3); and enhanced public policies regarding floodplain management (Theme 4). This strategic framework was presented to the public as an integrated approach to a very complex public governance issue.

The physics of the system is now well understood with a precise digital terrain model, a 2-D hydraulic model and a water balance model (WBM) that provides simulation results regarding the extent of floodplain inundation due to lake levels (without seiche or wave run-up). NOAA has made substantial progress in developing a sophisticated 3-D hydrodynamic model of the lake that includes the ability to forecast water levels inclusive of seiche, driven by high resolution weather modelling. In addition, a high-resolution version of the NOAA National Water Model for the Lake Champlain watershed has been developed and will be transitioned to National Weather Service forecast operations. An improved understanding of the the stage-discharge relationship is leading to assessments of how specific structural mitigation measures (Theme 1) can bring about flood level reductions. In March 2019, the Study held an expert workshop on climate risks; the 2-D and climate change models and WBM were deemed essential tools to advance research regarding climate risks scenarios to eventually formulate recommendations in that regard to the IJC. The workshop also identified and recommended a scaling decision approach to be analyzed in the LCRR basin in accordance with the IJC framework on climate change, taking advantage of the wealth of work already developed, in particular the HYDROTEL hydrological model, the downscaling of climate change scenarios, the 2-D hydraulic model and WBM. This approach will allow the Study Board to formulate robust flood mitigation measures taking into account climate change risks to future flooding and damages.

In addition, in 2019 static flood inundation maps for the complete US Lake Champlain shoreline (https://pubs.er.usgs.gov/publication/sir20185169) were updated from the work done in 2016. These maps show areas of land inundation along the Lake shoreline in New York and Vermont at 11 different lake levels. These inundation maps are currently being prepared for display on national USGS flood inundation map server.

Another major achievement of the study is the development of the Integrated Social-Economical-Environmental (ISEE) modelling platform, which will greatly facilitate the evaluation of flood mitigation measures through a suite of calibrated performance indicators that meet the needs of diverse stakeholders. The Board had its first practice decision that has helped identify decision criteria and improvements to the CDST to evaluate mitigation measures.

The incorporation of socio-economic vulnerabilities and political acceptability into the study components is a first for the International Joint Commission. The Study Board has initiated an in-depth study of current social and political perception of proposed structural and non-structural measures in order to map the level of desirability of those solutions in drafting the final recommendations. Amongst the tool used to evaluate the proposed mitigation measures, an analysis of the vulnerability and resilience of communities, their risk perception as well as the computing of stage-damage functions is close to completion.

Other significant progress includes: an active Public Advisory Group (PAG) that manages public meetings in both the US and Canada to describe study task and progress; and outreach support that coordinates numerous meetings with a wide-ranging number of stakeholder groups, from federal agencies, state/provincial and local agencies to citizen groups.

2.2 Delays

Despite this important progress, the Study has accumulated delays over the last two years, mostly due to three factors: personnel turnover, late and unpredictable appropriations for funding US study activities, and the U.S. government shutdown in early 2019.

Staff changes in a number of key technical and support positions over the past 2 years have caused delays in completing important study tasks. Changes in the leadership and membership of the Social Political and Economic Analysis Group in Canada, the Resource Response TWG in both Canada and the US and the replacements for the Canadian study manager have delayed the completion of important study tasks – from socio-economical analyses, managing study budgets and contracts to finalizing technical databases and reports.

Late and at times, unpredictable, total funding appropriations in the US have resulted in MOUs and contracts being delayed. This has created an inability to initiate work as originally planned – such as field work that are still not fully completed, potentially pushing some activities to the 2020 field season, the loss of critical experts, and the inability to meet study task completion dates.

During the U.S. government shutdown from December 22, 2018 to January 25, 2019, numerous actions could not be undertaken, creating delays that, months later, are still being dealt with. As examples, a Study Board meeting and two inter-technical working group integration workshops were cancelled, delaying strategic decisions to future meetings; working meetings with stakeholders were postponed (indigenous people, local groups, expert climate risk workshop); those meetings were planned months in advance to ensure availability of critical attendees. In total the US government shutdown has resulted in estimated study delays of up to 9 months.

Collectively, these factors have caused important delays in finalizing critical publications and results on which subsequent analyses hinge; this includes the report on the causes and impacts of flooding in the LCRR basin, development of performance indicators and the water balance model. Delays in the development of critical performance indicators in the US have hindered the ability of Study scientists to approximate the impacts of structural mitigation measures being considered. In turn, this has forced the delay of some public, stakeholder and government meetings. To compensate for these cumulative delays, the Study Board requested and received, by the IJC a one year study extension to March 31, 2022 to complete all study activities.

2.3 Moving forward

Early in the study, the Board realized that the definition of the interactions between the various tasks along the study timeline was essential for the timely delivery of all its products. This updated work plan provides the interrelations between the tasks and a detailed timeline with a critical path necessary to execute those tasks in a timely and efficient manner. Furthermore, this updated version of the work plan lays out the remaining work to be accomplished to support the Study Board in delivering the IJC with Flood Mitigation measures pertaining to the four thematic areas identified in the framework, and the needed products to substantiate the recommendations of the Study Board. This is described in the following sections.

3 A Strategic Framework for Integrated Flood Management

The Study Board developed a strategic framework to carry out various elements of the project in a holistic and integrated manner. The thematic essentials of the strategic framework are captured in figure 3.1.

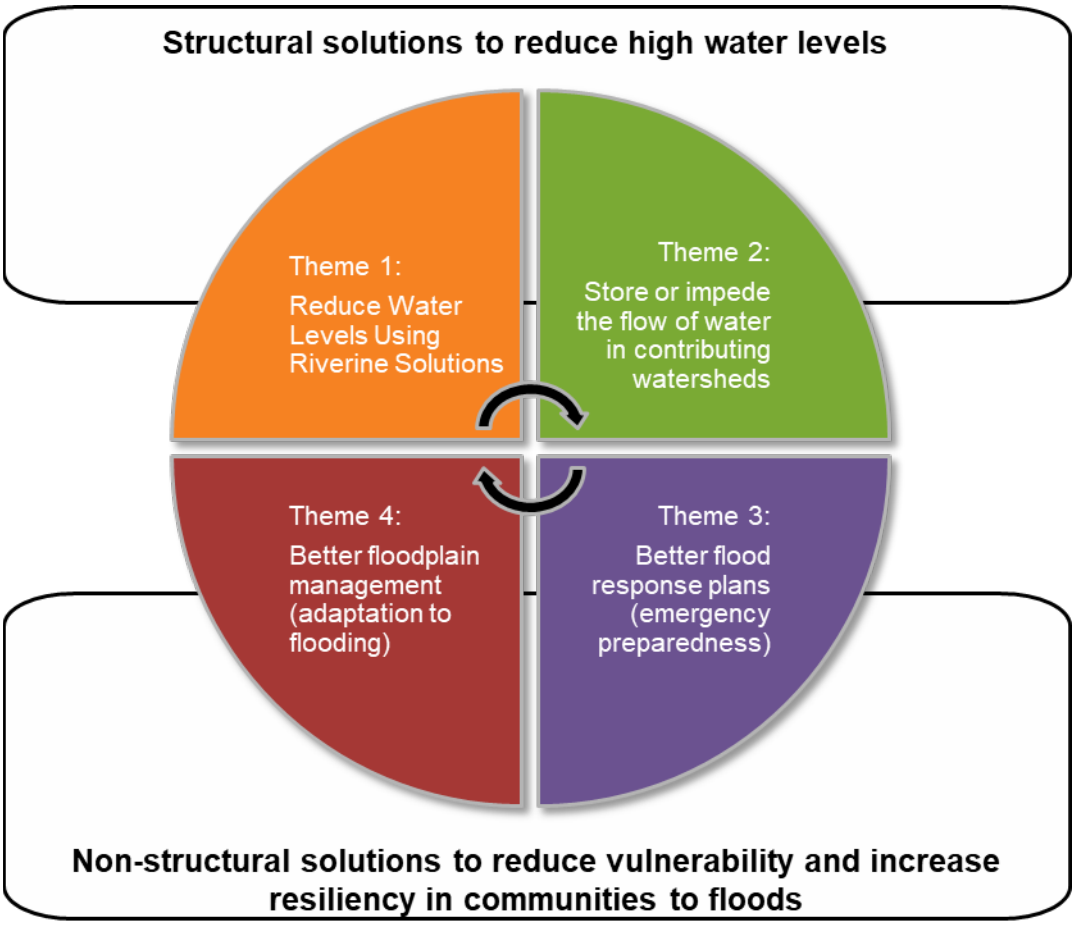

Figure 3.1. Four themes of integrated flood management as applied in the Lake Champlain Richelieu River study.

All four themes involve tasks that have been formulated to ensure delivery of recommendations from the study to IJC and the two counties. – including, a timeline for implementation, and resources required.

A series of tables for each mitigation theme follow that captures the tasks that are part of the critical path. The critical path signifies any slippage of the task will result in the delay of the overall study delivery and will be monitored accordingly. In the tables, tasks that are shaded in grey are on the critical path. Another point of importance to note is that all tasks that are shown with zero funds imply the costs of these activities are captured in the legacy tasks of the particular TWG/AG. Such tasks are identified in the work plan for the period 2017 to 2019. These are displayed in the overall Gantt chart and in the study's CPM workbook.

While not shown in the task tables, stakeholder and public acceptance of the possible mitigation measures will be assessed and tested. The measures having the greatest acceptance from the various sectors of society (i.e. governments, stakeholders, etc.) have the best potential for actual implementation in the future.

Major new task identified on this revised workplan and not previously in the original workplan include:

-a modeling study to identify the potential impacts on flood water levels from upland and flood plains water storage throughout the basin.

-a series of studies designed to quantify climate change impacts on net basin supplies and flood levels over the next 40 years to 2060.

-develop measures and assess their effectiveness for acceptability by governments, stakeholders and the public of the study's recommendations that will go into the final report.

3.1 Theme 1

This theme is exclusively focused on different types of interventions in the Richelieu River. Most of the options in this theme are located in and around Saint-Jean-sur-Richelieu, which sustained great flood losses in the 2011 event. Any flood damage reduction option here, by extension will reduce flooding along Lake Champlain shoreline, albeit with a smaller impact.

Options: The study has proposed five structural mitigation options for further consideration. A large number of options were evaluated and rejected as not practical for the amount of flood relief that was warranted or being outside of the study objectives. Explanation as to why these options were rejected will be communicated to stakeholders and the public. The five instream interventions that will be further analyzed include: 1) excavation of the Richelieu channel, removal of flow obstructions and stabilizing the river bed; 2) flow diversion through the Chambly Canal below Lock 9 that is linked to a regulation plan; 3) a combination of options 1) and 2); 4) dredging of the rapids and shoals and Saint-Jean-sur-Richelieu and modifying the shoal-like features upstream of the city; and, 5) dredging of the rapids and shoals and Saint-Jean-sur-Richelieu and installing a fixed weir that includes adjustable water level controls to manage flows. Water level controls would be based on a binational water regulation plan.

Potential benefits: In all the five options described, the objective is to reduce the water levels in the Richelieu River and Lake Champlain by various amounts to reduce flood damages and impacts. The best option will be with the best benefit-cost ratio and with political and societal acceptance.

Considerations: Certain options will reduce water levels not only during floods but also under normal flow years and especially during droughts. There are societal concerns with building instream structures from an environmental and recreational boating perspective. The Chambly Canal option could be less intrusive than dredging and control weir options.

Table 3.1 presents the tasks and activities that will deliver the objectives enunciated in this section.

Table 3.1 Listing of tasks that will meet the objectives of Theme 1

TWG Task	Task Name	Start	Finish
	Theme 1 Tasks Total	**2019-12-01**	**2021-03-31**
HHM14-CDN	Prepare water balance and ISEE hydraulics for Theme 1	2019-12-01	2020-03-30
FMMM22-US	Prepare CDST with Theme 1 Alternative Rankings	2020-03-31	2020-07-29
FMMM22-CDN	Prepare CDST with Theme 1 Alternative Rankings	2020-01-31	2020-05-30
RR13-US	Evaluate environmental impacts, Theme 1	2019-12-01	2020-03-30
RR13-CDN	Evaluate environmental impacts, Theme 1	2019-12-01	2020-03-30
SPE16-CDN	Evaluate economic impacts, Theme 1	2019-12-01	2020-03-30
SPE16-US	Evaluate economic impacts, Theme 1	2019-12-01	2020-03-30
RR19-US	Evaluate environmental impacts, Theme 1	2020-10-01	2021-01-29
RR19-CDN	Evaluate environmental impacts, Theme 1	2020-10-01	2021-01-29
SPE21-CDN	Evaluate economic impacts, Theme 1	2020-10-01	2021-01-29
SPE21-US	Evaluate economic impacts, Theme 1	2020-10-01	2021-01-29
HHM20-CDN	Prepare water balance and ISEE hydraulics for Theme 1	2020-10-01	2021-01-29
FMMM27-CDN	Prepare CDST with Theme 1 Alternative Rankings	2020-10-01	2021-01-29
FMMM27-US	Prepare CDST with Theme 1 Alternative Rankings	2020-12-01	2021-03-31

3.2 Theme 2

This theme mostly considers tributaries flowing into Lake Champlain, but also reviews the benefits of using undeveloped lands (wetlands, fields and agricultural lands) for storage of excess flows to reduce water levels in the entire LCRR drainage upstream of St. Jean sur Richelieu. The objective is to store or impede the flow of water in the contributing watersheds and along the Richelieu River. This in turn will change the phase and amplitude of floods into the lake and the river thereby reducing water levels and flood impacts.

Options: There are three major options in this theme. First is for flow retention through the development of nature-based solutions like wetlands; second, stream rehabilitation and reconnecting of floodplains; and, third, temporary flooding of agricultural land or less economically viable land.

Potential benefits: In this theme, the objective is to reduce/slow down timing of inflows into Lake Champlain and the Richelieu River and thereby lowering of peak water levels, and to identify the value of enhanced on-land storage of high flows to reduce water levels at critical locations.

Considerations: These options provide for the nature-based solutions which are broadly supported in the US. These may also reduce nutrient loading to the lake and river. These options may provide limited impact during extreme high-water level events. In the third option, because of potential negative impacts on agriculture, other privately-owned land and water quality, there may be a need for compensation.

Table 3.2 presents the tasks and activities that will deliver the objectives developed for Theme 2. The Study Board approved conducting studies in Lake Champlain watersheds to study the impacts of watershed storage, whether in wetlands, connected floodplains, etc. These are displayed in the overall Gantt chart and in the CPM workbook.

Table 3.2 Listing of tasks that will meet the objectives of Theme 2

TWG Task	**Task Name**	Start	**Finish**
	Theme 2 Tasks Total	2019-08-01	2020-03-31
FMMM14-US	Assess potential of watershed storage for Theme 2	2019-08-01	2020-03-31
FMMM14-CDN	Assess potential of watershed storage for Theme 2	2019-08-01	2020-03-31

3.3 Theme 3

This theme focuses on the reduction of vulnerability of high water and flooding and building flood resiliency through the use of enhanced flood forecasting and flood plain inundation mapping predictions. The backbone of this theme lies in the development and associated recommendation for implementation of a binational flood forecasting and real-time inundation mapping system. There are nearly a dozen communities in the three jurisdictions of Quebec, New York and Vermont where the availability of advanced information and mapping tools will help in the emergency management. A major achievement will be to collaborate with first responders in some of those communities to allow them to make sound recommendations that could help improve decision schemes when a flood is occurring by integrating forecasting in a timely manner to decision criteria for interventions in the field.

Options: There are four major options in this theme. First, flood forecasting to improve response time; second, greater spatial detail in predicting impact areas, and incorporating influences of wind and waves on flood potential, temporary or long-term flood proofing through sand bagging, flood walls or diking; third, efforts in reducing exposure through mobilization of the potentially impacted population; and, fourth, protecting the vulnerable portion of the population and critical services.

Potential benefits: In this theme, the objective is to build population and economic resilience to flood water levels by making use of flood forecasting which includes wind and wave impacts.

Considerations: There are several features in this theme that will require careful evaluation. These include: a significant potential to reduce flood impacts ahead of and during the event, a controlled and moderate lowering of flood levels in the system, emergency evacuation plans to be developed, established and tested, and emergency evacuation plans to address the most vulnerable**.**

Table 3.3 captures all the tasks that feed into the proposed successful completion of Theme 3 objectives. These 31 tasks efforts were designed based on consultation among the emergency responders from the three jurisdictions in Quebec, New York and Vermont, forecast developers who identified performance indicators. These tasks have input from all

TWGs/AG and will require extensive consultation. With the timing of various tasks that may be adjusted through consultation, tasks HHM task 9 and 10 are critical tasks along with a white paper on a flood forecasting and real-time inundation mapping program which will address governance of a binational forecast system.

Table 3.3 Listing of tasks that will meet the objectives of Theme 3

TWG Task	Task Name	Start	Finish
	Theme 3 Tasks Total	**2018-08-01**	**2021-01-29**
RR12-US	Evaluate environmental impacts, Theme 3	2020-01-31	2020-05-30
RR12-CDN	Evaluate environmental impacts, Theme 3	2020-01-31	2020-05-30
SPE15-CDN	Evaluate economic impacts, Theme 3	2020-01-31	2020-05-30
SPE15-US	Evaluate economic impacts, Theme 3	2020-01-31	2020-05-30
HHM13-CDN	Prepare water balance and ISEE hydraulics for Theme 3	2020-01-31	2020-05-30
FMMM21-CDN	Prepare CDST with Theme 3 Alternative Rankings	2020-04-01	2020-07-30
FMMM21-US	Prepare CDST with Theme 3 Alternative Rankings	2020-04-01	2020-07-30
FMMM16-US	Prepare for and conduct Theme 3 workshop	2019-10-01	2019-11-30
FMMM16-CDN	Prepare for and conduct Theme 3 workshop	2019-10-01	2019-11-30
RR18-US	Evaluate environmental impacts, Theme 3	2020-10-01	2021-01-29
RR18-CDN	Evaluate environmental impacts, Theme 3	2020-10-01	2021-01-29
SPE20-CDN	Evaluate economic impacts, Theme 3	2020-10-01	2021-01-29
SPE20-US	Evaluate economic impacts, Theme 3	2020-10-01	2021-01-29
HHM19-CDN	Prepare water balance and ISEE hydraulics for Theme 3	2020-10-01	2021-01-29
FMMM26-CDN	Prepare CDST with Theme 3 Alternative Rankings	2020-10-01	2021-01-29
FMMM26-US	Prepare CDST with Theme 3 Alternative Rankings	2020-10-01	2021-01-29
HHM8-US	Perform a comparative analysis from tool to end users	2019-08-01	2019-11-29
HHM8-CDN	Perform a comparative analysis from tool to end users	2019-08-01	2019-11-29
FMMM17-US	Survey responders to ask how they use forecasts	2018-08-01	2018-11-29
FMMM17-CDN	Survey responders to ask how they use forecasts	2018-08-01	2018-11-29
SPE12-US	Review media stories, determine how people use forecasts	2018-08-01	2018-11-29
SPE12-CDN	Review media stories, determine how people use forecasts	2018-08-01	2018-11-29
HHM9-US	Write manual on forecast products	2019-12-02	2020-03-31
HHM9-CDN	Write manual on forecast products	2019-12-02	2020-03-31
HHM10-US	Write report on governance of binational forecast system	2019-12-01	2020-03-30
HHM10-CDN	Write report on governance of binational forecast system	2019-12-01	2020-03-30
SPE13-US	Analyze the economic benefits of flood response plans	2019-10-01	2020-01-29
SPE13-CDN	Analyze the economic benefits of flood response plans	2019-10-01	2020-01-29
FMMM18-US	Conduct U.S. pilot flood response project	2019-10-01	2020-01-29
FMMM18-CDN	Conduct Canadian pilot flood response project	2019-10-01	2020-01-29

3.4 Theme 4

The onus on flood reduction is through preventative measures like floodplain mapping, designation and regulation. There is a wealth of information from Quebec regarding application of floodplain management policies and from Federal Emergency Management Agency (FEMA) and state flood managers in New York and Vermont. Currently, as Quebec is considering options for floodplain management in the province, the study could play a vital role in this area.

Options: There are four major strategies in this theme. The first is to create flood damage curves unique to the LCRR basin; the second is to analyze the designation of buffer zones, like floodway or flood fringe; the third, is to examine existing floodplain policies and regulations within the best management practices (BMP); and, the fourth is to investigate strategies for flood prone communities.

Potential benefits: In this theme the objective is to reduce flood damages associated with extreme water levels through adaptation to flooding and improved floodplain management.

Considerations: There are several features in this theme that will require careful evaluation. These include: a challenge to establish accurate flood damage curves; a need to develop an effective framework to aid communities when planning floodplain policies; a concern as jurisdictions with entrenched policies take time to change; and, another concern that it can be a politically and societally sensitive issue the governments are struggling to address.

Table 3.4 captures all the tasks that feed into the proposed Theme 4 objectives. Theme 4 also addresses the key issues of floodplain management. An earlier effort of FMMM TWG to document some of these measures will provide a good backdrop to the proposed workshop of the experts. The outputs from the decision scaling tasks will also help assist the work in this area. Of the 17 identified tasks that feed into this theme, there is one task from HHM TWG that is on the critical path.

Table 3.4 Listing of tasks that will meet the objectives of Theme 4

TWG Task	Task Name	Start	Finish
	Theme 4 Tasks Total	**2019-10-01**	**2021-01-29**
HHM18-CDN	Prepare water balance and ISEE hydraulics for Theme 4	2020-10-01	2021-01-29
FMMM19-US	Prepare for and conduct Theme 4 workshop	2019-10-01	2020-01-29
FMMM19-CDN	Prepare for and conduct Theme 4 workshop	2019-10-01	2020-01-29
HHM11-CDN	Prepare 12 NBS Datasets for robustness testing, run WBM	2019-10-01	2020-01-29
RR11-US	Evaluate environmental impacts, Theme 4	2019-12-01	2020-03-30
RR11-CDN	Evaluate environmental impacts, Theme 4	2019-12-01	2020-03-30
SPE14-CDN	Evaluate economic impacts, Theme 4	2019-12-01	2020-03-30
SPE14-US	Evaluate economic impacts, Theme 4	2019-12-01	2020-03-30
RR17-US	Evaluate environmental impacts, Theme 4	2020-10-01	2021-01-29
RR17-CDN	Evaluate environmental impacts, Theme 4	2020-10-01	2021-01-29
SPE19-CDN	Evaluate economic impacts, Theme 4	2020-10-01	2021-01-29
SPE19-US	Evaluate economic impacts, Theme 4	2020-10-01	2021-01-29
FMMM25-US	Prepare CDST with Theme 4 Alternative Rankings	2020-10-01	2021-01-29
FMMM25-CDN	Prepare CDST with Theme 4 Alternative Rankings	2020-10-01	2021-01-29
HHM12-CDN	Run ISEE hydraulics for Theme 4	2019-12-01	2020-03-30
FMMM20-CDN	Prepare CDST with Theme 4 Alternative Rankings	2020-01-31	2020-05-30
FMMM20-US	Prepare CDST with Theme 4 Alternative Rankings	2020-01-31	2020-05-30

3.5 Climate change assessment tasks

One of the objectives of the study was to consider climate variability and change in all deliberations in addressing flood risk reduction. Earlier in 2019, the study organized a workshop in Montreal to address climate related matters. One of the outcomes was to tackle this issue not as a traditional climate downscaling approach, but rather as a decision scaling challenge. As any outcome will be equally applicable to all the themes, these were classified as cross-cutting measures in addressing climate variability and change. The Study Board approved the development of a detailed scope of work in conducting additional work associated with understanding climate change impacts on flooding – these efforts and tasks may include conducting decision scaling projects and development of stochastic, climate change and related net basin supplies (NBS) into Lake Champlain with a probable maximum flood (PMF).

Options: There are four major themes in addressing the study objective of reducing flood damages. In the cross-cutting measures, a large number of supply series representing possible futures will be generated and tested against the decision scaling criteria developed and used in other IJC studies.

Potential benefits: The use of decision scaling approach will provide for a more robust approach in addressing and delivering tools to aid in flood damage reduction in the LCRR basin.

Considerations:. There are challenges in ensuring there are sufficient net basin supply estimates produced through climate modelling, stochastic analysis and PMF determination.

Table 3.5 presents the three tasks in fulfilling the objectives of conducting the decision scaling exercise for the study. All four themes will benefit from the outcomes and provide for recommendation that will be useful in the long-term recommendations for a combination of themes in delivering the study objectives. The efforts in this area are quite essential as shown by the two out of three tasks being on the critical path.

Table 3.5 Listing of tasks that will meet objectives of cross-cutting measures

TWG Task	Task Name	Start	Finish
	Cross-Cutting Tasks Total	**2019-08-01**	**2020-11-29**
FMMM15-US	Produce NBS estimations with different tools to reduce uncertainty in future water supplies	**2019-08-01**	**2019-12-29**
FMMM15-CDN	Produce NBS estimations with different tools to reduce uncertainty in future water supplies	**2019-08-01**	**2019-12-29**
HHM17-CDN	Prepare 12 NBS Datasets for robustness testing	**2020-08-01**	**2020-11-29**

Here is a listing of the crosscutting legacy task that are required to deliver the tasks in the four noted themes. Several of the legacy tasks are already complete and are providing input into the dependent tasks. For other details on costs, dependencies, etc. please refer to the full output of the Gantt charts captured in Appendix 2.

Table 3.6 Listing of the crosscutting legacy tasks that are feeding into the new thematic tasks

TWG Task	Task Name	Start	Finish
	HHM Cross-Cutting Tasks	**2017-04-01**	**2022-02-17**
HHM1-CDN	Hydrometeorological & basic modelling & data collection	2017-04-01	2017-12-17
HHM2-CDN	Hydrology & meteorology modeling	2017-12-18	2018-08-15
HHM3-CDN	2D hydrodynamic (flood mitigation) model development	2018-08-16	2019-04-13
HHM4-CDN	Hydroclimatology scenarios	2017-04-01	2019-05-21
HHM1-US	Hydrometeorological & basic modelling & data collection	2017-04-01	2017-12-17
HHM2-US	Hydrology & meteorology modeling	2017-12-18	2018-08-15
HHM3-US	2D hydrodynamic (flood mitigation) model development	2018-08-16	2019-04-13
HHM4-US	Hydroclimatology scenarios	2017-04-01	2017-10-18
HHM5-CDN	Hydrometeorological analysis of past floods	2017-12-18	2018-02-16
HHM5-US	Hydrometeorological analysis of past floods	2017-12-18	2018-02-16
HHM6-CDN	Analysis of mitigation plans	2019-04-14	2020-09-15
HHM6-US	Analysis of mitigation plans	2019-04-14	2020-09-15
HHM7-CDN	Development of real-time flood forecasting system	2019-04-14	2022-02-17
HHM7-US	Development of real-time flood forecasting system	2019-04-14	2022-02-17
	RR Cross-Cutting Tasks	**2017-04-01**	**2021-04-18**
RR1-CDN	Review of impacts of past floods on resources	2017-04-01	2017-12-17
RR1-US	Review of impacts of past floods on resources	2017-04-01	2017-12-17
RR2-CDN	Iterative review and selection of indicators	2017-04-01	2017-07-30
RR3-CDN	Analysis of water uses and water intakes	2017-04-01	2019-05-21
RR4-CDN	Analysis of shoreline and floodplain built environment	2017-04-01	2019-05-21
RR5-CDN	Analysis of impacts on agriculture	2017-04-01	2017-12-17
RR6-CDN	Indicators for the natural environment analysis	2017-04-01	2018-04-01
RR7-CDN	Integrative tool for the assessment of impacts on resources	2018-04-01	2020-05-20
RR8-CDN	Resource baseline impact assessment	2020-04-01	2020-12-17
RR2-US	Iterative review and selection of indicators	2017-04-01	2017-07-30
RR3-US	Analysis of water uses and water intakes	2017-04-01	2019-05-21
RR4-US	Analysis of shoreline and floodplain built environment	2017-04-01	2019-05-21
RR5-US	Analysis of impacts on agriculture	2017-04-01	2017-12-17
RR6-US	Indicators for the natural environment analysis	2017-04-01	2018-04-01
RR7-US	Integrative tool for the assessment of impacts on resources	2018-04-01	2020-05-20
RR8-US	Resource baseline impact assessment	2020-04-01	2020-12-17
RR9-CDN	Indicator Calibration	2020-06-01	2021-02-16
RR10-CDN	Assessment of Cumulative impacts of anthropogenic modificat	2020-08-01	2021-04-18
RR9-US	Indicator Calibration	2020-06-01	2021-02-16
RR10-US	Assessment of Cumulative impacts of anthropogenic modificat	2020-08-01	2021-04-18
	SPE Cross-Cutting Tasks	**2017-04-01**	**2021-07-30**
SPE1-CDN	Historical analysis of flooding from a social, political and econ	2017-04-01	2017-12-17
SPE1-US	Historical analysis of flooding from a social, political and econ	2017-04-01	2017-12-17
SPE2-CDN	Press review of past floods	2017-04-01	2017-07-30

SPE3-CDN	Inventory of existing studies with relevant social, political and e	2017-04-01	2017-07-30
SPE4-CDN	Vulnerability and resilience of local communities assessment	2017-04-01	2017-12-17
SPE5-CDN	Risk perception analysis	2018-04-01	2019-09-03
SPE2-US	Press review of past floods	2017-04-01	2017-07-30
SPE3-US	Inventory of existing studies with relevant social, political and e	2017-04-01	2017-07-30
SPE4-US	Vulnerability and resilience of local communities assessment	2018-04-01	2018-12-17
SPE5-US	Risk perception analysis	2018-04-01	2019-09-03
SPE6-CDN	Development of social, political, economic, and public health i	2017-04-01	2018-09-03
SPE6-US	Development of social, political, economic, and public health i	2017-04-01	2018-09-03
SPE7-CDN	Develop a IJC LCRR outreach plan	2017-04-01	2017-05-01
SPE8-CDN	Governance analysis on flood preparedness and response	2017-04-01	2018-09-03
SPE9-CDN	Development of multi-agent governance model	2018-09-04	2020-02-06
SPE10-CDN	Cost-Benefit Analysis of Potential Mitigation Measures	2019-06-11	2021-07-30
SPE11-CDN	Vulnerability and impact assessment	2019-08-11	2021-01-12
SPE7-US	Develop a IJC LCRR outreach plan	2017-04-01	2017-05-01
SPE8-US	Governance analysis on flood preparedness and response	2017-04-01	2018-09-03
SPE9-US	Development of multi-agent governance model	2019-06-11	2020-11-12
SPE10-US	Cost-Benefit Analysis of Potential Mitigation Measures	2019-06-01	2020-11-02
SPE11-US	Vulnerability and impact assessment	2019-04-01	2020-09-02
	FMMM Cross-Cutting Tasks	**2017-04-01**	**2021-09-30**
FMMM1-CDN	Develop collaborative decision support tool (and report)	2018-04-01	2021-09-30
FMMM1-US	Develop collaborative decision support tool (and report)	2018-04-01	2021-09-30
FMMM2-CDN	Develop metrics/performance indicators to evaluate the propo	2018-09-04	2021-09-30
FMMM2-US	Develop metrics/performance indicators to evaluate the propo	2018-09-04	2021-09-30
FMMM3-CDN	Working with TWGs, project developers, etc. finalize metrics/	2019-06-11	2021-09-30
FMMM3-US	Working with TWGs, project developers, etc. finalize metrics/	2019-06-11	2021-09-30
FMMM4-CDN	Preliminary assessment of probable in-stream structural or cha	2019-08-11	2021-08-10
FMMM4-US	Preliminary assessment of probable in-stream structural or cha	2019-08-11	2021-08-10
FMMM5-CDN	Engagement of decision-makers/stakeholders in mitigation solu	2017-04-01	2019-04-01
FMMM5-US	Engagement of decision-makers/stakeholders in mitigation solu	2017-04-01	2019-04-01
FMMM6-CDN	Survey of basin jurisdictions' approaches to flooding	2017-04-01	2019-04-01
FMMM6-US	Survey of basin jurisdictions' approaches to flooding	2017-04-01	2019-04-01
FMMM7-CDN	Literature review on structural options	2019-06-14	2021-06-13
FMMM7-US	Literature review on structural options	2019-06-14	2021-06-13
FMMM8-CDN	Literature review of non-structural options	2017-04-01	2019-04-01
FMMM8-US	Literature review of non-structural options	2017-04-01	2019-04-01
FMMM9-CDN	Expert workshop on options for LCRR basin	2019-10-01	2021-09-30
FMMM9-US	Expert workshop on options for LCRR basin	2018-04-01	2020-03-31
FMMM10-CDN	Initial assessment and prioritization of proposed metrics/ perfo	2018-09-04	2018-10-04
FMMM10-US	Initial assessment and prioritization of proposed metrics/ perfo	2018-09-04	2018-10-04
FMMM11-CDN	Stakeholders shortlist of mitigation measures (structural and no	2018-09-04	2018-10-04
FMMM11-US	Stakeholders shortlist of mitigation measures (structural and no	2018-09-04	2018-10-04
FMMM12-CDN	Engineering feasibility assessment	2019-04-01	2019-05-01
FMMM12-US	Engineering feasibility assessment	2018-11-04	2018-12-04
FMMM13-CDN	Recommend a governance mechanism for the operation of flo	2019-06-14	2019-07-14
FMMM13-US	Recommend a governance mechanism for the operation of flo	2019-06-14	2019-07-14

3.6 Study priorities 2019-2022

The Study intends to submit recommendations to the IJC for all four themes of the strategic framework that will be submitted for discussion with governments, stakeholders and the public to weigh the political and social acceptability of the proposed measures which can be summarized as:

Theme 1: Explore the effectiveness of removing structural artifacts from the Saint-Jean shoal portion controlling the flow, using the upper portion of the Chambly Canal below lock No 9 to enhance the conveyance of water in the system, moving the control section upstream of Saint-Jean-sur-Richelieu, and combinations of those actions.

Theme 2: Examine the flood reduction capacities offered by restoring floodplains and wetlands in the basin

Theme 3: Develop and implement a binational flood forecasting and real-time inundation mapping system: design the products and delivery mechanism to address first responders and municipalities needs in optimizing their flood response plans.

Theme 4: Improve floodplain management strategies and regulations by gaining information on flood plain management best practices from local and national perspectives, consulting governments on flood risk reduction measures, and participate in inter-departmental committees

The Study Board also put a clear focus on assessing the political acceptability of its proposed flood mitigation measures and in ensuring its potential impacts on First Nation and Tribes sites of significance are understood and taken into account in its recommendations. Hence, work was initiated with the Waban Aki, Abenaki and Mohawk Nations to gather evidence on the extent of the use of the territory as well as the identification of sacred sites that could be impacted by the flood mitigation measures.

Finally, all recommendations will be formulated in light of a sound approach to assessing the variability of future potential water supplies, hence maximizing their robustness and reliability.

4 Preliminary Decision and Modeling Tools

4.1 Decision Making Framework

The LCRR study will use a series of hydrologic, hydraulic and decision support modeling tools to generate the study's recommendations. The Board's recommendations will be based on Board decision criteria (Table 4.1) that will be incorporated into decision support modeling, and that will be applied in several practice decisions in the second half of the study, and then in final decision workshops done in conjunction with study board meetings. Practice decisions use the study decision criteria to judge the suitability of the spectrum of proposed flood mitigation actions. The PAG, technical work groups and the Study Board will be involved in each practice decision and the results will be shared in study newsletters and public meetings. The ISEE modeling tool and hydrologic models will be used to estimate how different alternatives in each of the four themes will affect the extent, depths and impacts of floods. Figure 4.1 shows the flow of estimated flood related information from future water supplies in the LCRR basin to future impacts under a wide variety of alternative management approaches.

Table 4.1 Study Board Decision Criteria (preliminary)

Id	Criteria	Definition
1	Likely to be implemented	Meets politically acceptable assessments
2	Reduces flooding in a cost-effective manner	Significant reduction of costs (societal, environmental, etc.)
3	Good for the environment	Minimal or mitigated impact
4	Minimal induced losses	Flood damages go down, but recreation activities are limited
5	Fair/equitable	B/C analysis can lead to levees for expensive dwellings
6	Financially sustainable	Not subsidized from outside the floodplain
7	Reliable	Provides durable benefits and minimal risk of failure
8	Addresses coastal, not upper basin floods	IJC guidance requires shore benefits, but accommodates collateral upper basin and WQ benefits
9	Robust	Works about as well as any comparable alternative over a wide range of climate futures

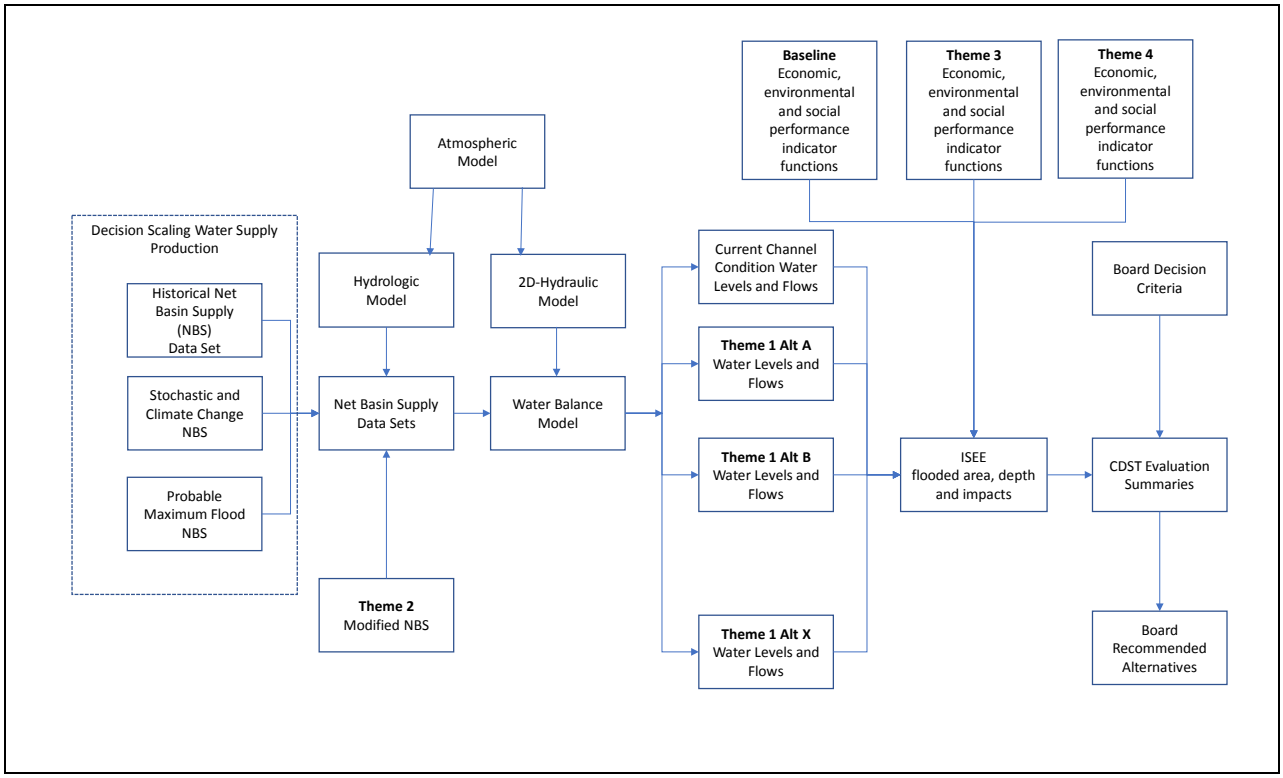

Figure 4.1. Converting possible future water supplies to impacts under different alternatives

4.2 Hydrology

Three hydrologic models are now in use: a NOAA model (WRF-Hydro), an ECCC model (GEM-Hydro) and a MELCC model (HYDROTEL). To simplify the description and illustrate the relative importance in the decision framework, hydrology is described in one entity.

WRF-Hydro is both a stand-alone hydrological modeling system as well as an architecture for coupling hydrological and atmospheric models. In this study, WRF-Hydro will be used for hydrological forecasting for providing inflows to the Lake Champlain hydrodynamic model. The WRF-Hydro system provides an extensible areal and temporal multi-scale and multi-physics land-atmosphere modeling capability for assimilation and prediction of water cycle components such as precipitation, soil moisture, snowpack, groundwater, streamflow, and inundation. WRF-Hydro is the accepted National Weather Service enterprise model, and the Lake Champlain application will be transition to operations in the NOAA National Water Model for operational flood forecasting.

GEM-Hydro is a hydrological model that has been implemented and calibrated on the Lake Champlain watershed. GEM-Hydro is made of the SVS (Soil Vegetation Snow) land-surface scheme and the Watroute routing scheme. GEM-Hydro can be used to perform streamflow

forecasts and to feed the 2-D model. In the next year, GEM-Hydro will be validated and corrected until the USGS drainage area and model area at each gauge agree within +/- 5%. Also, the dams with the capacity of at least 13 000 acre-feet or 0.016 km3 will be added to the system and the two coefficients that are controlling the outgoing discharge of a reservoir will be determined. In the longer-term plans, the ensemble version of the hydrological system will be developed. This new system will use the land-surface conditions produced by the new Land Data Assimilation System (CaLDAS-Satellite) as initial conditions and will use the atmospheric forcings produced by the REPS (Regional Ensemble Prediction System) and by the GEPS (Global Ensemble Prediction System). The development of the monitoring and verification system for the ensemble hydrological model will be set up.

HYDROTEL is a spatially distributed hydrological model where a given watershed is divided in several simulation units called Relatively Homogeneous Hydrological Units (RHHUs) and river reaches. Often referred to hydrologic response units (HRU) in the literature, RHHUs represent elementary sub watersheds taking into account the spatial variability of topography, land use, soil types, and meteorological variables. For the LCRR study, the network discretization was pushed to a high resolution. According to this configuration, the entire Richelieu basin is composed of 8032 RHHUs and 3208 river reaches. Streamflow simulation in HYDROTEL takes into consideration many important processes, such as snow accumulation and melt, evapotranspiration, moisture in the soil column, runoff generation and horizontal flow. The calibration of HYDROTEL was done using measured streamflow at 18 U.S. tributaries of the Lake Champlain that contribute to 73% of the total lake inflow.

4.3 Two-dimensional hydrodynamic model (2D-model)

The 2D-model is a numerical tool spatially calculating the water depths, levels and velocities in the river and the lake; the model uses the current high-definition bathymetry and topography of the river and the lake. The Saint-Jean-sur-Richelieu sill is represented in detail in order to precisely simulate water levels in the river and lake from the outflows of the lake and, hence define the stage-discharge relationship that is used in the water balance model to test different Theme 1 mitigation solutions that command a modified bathymetry. Paired with a high definition Digital Elevation Model (DEM), the 2D-model is used in the ISEE grid (discussed below) to produce flood extent in the flood plain for each Theme 1 mitigation measures as well as data input to compute performance indicators.

4.4 Water Balance Model

The water balance model is an Excel spreadsheet that estimates Lake Champlain levels, releases into the Richelieu River and Richelieu River levels at St. Jean-sur-Richelieu over ninety-two years of observations (or any other time series) at a quarter monthly time step. The two inputs to the model are the net basin supplies and channel configurations. Theme 2 (upland storage) alternatives store water temporarily in the watershed and so reduce and reschedule net basin supplies. The impact of Theme 2 alternatives will be tested in the water balance model by running the model with net basin supplies as modified by upland and flood plains storage. Theme 1 alternatives will change the stage-discharge equations used to calculate releases from

the Lake. Water balance model results for any combination of Theme 1 and 2 alternatives can be used to produce a time series of water levels that can be used to evaluate any Theme 3 or 4 alternative. The discharges from the water balance model will be distributed by a two-dimensional hydraulic model to show flows and depths of flooding down the Richelieu River, forming the base layer of the ISEE model for evaluations.

4.5 Three dimensional hydrodynamic circulation model (3D-model)

The 3D-model for Lake Champlain predicts water levels, currents, and temperatures throughout the lake. It is based upon the Finite Volume Coastal Ocean Model (FVCOM) and uses triangular, unstructured grid to represent the lake and low-lying nearshore areas. The model is forced by weather conditions (wind, air temperatures, solar radiation) and hydrologic inflows (both point (i.e., rivers) and non-point sources) to model the lake levels, horizontal and vertical currents throughout the lake, and 3D temperatures. This model will provide critical information for flood forecasting for the lake by predicting changes in lake levels caused not only by rainfall, snowmelt, and resulting stream flows, but also by wind events, which can cause an additional set-up in water levels of several feet at each end of the lake, flooding low-lying areas. The model will run every 6 hours year-round providing guidance for forecasts out to five days. It will receive inflows from a distributed hydrologic model (WRF-Hydro) so that government forecasters can predict the expected flood conditions around the lake and flowing into the Richelieu River. FVCOM is the accepted National Weather Service enterprise model, and the Lake Champlain application will be transition to operations in the NOAA National Center for Environmental Prediction for operational flood forecasting.

4.6 Performance indicators (PIs)

Performance indicators are measurable values expressing the link between the water level or discharge and a given interest, resource or process. These Indicators quantify the impacts of flood levels and a given mitigation solution for a given NBS time-series. Various layers of information can be used to develop and calculate PIs that are linked to water level, water level variations or water temperature. PIs can be simple such as linking water levels with property damage for a large region or can be more sophisticated and provide spatially distributed results, like maps displaying flood and wave-damaged properties or the distribution of wetlands at various water depths. Social, economical and environmental PIs developed during the LCRR study will be used to assess impacts to recreational, domestic, industrial and municipal water uses, shoreline and floodplain infrastructures and buildings, agriculture, to vulnerable populations and to the natural environment (habitats, vegetation and wildlife).

Among the evaluated PIs, special attention will be paid to territorial and regional social vulnerability of the LCRR basin. For example, social sensitivity can include factors associated to the economic state of a region (i.e. median income), age, proportion of home ownership, home value, unemployment, etc. Those variables can be combined and mapped as a social sensibility index.

4.7 Integrated Social-Economic-Environmental (ISEE) System

ISEE relies on a georeferenced database specialized for modelling aquatic and riparian areas, combined with a script library allowing to model performance indicators over long-term hydrological time-series (discharge or level). The ISEE system comprise a combination of temporal and spatial layers of observed (measured) and simulated (results from various models) information, such as hydraulics as well as land use, infrastructure, socio-economic disparity and natural environment. Each layer consists of nodes distributed on grids of different resolution. The first layer of ISEE is a Digital Elevation Model (DEM) from which various physical variables can be calculated (e.g. slope of the flood plain).

For each time step of the time series, hydrodynamic models are integrated in ISEE. As a result, all relevant physical variables are available at each point of the ISEE grid such as water depth, currents velocities, shears stress, etc. All these variables can be used to create simple Performance indicators (PIs) such as stage-damage curve or very complex models (combination of water saturation, currents and wave erosion models) over different time periods (e.g. during a specific event or over long-term time series) if needed. PIs addressing various concerns of stakeholders and population are then computed to evaluate mitigation measure scenarios. The PI values for each mitigation measures are then compared to a baseline condition scenario (present conditions defined by historical NBS series), i.e. the hydrological regime and floodplain management policies that would be in place if no intervention/action were undertaken.

Results from ISEE are georeferenced and time-referenced and can be easily imported into any GIS software for visualization or further analyses. Because the system is driven by temporal series, animations (videos) can be easily produced from sequential images. Results can be spatially and temporally integrated over a season, a year or a full long-term time series for an easy analysis of a specific region or the entire drainage basin. ISEE could also be used in a real-time and forecasting mode, as a mapping tool for flood forecasting, although at this stage in the study, the final approach for mapping real-time flood inundation based on flood forecasts has yet to be determined. Furthermore, many different layers can be used to calculate other variables at different time-steps as illustrated in Figure 4.2.

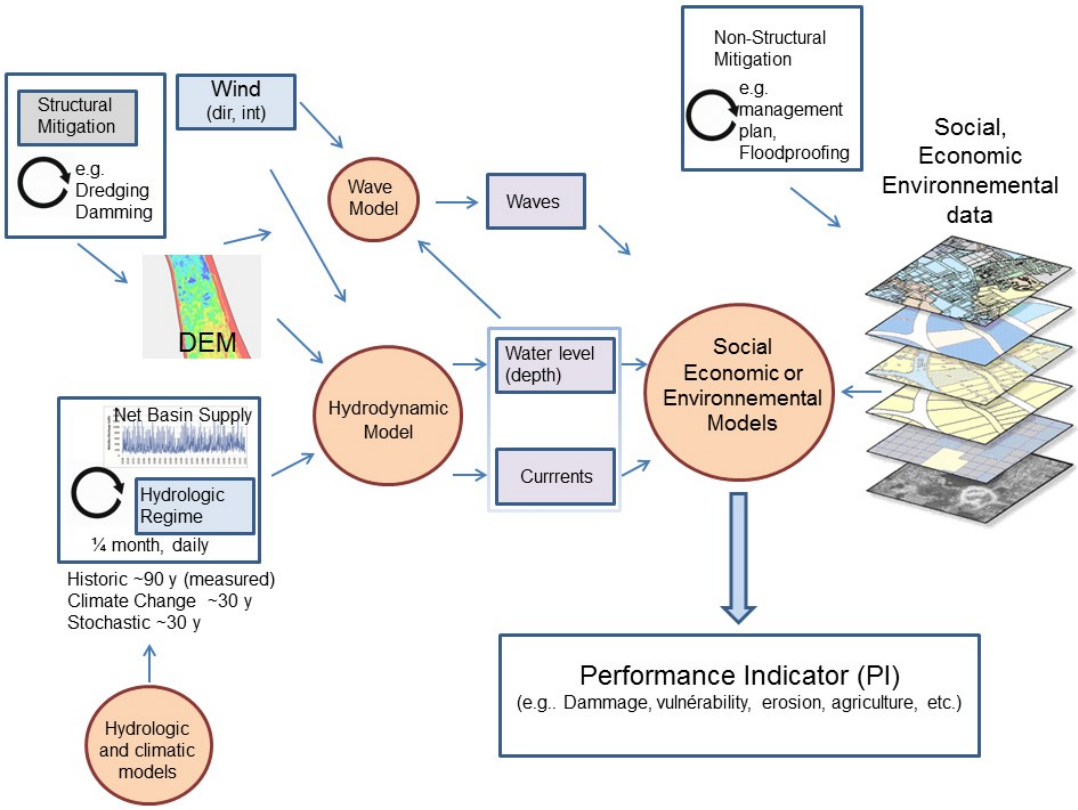

Figure 4.2 Workflow for the modelling of performance indicators(PI) of social, economic and environmental impacts for each time step (daily or ¼ month) of hydrologic time series (historic, stochastic or climate change) under scenarios of structural or non-structure

All results, directly from ISEE, or post-processed, can be integrated per region or for the entire basin for the direct use in the Collaborative Decision Support Tool.

4.8 Collaborative Decision Support Tool (CDST)

The Collaborative Decision Support Tool (CDST) is an easy to use and understand Excel model, that bridges the sophisticated complex outputs of ISEE and the relatively simple decision criteria the Board will use to decide whether to recommend alternatives or mitigation measures.

One or more Collaborative Decision Support Tools (CDSTs) will be used to present ISEE model results. CDSTs are developed collaboratively with decision makers and stakeholders to assure not only that the CDST is most useful but also to assure that the study is producing the results needed. The term CDST is being used in this study in place of “Shared Vision Model” used elsewhere.

The four flood mitigation themes are different enough that there may be different CDSTs for different alternatives, but because some decision makers might be interested in how different types of alternatives interact, there may be larger CDSTs that allow the user to select from a menu listing alternatives of each of the four types to evaluate combinations of alternatives.

CDST connects the Board's decision making to the technical analysis and modeling. FMMM works with the Board to help them define what they are deciding, how they are deciding it, and what answers they want to support those decisions. The LCRR Board determined, in a meeting in Plattsburgh in the fall of 2018, that their goal was to reduce flood damages along the Lake Champlain shore and down the banks of the Richelieu River. This goal not only includes formulating ideas that could reduce flood damages, but consider options it believes are politically acceptable and that governments/stakeholders are inclined to support. ISEE will generate a large dataset of PIs; the CDST will be designed to present some statistical characterization of those results in ways that address the Study Board's questions.

4.9 Benefit / Costs analysis

Since the Flood Control Act of 1936 in the United States, flood project benefits have been monetized and compared to costs, and the difference or ratio used as the primary indicator of the rationality of the project investment. Since then, two significant issues have reduced the utility of the benefit-cost analysis; some benefits are difficult to monetize in meaningful way, and statistical representation of flood impacts has been undermined by climate change and variability has been difficult.

For those impacts that cannot be monetized with confidence, the benefit of an alternative can be measured in a native performance indicator, such as acres of wetland flooded, expressed as a ratio to the baseline. Uncertainty about flood frequencies will be addressed using sensitivity analysis, testing for the robustness of the finding that the alternative costs will be smaller than the benefits over a wide range of estimated flood frequencies.

5 Study timeline 2019-2022 and Management Tools

For a study the size and complexity of Lake Champlain Richelieu River Study, the study management and the tools used in its successful delivery become key components. This study, like similar IJC References, have multiple tasks teams, technical and advisory groups supporting the Study Board. There are four technical working groups, one advisory group and one communication group assisting the Board in the delivery of the Study. For this purpose, the Study Board established a task force to deliver on two key pieces that are important for the study management purposes. The first is an Excel based Critical Path Method (CPM) workbook; the second is an MS Project based Gantt chart and critical path analysis tool to capture all tasks identified and listed by the task force.

Managing in excess of 270 tasks that define the LCRR study from its inception to its projected timeline of study completion was the central core of the two exercises. The Excel based CPM toolkit was provided to all working groups for maintaining and updating work group based activities. The Project based information is used by the study's management team to capture and track the progress of the study, ensure there is no slippage on the activities identified on the critical path. This will be updated as required. This tool will also be used to report progress.

Figure 5.1 captures a window of information from Project tool kit for generating the Gantt charts. MS Project has a total of 273 tasks defining the work authorized under the Reference.

This has two major components. The activities from the start of the study until the writing of the revised work plan, comprising of 105 tasks were captured on the traditional work group breakdowns.

For the period moving forward from 2019 to 2022, the information was aligned with the strategic framework for the study with an assumed outcome for each of the four themes; these themes were described earlier in the workplan. The Study Board has divided the proposed work into 159 separate tasks with several key areas identified as Study Board meetings, cross-cutting tasks, theme-based tasks, public and indigenous consultation, several rounds of decision workshops and multiple drafts of report, translation and publication. The tasks are grouped to deliver a stated outcome. Annex 2 presents the entire Gantt chart for the project. All critical tasks are listed in Annex 3 and will be monitored for any slippage and adverse impacts

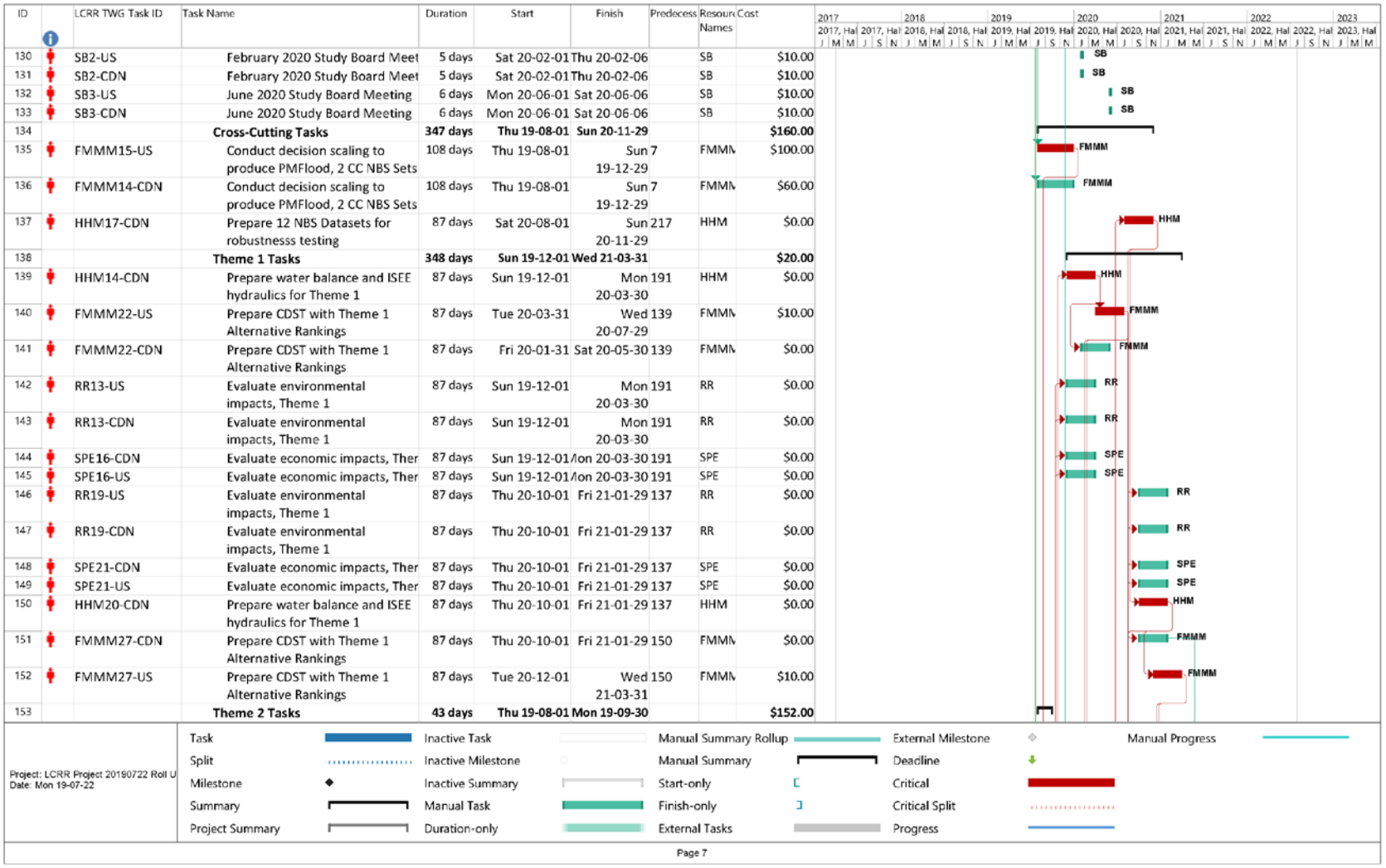

Figure 5.1. Screen capture from the Gantt chart showing cross-cutting and Theme 1 tasks.

Please note any activity in progress bar shown in red indicates a critical path tasks. The full Gantt chart for the Study is presented in annex 2.

6 Study finances

Canadian and United States study management has worked closely with the TWG co-leads to re-assess all tasks initially planned and integrate the new tasks that the Study Board agreed to incorporate during its June 2019 face to face meeting. This effort has eliminated overlaps between tasks, double-counting occurrences, as well as re-scoping some tasks, re-allocating funds, and ensuring that all activities can be done within the available time and resources allocated by the Governments of Canada and the US, taking into account dependencies and timeliness between tasks.

6.1 Canada

Table 5.1 provides the resources actually spent over the first three years of the Study, and those budgeted for each remaining year. It is break-down by working group and shows the resources required to execute the updated work plan. The additional tasks agreed to by the Study Board are shown in the lower portion of table 6.1.

The ability to carry over annual surplus has allowed to present a balanced budget including a reallocation of funds over the entire duration of the Study. From the Canadian perspective, management is confident that this revised work plan will be executed with the initially allocated resources and the one-year extension granted by the IJC; its adopted management approach allow for continuous adjustment of efforts to address any upcoming issues.

Table 6.1 Canadian Summary Funding for 2019-2022

			CA Summary Funding (x 1000$)				Total
	2016-2017	2017-18	2018-19	2019-20	2020-21	2021-22	
Initial planning as per Work Plan V1 (updated)							
FMMM	0 $	60 $	125 $	145 $	157 $	46 $	**534 $**
HHM	0 $	290 $	375 $	527 $	420 $	159 $	**1 771 $**
IM/IT	0 $	54 $	32 $	0 $	0 $	0 $	**87 $**
IRG	0 $	10 $	0 $	20 $	20 $	20 $	**70 $**
Outreach / PAG	16 $	77 $	130 $	116 $	116 $	116 $	**571 $**
RR	0 $	0 $	29 $	685 $	464 $	181 $	**1 359 $**
Study Board	0 $	16 $	27 $	20 $	50 $	147 $	**260 $**
Secretariat	0 $	7 $	20 $	30 $	30 $	30 $	**116 $**
SPE	20 $	25 $	119 $	492 $	302 $	52 $	**1 009 $**
Study Management	37 $	180 $	182 $	189 $	139 $	164 $	**890 $**
Total Initial planning (updated)	**73 $**	**719 $**	**1 039 $**	**2 224 $**	**1 698 $**	**915 $**	**6 668 $**
Tasks added for Work Plan 2							
Assess potential of upland storage	0 $	0 $	0 $	150 $	0 $	0 $	**150 $**
Conduct decision scaling to produce Probable Maximum Flood, Net Basin Supplies and other data sets	0 $	0 $	0 $	60 $	0 $	0 $	**60 $**
Prepare for and conduct Theme 3 workshop	0 $	0 $	0 $	25 $	0 $	0 $	**25 $**
Prepare for and conduct Theme 4 workshop	0 $	0 $	0 $	20 $	0 $	0 $	**20 $**
Aboriginal consultation	0 $	0 $	0 $	78 $	72 $	0 $	**150 $**
Total added Tasks	**0 $**	**0 $**	**0 $**	**333 $**	**72 $**	**0 $**	**405 $**
Grand Total	**73 $**	**719 $**	**1 039 $**	**2 557 $**	**1 770 $**	**915 $**	**7 073 $**

6.2 U.S.

As of the end of fiscal year 2019 (September 30, 2019), the US expenditures on the study are anticipated to be slightly ahead of initial projections with approximately 60% of total projected

study funding to be spent. Other project management approaches to ensure adequate work is completed with available funding, such as tight activity and budget controls, will be used.

Table 6.2 provides the funding spent over the first three years of the Study by each working group, and funding budgeted for each remaining year of the study.

Table 6.2 US Summary Funding for 2019-2022

			US Summary Funding (x 1000$)					Total
Initial planning as per Work Plan V1 (updated)	**2015-2016**	**2016-2017**	**2017-2018**	**2018-2019**	**2019-2020**	**2020-2021**	**2021-2022**	
FMMM			272 $	76 $	183 $	163 $	114 $	**808 $**
HHM		340 $	511 $	245 $	270 $	85 $	0 $	**1 451 $**
IM/IT								**0 $**
IRG				5 $	8 $	10 $	8 $	**31 $**
PAG		37 $	38 $	41 $	41 $	41 $	20 $	**219 $**
Outreach			47 $	0 $	0 $	55 $	0 $	**102 $**
RR			90 $	132 $	178 $	89 $	25 $	**513 $**
Study Board					13 $	13 $	8 $	**33 $**
Secretariat		104 $	100 $	0 $	50 $	50 $	25 $	**329 $**
SPE			143 $	184 $	175 $	120 $	30 $	**653 $**
Study Management	500 $	19 $	344 $	296 $	177 $	184 $	91 $	**1 611 $**
Grand Total	**500 $**	**500 $**	**1 545 $**	**979 $**	**1 095 $**	**809 $**	**321 $**	**5 750 $**

7 Major Study Products and Independent Review Group Involvement

The LCRR study will be producing a large amount of data, interim studies, and final reports that present study work and results. An inventory of all study products is maintained by the study managers to ensure study commitments and tasks are being met, and to ensure that the work of the study is inventoried and maintained for future needs.

Study products that are especially critical for presenting important results, major interim results, documenting significant study tools, and final reports – are considered major products. Many, if not most, of the major products will also require technical and other expert review by the study's Independent Review Group (IRG). The Study has identified six major study products needing review by the IRG or other appropriate technical/subject matter expert (table 7.1). An estimated $60,000 in study funds have been allocated for IRG product reviews.

Table 7.1 Major Study Products to be submitted to IRG

Product name	**Current Status**	**Date for IRG Review**	**Projected Completion Date**	**Report Lead**	**Cost US x 1000**	**Cost CAN x 1000**	**Total Cost x 1000**
Causes and Impacts of past floods in LCRR	In review	Jul-19	Oct-19	US/CDN RR TWG	5 $	5 $	10 $
White paper on the flood prediction/forecasting system	Being Prepared	Nov-19	Jan-20	US/CDN HHM TWG and Study Board	5 $	5 $	10 $
LCRR Climate Change Strategy	to be initiated Fall 2020	Nov-20	Mar-21	US/CDN FMMM and HHM TWGs	5 $	5 $	10 $
Potential Structural Flood Mitigation Measures for the LCRR Basin	Being Prepared	Dec-20	Jul-21	US/CDN FMMM TWG	5 $	5 $	10 $
Social and Political Acceptability of proposed mitigation measures	to be initiated Winter 2021	May-21	Apr-20	US/CDN SPE	5 $	5 $	10 $
Final LCRR Study report to the IJC	to be initiated Spring 2021	Sep-21	Mar-22	Study Board	5 $	5 $	10 $
				Total Cost x 1000	30 $	30 $	60 $

Other study products to be submitted to technical and other expert review are listed in table 7.2.

Table 7.2 Major Study Products to be submitted to technical review

Product name	Current Status	Date for IRG Review	Projected Completion Date	Report Lead
Hydroclimatology of the LCRR system	peer reviewed (journal)	Sep-19	Dec 2019	CA HHM
Hydrodynamics of the LCRR system	to be finalized	Feb-20	April 2020	US/CA HHM
Watershed Storage Report	to be initiated Spring 2020	Mar-20	May 2020	US/CA FMMM
Water Balance Model	to be initiated Fall 2019	Mar-20	June 2020	CA HHM
Collaborative Decision Support Tool Manual	to be initiated Winter 2020	Jun-20	Dec 2020	US/CA FMMM
Social Network Analysis and Governance	to be initiated Fall 2019	Sep-20	Dec 2020	US/CA SPE
Report on Lake Champlain hydrodynamic model configuration and skill	To be written	Jan-20	March 2021	US/CA HHM
Final report on PIs for baseline and mitigation scenarios	to be initiated Fall 2019	Dec-20	March 2021	US/CA RR TWG
Final report on PIs and hydrologic scenarios (stocastic, future climate, watershed storage)	to be initiated Fall 2019	Mar-21	June 2021	US/CA HHM and RR TWG
Report on Lake Champlain wave model (addendum to LC model report)	To be written	Jun-21	Sep-21	US HHM
WRF-Hydro & GEM -Hydro/Watroute hydrological modelling	to be writen	Sep-21	Dec-21	US/CA HHM

8 Study linkages with current government's efforts in flood mitigation

In Canada, the Study Board maintains regular communications with several Canadian governmental organizations at the provincial and federal levels (tables 8.1 and 8.2) and less formally with regional governments (MRCs, Counties) and municipalities. The goal is to inform them on the progress of the study and get their feedback on the suite of mitigation measures that we are developing. Aside from those wide-ranging committees, the Study will seek dialogue with the Quebec Steering committee in charge of reviewing the Politique de protection des rives, du littoral et des plaines inondables (PPRLPI; Policy for the protection of shorelines and floodplains). The Quebec government review of the regulatory framework regarding floodplains management comes at a key moment in our Study and contributes to raise the profile of flooding issues in the public forum.

Table 8.1. Interdepartmental Committee - Government of Canada

National Research Council of Canada (NRC)
Public Safety Canada (PSC)
Natural Resources Canada (NRCAN)
Transport Canada (TC)
Parks Canada Agency (PCA)
Department of Fisheries and Oceans (DFO)
Department of national Defense (DND)

Table 8.2. Interdepartmental Committee - Government of Quebec

Ministère de l'Énergie et des Ressources naturelles (MERN)
Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ)
Ministère du Tourisme (MTO)
Ministère de la Sécurité publique (MSP)
Ministère de la Santé et des Services sociaux (MSSS)
Ministère de l'Économie et de l'Innovation (MÉI)
Ministère des Forêts, de la Faune et des Parcs (MFFP)
Ministère des Affaires municipales et de l'Habitation (MAMH)
Ministère des Transports du Québec (MTQ)
Ministère de l'Environnement et de la Lutte contre les Changements climatiques (MELCC)

In the US, study activities have been discussed with a broad group of federal and state agencies. In 2018, study team members briefed the US Lake Champlain Federal Partners group on the scope and activities of the study and received constructive feedback on connection to a number of existing federal programs in the basin. Also in 2018, a meeting of the NY and VT Silver Jackets groups was dedicated to the LCRR study. The Silver Jackets are state based and include state and federal emergency response and flood management agencies for the purpose of coordinated flood emergency response and planning. Important contacts and feedback were received at this meeting. Continued briefings and study progress updates are being made to all of these groups.

9 Outreach, Communication and PAG activities

9.1 Outreach

After more than two years of work, the LCRR Study has made significant progress in several areas of its research. In parallel with this work, numerous efforts have been made to make the study known by as many people as possible for whom the notion of flooding and management of Lake Champlain and the Richelieu River is important. This is not an exhaustive list, there is, for example, a complete and regularly updated website, a general public newsletter, a video on the study available online, and so on. In addition, two series of public meetings were organized in 2017 and 2018 to inform the local population of the preliminary results of the research. The SPE technical committee held several meetings and queries in Canada and the US with target audiences in order to better understand the interests and concerns of the local populations in the face of floods. Finally, a series of 10 bilateral meetings with various organizations interested in flood issues were held in 2018-19 in Quebec.

From 2019 onward, these meetings will continue with the same interest groups (and others that will be added),and will include more targeted analyses of their reactions and assessments of work in progress. Thus, focus on outreach and communications going forward will be with targeted stakeholder groups that are critical for ensuring study success.

Community meetings will be held in Vermont and New York in August 2019 to further inform local people. Bilateral meetings in Quebec will intensify during the fall of 2019 and the winter of 2020. Consultations will be held on both sides of the border in order to collect and analyze the reactions of local groups and stakeholders to the results of the work in progress, while the general public meetings will resume in the spring of 2020. Other communication products will be developed (perhaps including a more detailed video on possible solutions), summaries of research results will be posted, announcements and consumer-type articles will be posted on the study newsletter, etc. Social media outreach will also ramp up as the study timeline moves forward.

Table 9.1 Examples of key outreach events planned for upcoming years

Activity	Targeted audience	Date
Meeting of the Public advisory Group (PAG)	People representative of multiple areas of interest and various geographic locations across the LCRR basin.	Twice a year
SPE University of Montreal Café-climat	Café-climat	Info à venir
Canada Outreach Bilateral meetings and consultation and development of a Social network analysis with SPE ENAP	Organized groups interested in flooding from various angles: environment, economy, municipal affairs, etc.	Minimum of 8 meetings a year (both in 2019-2020 for theme 1 & 2 and 2020-21 for all the themes (4))
Consultations and discussions with Government of Canada	Federal government departments (Ex: Fisheries & Oceans Canada, Parks Canada, Environment &CC Canada and others)	Ongoing from fall 2019 up to the end of 2020
Consultations and discussions with Quebec Government	Quebec government ministries (ex: Municipal affairs, Environment, and others)	Ongoing from fall 2019 up to the end of 2020
Public consultation meetings in Canada and US	Community members within the watershed (in Quebec, Vermont and NY state)	Spring 2020 and 2021 (tentative)
US Outreach: information table/booth at select community lakeside events	Riparian community members	Summer 2019 and 2020
US Outreach meetings with lakeside property owners and residents	4 different cities and communities in NY and Vermont	August 2019 and 2020
Presentations to county government boards in New York	Clinton County legislature and Essex County board of supervisors	Winter of 2019-20 (tentative)
Outreach to county EMS coordinators and other first response administrators	Vermont and New York emergency medical service and first responder coordinator agencies	As needed, when new reports or information is available

9.2 Public Advisory Group

As of May 2019, the binational Public Advisory Group was made of 14 members: 7 members from each country representing various areas of interest and regions across the Lake Champlain – Richelieu River basin who share their knowledge, contacts and experience with the Study.

9.2.1 Accomplishments (2017- June 2019)

The PAG has held four meetings so far, the first being in December 2017 in Venise-en-Quebec and then twice a year so: in May 2018 in Grand Isle Vermont, in October 2018 in Saint-Paul-de-l'Île-aux-Noix, Quebec and lastly in May 2019 in Swanton, Vermont. At each of these key occasions, study experts and communication staff have presented their work and received feedback from PAG members. Meeting minutes and a PAG Story Map are available on LCRR website. They have provided comments on many communication products (factsheets, The Current newsletter, brochures, video) that are now on the LCRR website.

PAG has also provided on going advice to the Study on public meetings such as the ones led in July 2017 and November 2018 that PAG members attended and other types of consultations as well as on associated products such as stakeholder and media lists. PAG has been working closely with Outreach Coordinators; PAG Co-Chairs also chaired the Special Planning Committee for the 2018 public meetings.

PAG members have also shared their knowledge of the watershed with various study members, shared exiting documents and provided their views when solicited. Some examples so far are the review of the draft Study work plan, the Outreach plans and Communication Plans.

Work has also been started on Indigenous People's engagement in the Study. A work plan has been established and a MOU has been signed with the *Grand Conseil de la Nation Waban-Aki*.

9.2.2 Next steps (July 2019 to end of Study)

PAG meetings will continue twice a year in the Fall and Spring until the end of the study and technical experts and communication staff will continue to be key invitees. The PAG will also continue to help with planning and hosting LCRR public meetings such as the series planned to take place in spring 2020.

Members will continue to provide advice and comments on key Communication products and web content (factsheets, newsletters, frequently asked questions and videos), assist Outreach coordinators as best as possible (for example at Farmers' markets or similar events this summer in the US) and provided various requested feedback to the Study Board.

Looking ahead, as Study results start coming out, we will both review as requested and help disseminate the results. Also in May 2019, PAG identified two key challenges going forward. We hope to find ways of improving PAG members' knowledge of study progress as well as work with the SPE-AG to reflect on how to better capture and synthesize information from public meetings and other activities.

We will also continue to engage Indigenous People in the Study and follow the reports coming out of the MOU. PAG Co-Chairs will continue their work on the LCRR study board. At the end of the study, the PAG plans to table a report to the study board and the IJC on PAG achievements, lessons learned and the effectiveness of public input in Study Outcome.

10 Study challenges

The main objective of the Study is to recommend a comprehensive suite of mitigation measures to the IJC, which in turn will support and provide recommendations to the US and Canadian

governments that will reduce the damages caused by floods. Those measures needs to be well accepted by the population and interested stakeholders to be considered favorably by governments. Considering the many diverging interests of stakeholders, this is a major challenge faced by the Study. Continued open dialogue with the pubic and important stakeholder groups should bring buy-in from a vast array of stakeholders. That being said, it is also a study challenge that implementers as well as stakeholders will not all be in agreement.

On the operational front, past issues faced by the Study could still resurface; that is to say, the maintenance of the personnel and secure and timely funding. The loss of scientific and technical expertise developed over a number of years represent a major step back, so all efforts will be directed in maintaining our work force.

The study has a number of major products/reports under preparation and needing subsequent review by the IRG and other technical experts. It has been a challenge to get study findings synthesized and reviews prior to release to the public. This needs to be a focus of the study team moving forward so that stakeholders and the public see meaningful study results that will in the end support important recommendations.

From a management perspective, the Study will aim to maintain and improve its cohesion and efficiency, and its productivity in order to deliver its products on time and in budget.

11 Conclusion

The LCRR study board has expressed in this revised work plan its vision for delivering sound measures for the mitigation of flooding and its impacts on the Lake Champlain Richelieu River Basin and even more importantly, measures that could be actually implemented and used by the responsible entities.

The study board sincerely hope that its revised work plan will be positively received by the IJC and is looking forward to discuss any of its aspects with the IJC.

Annex 1: Study Task Status as of March 2019

Adobe Acrobat Document

Annex 2 Gantt chart and critical path

Adobe Acrobat Document

Annex 3 – List of critical tasks

Adobe Acrobat Document