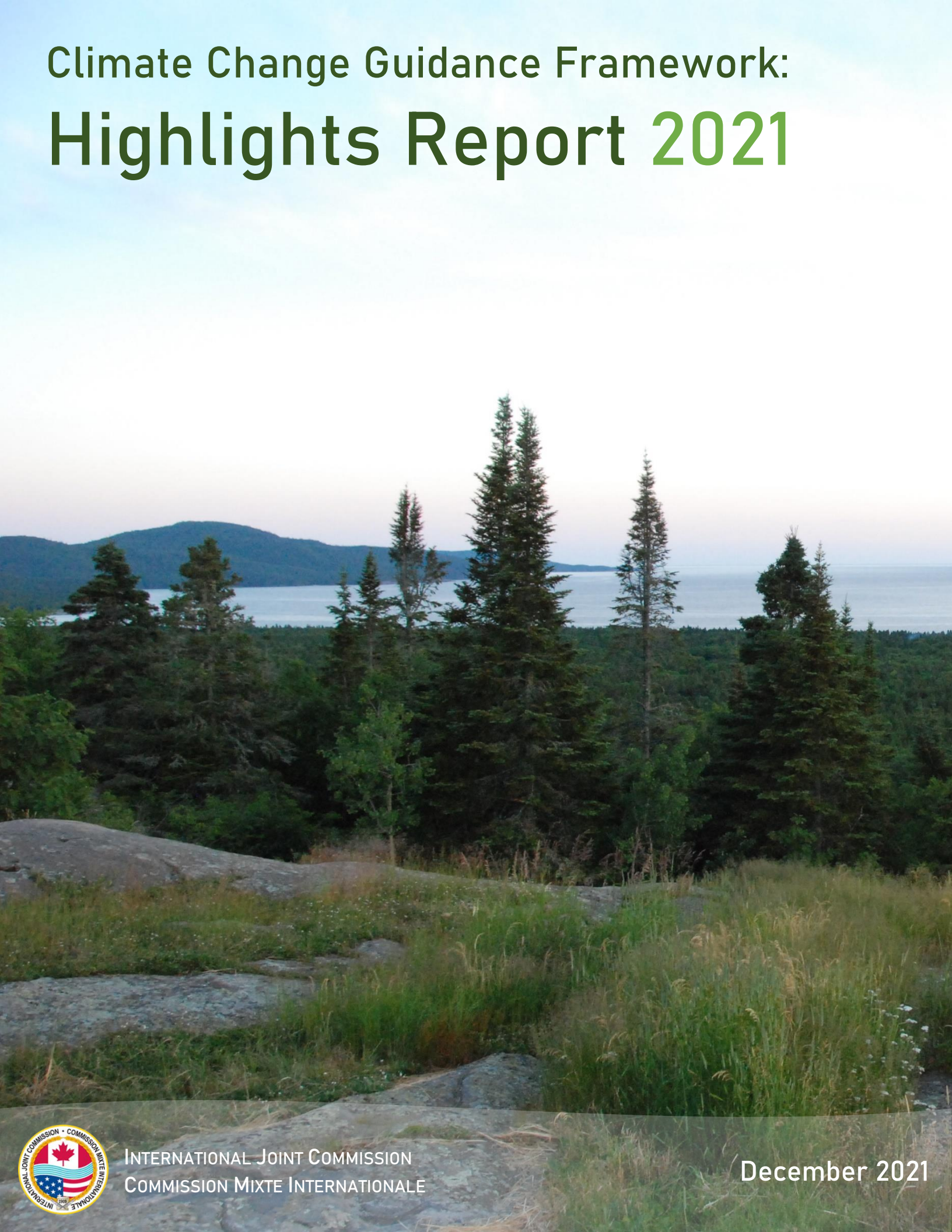
Climate Change Guidance Framework:

Highlights Report 2021



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Acronyms, Key Phrases, and Abbreviations

CCGF	Climate Change Guidance Framework
DEQ	North Dakota Department of Environmental Quality
EROS	USGS Earth Resources Observation and Science Centre
ET	Evapotranspiration
GDCD	Garrison Diversion Conservancy District
GCM	Global Climate Model
GLAM	Great Lakes - St. Lawrence River Adaptive Management Committee
IJC	International Joint Commission
IOLBC	International Osoyoos Lake Board of Control
IRLWWB	International Rainy-Lake of the Woods Watershed Board
IRRWB	International Red River Watershed Board
ISEE	Integrated Social, Ecological and Economic (model)
IWI	International Watersheds Initiative
LCRR	Lake Champlain-Richelieu River
MFLNRORD	British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development
OLRS	Okanagan Lake Regulation System
RRVWSP	Red River Valley Water Supply Project
PMF	Probable Maximum Flood
RCM	Regional Climate Model
USGS	United States Geological Survey

Vertical analysis refers to a board going through all four steps of the IJC's CCGF planning process.

Horizontal analysis refers to one part of the IJC's CCGF planning process, such as self-assessments under the organize step, applied across many boards.

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WELCOME

Globally, water resource managers wonder whether the systems they govern will be able to deliver on their responsibilities and provide the services people expect as climate changes. The International Joint Commission (IJC) developed a Climate Change Guidance Framework (CCGF) in 2017 to help the people who manage the basins that straddle the United States - Canada border better understand and anticipate expected impacts from climate change. Prior reports identified the need for a central repository or tool through which IJC control, watershed, and pilot watershed boards could learn from each other and apply lessons learned as they plan for the future of their watersheds. This 2021 Highlights Report is a step toward that goal, by identifying and surveying recent ongoing activities, and recommending a more functional mechanism for information sharing and collaboration than the periodic reports published previously.

The activities described in this report cover a wide range of circumstances; efforts large and small, some managed and paid for by the IJC, some led by others with IJC collaboration. Some are comprehensive, some focus on particular elements of an adaptation to climate change. Many climate change-related activities described in this report are implemented using a phased approach, which supports the adaptive management approach described in the CCGF. The duration and outcomes of each phase differ from project to project, with some projects and phases lasting much longer than others and resulting in a variety of deliverables and actions.

Each board has begun or may begin applying the CCGF to their climate change-related activities at different points since the CCGF was published in 2017. Therefore, it should be emphasized that this Highlights Report captures only a snapshot of the ongoing climate change-related activities of each board. These Highlights Reports are one way in which the IJC recognizes the continued efforts of each board, and readers are reminded that the implementation of climate change-related activities varies greatly between boards. Updated reports will be issued as ongoing studies progress and new studies and actions are established. Another goal of this ongoing initiative is for an online version of this report to become a platform that facilitates the gathering and sharing of climate change information between IJC boards.

OVERVIEW

As basins across the shared border between Canada and the United States experience more significant and frequent impacts associated with climate change, activities to identify and address vulnerabilities will become increasingly important. The CCGF provides a tool for IJC boards to assess, test, and act to mitigate their vulnerabilities to the impacts of climate change using adaptive management. This framework has already been used in the St. Croix River basin and is currently being applied in the Osoyoos Lake, Rainy-Lake of the Woods, and Great Lakes basins. Ensuring other basins with IJC boards complete the vertical analysis is critical to ensuring IJC Order requirements are met and the most severe consequences of climate change on water management are mitigated. This report is one of a series of updates on the status of climate change work

in transboundary basins under the CCGF initiative, the prior update being the 2018 Climate Change Guidance Framework Highlights Report.

This report includes a brief introduction to the history of the Climate Change Guidance Framework, a summary of the framework itself and its intended use, and an update on transboundary activities carried out by IJC boards along the United States - Canada border since the 2018 report. On page 6, this report discusses how the IJC is implementing recommendations from the 2018 Climate Change Guidance Framework Highlights Report to improve inter-board communication and information exchange on topics related to climate change across the transboundary.

Evolution of the Climate Change Guidance Framework (CCGF)

The CCGF was published in February 2017, and has three main elements:

1. A strategy to pool useful information
2. A discussion of the practical application of adaptive management
3. A planning process with four steps (Organize, Analyze, Act, Update) that IJC boards can follow to prepare for the impacts of climate change related to their responsibilities.

The first step in the CCGF planning process (Organize) aims to address the question: how prepared is the board to manage its responsibilities given the future impacts of climate change? In 2017, nine IJC boards responded to a request to conduct a brief self-assessment, which included a horizontal application of the CCGF following only the "Organize" step across all the control, watershed, pilot watershed boards, and the health board. The outcome of this self-assessment activity for those boards is shown in (Figure 1). There was a variety of responses from boards in terms of their self-perceived preparedness for climate change. On a scale of one to ten, two boards scored themselves as high as seven and one board scored itself as one.

- 10 meant the board had clearly established in a public process that climate change would not impact their responsibilities or had gone through all four guideline steps, had an adaptive management plan in place with some actions already taken and the ability to take more as needed, all documented and worked out with stakeholders
- 8 meant the board had gone through the first three steps (i.e., Organize, Analyze and Act) to produce a quantified assessment of how outcomes related to the board's missions were likely to be impacted because of climate change, but there was no adaptive management effort established that would allow the board to update that assessment with new information and in collaboration with their partners and stakeholders
- 6 meant the board had done steps one and two (i.e., Organize and Analyze) but had not agreed on actions
- 4 meant the board had completed step one (i.e., Organize). The board had discussions about how its mission might be affected by climate change, some relevant science had been identified and considered by the board, and the board had made a statement on the potential impact of climate change on specific responsibilities of the board. No quantitative analysis had been done,

Figure 1: Assessments of climate change readiness in 2017 (IJC, 2017)

but the board had determined what would be necessary to do that

- 2 meant the board had some elements of step one but hadn't produced a summary report. For example, board minutes might show which missions board members were concerned about; the board may have invited presentations on climate change and discussed what actions the board should be considering
- 1 meant the board had not considered how climate change could affect the board's missions

Recommendations from the 2018 Highlights Report

The 2018 CCGF Highlights Report included some recommendations for the near future. The report explained why a decision-scaling approach is well-suited to fulfill the IJC's water resource management responsibilities; it encourages a collective expression of how climate could affect the performance of systems the board oversees, and then provides a more robust and informative test of that system than downscaling predictions would. The report summarizes the International Lake Champlain – Richelieu River (LCRR) Study board's use of decision scaling to assess how the risk of flooding could change in that basin as a result of climate change. The 2018 report also advocated for working closely with those affected by climate change in the basin, using trend analyses to monitor the onset of climate change, and improving the ability of boards to access data and to obtain expert advice on planning, decision support, and risk management approaches. Finally, the report recommended exploring mechanisms to improve climate change knowledge transfer and lessons learned, both across boards and within them.

This 2021 update raises the issue of improving information sharing through an "efficient web-based collaborative space or hub where information can be stored, built upon, and shared." This platform/hub would include pertinent climate change investigations, especially those from basins where the IJC's mandate is applied.

IWI 5th Report to Governments Discussion of Climate Change

The CCGF is part of the IJC's International Watershed Initiative (IWI), and since the last CCGF Highlights Report (2018), the IJC published its Fifth IWI Report to Governments as part of the IWI regular reporting cycle. The Fifth IWI Report, sent to Canadian and U.S. governments in 2020, describes IWI activities from 2015 to 2019, including the development and application of the CCGF. The report presented five IJC activities related to climate change preparedness:

1. The development of a Similkameen Basin hydrologic model for the Osoyoos Lake Board of Control (described further on page 13). The model will be integrated with other hydrologic and hydraulic models of the Okanagan Basin to analyze the vulnerability of Osoyoos Lake, the Okanagan/Okanogan River, and the Similkameen River to projected shifts in climate and hydrology within the basins. This analysis will help prevent future conflict by allowing the board to predict the timing and frequency of changes in projected lake levels and evaluate those in relation to the IJC Orders of Approval for Osoyoos Lake including the rule curve and drought criteria.
2. The collateral study of climate change impacts as part of a study of dissolved oxygen levels at different flows along the Souris River (discussed on page 15). The board's report is available on the IJC website.
3. The measurement of evapotranspiration in the St. Mary-Milk River Basin using satellite imagery (described on page 12). The immediate application of these findings will be used to more accurately define the components in a water balance but might also be useful in determining the degree to which increased temperatures and the associated increase in evapotranspiration will offset increased precipitation as a result of climate change. The results of this work in the St. Mary-Milk River Basin also informed work on the Lake Champlain climate analysis, showing the potential to improve cross-board communication and knowledge sharing. The connection between the evapotranspiration analysis on the St. Mary-Milk River Basin and the work of the Lake Champlain – Richelieu River Study Board is explained on page 11.
4. The CCGF initial assessment of climate-change related to the mandate of the St. Croix River Board. That work is described online and on page 9 of this report.
5. The development of "Threats to Water Quality in Shared Waters between Canada and the United States in the Climate Change Era". This white paper alerted the governments to existing and emerging water quality issues and concerns that could grow into binational disputes. The IJC and its boards have identified key water quality issues and concerns in transboundary watersheds including algal blooms, chemical contamination of aquatic biota and associated risks to human health, and aquatic invasive species.

The Fifth Report to Governments also included a discussion of the IWI and climate change, acknowledging that climate change strongly impacts waterboard levels, flows, and quality. The Report underscored the importance of the following activities:

- Transboundary water quality objectives for watershed boards need to be updated to reflect new conditions influenced by climate change, and water quality issues need to be detected and addressed before they become problematic.
- Water level vulnerabilities induced by climate change need to be identified for all transboundary watersheds and appropriate jurisdictions should be engaged in the identification process.
- Water quality and ecosystem function vulnerability assessments should help guide the actions taken by any party to the decision making, whether the board or another entity.
- The CCGF should be applied by all IJC boards which have a mandate to manage water levels and flows, or to apportion water.
- Resiliency models should be developed in partnership with governments and made available for use in transboundary watersheds.
- Tools to evaluate climate change and the socioeconomic and cultural impacts associated with resulting high/low water events have been developed for the Souris River basin (see page 15) and as part of the LCRR study (page 10), and need to be shared.

The Fifth Report to Governments makes it clear that the IJC intends to apply the CCGF to all control boards and reviews of orders.

IJC Climate Resiliency Strategy

In July 2021 the Commission approved the preparation of an IJC Climate Resiliency Strategy. The Strategy is expected to be completed by mid-2022 and complement the CCGF by informing the decisions of the Commission's boards, Study Boards and Task Teams related to water quantity, levels, and flows. The Strategy will also develop advice to the governments of Canada and the United States under the IJC's responsibilities included in the Great Lakes Water Quality Agreement.

2020-25 IWI Plan – CCGF Goals and Timeline

Application of the CCGF is a core component of Element #3 of the IWI Plan for 2020-2025 (*Adaptively Managing Transboundary basins for Watershed Management Resiliency*). The plan was drafted in May 2020 and set out specific, measurable, achievable, realistic, and time-bound (SMART) goals for the IWI program until 2025. The CCGF will help boards prepare for climate change-related challenges pertaining to three management issues: water levels and flows, water quality, and water apportionment. Specifically, the IJC wants to apply the CCGF in the Expedited Review of Plan 2014 on Lake Ontario-St. Lawrence River, the Osoyoos Lake Board hydrologic model, the International Rainy-Lake of the Woods Watershed Board (IRLWWB), and the St. Mary-Milk. Only the IRLWWB and Osoyoos Lake Board would use IWI funding; the Lake Ontario-St. Lawrence River and St. Mary-Milk River basins have separate funding established for reviews in which climate is one factor. Following that, the intention is to apply CCGF to the Kootenay and Red River Boards,

International Lake of the Woods Control Board (only active during high water conditions under the 1925 Lake of the Woods Convention and Protocol), and the International Souris River Board. The Souris River Study Board recently completed their climate investigation subtask. The CCGF would then be applied by the Great Lakes-St. Lawrence River Adaptive Management (GLAM) Committee. Midway through the 2020-2025 IWI Plan period, a program review would assess how well the application of the CCGF has helped achieve management goals and would provide a foundation for charting future activities.

CCGF Activity Across the Transboundary Since 2018 Highlights Report

St. Croix River

The St. Croix River Board did a vertical analysis in 2018, going through the four-step CCGF planning process (Organize, Analyze, Act, Update), placing an emphasis on the Analysis step. Figure 2 includes three graphs that overlay and connect climate projections and system performance at three points in the basin. Based on a variety of Global Climate Models (GCMs), each graph plots the percentage of precipitation increase projected on the horizontal-axis versus the temperature increase projections on the vertical-axis. Each incremental square on the graph spans a change of 10% precipitation and 1°C change in temperature. A "weather generator" was used to impose various realizations of those average annual

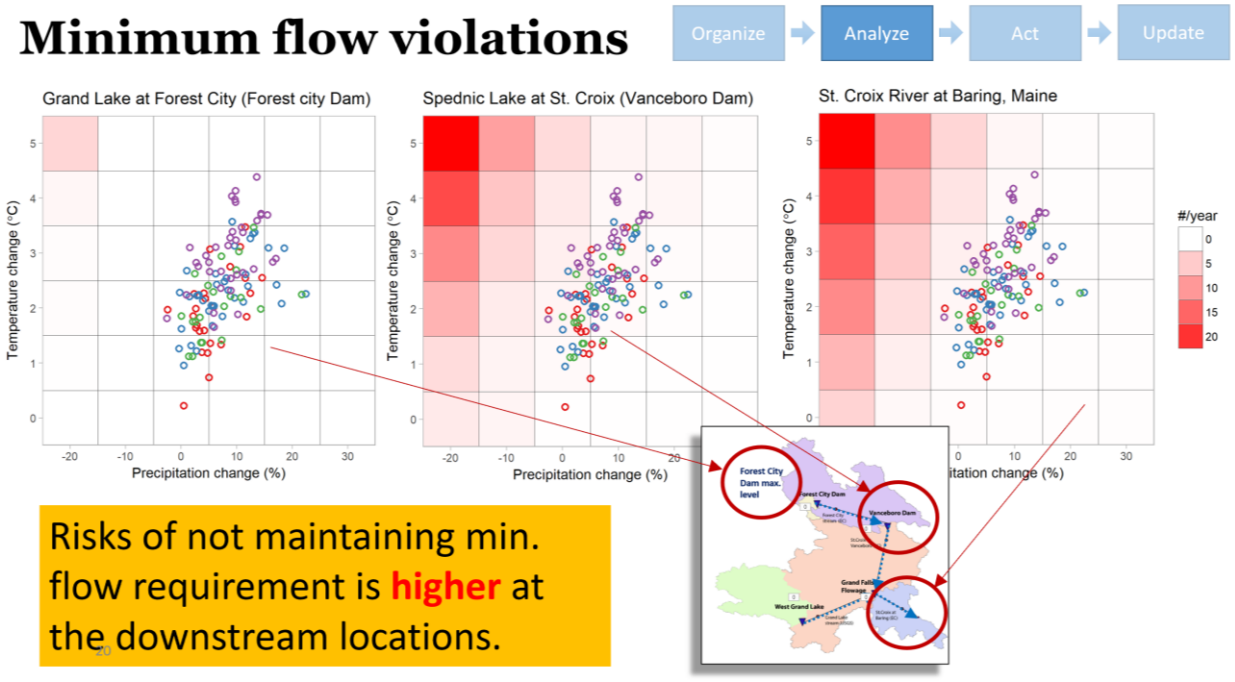

Figure 2: Sample results from the St. Croix River flow analysis

precipitation and temperature changes on a hydrologic basin model to produce inflows representing those climate changes. The inflows were used in a water balance simulation to produce an array of outflows at different points in the system and those flows were compared to the minimum flows required.

The squares are shaded white to deep red to indicate the frequency of failures to meet IJC Order requirements based on the projected events. At the Forest City dam, high in the basin, only the combination of a 20% decrease in annual precipitation and a 5°C warming will produce a failure to meet the minimum instream flows, and that scenario is expected five times or less per year. None of the GCM projections (the little circles) are in that range. However, for Spednic Lake and Baring, ME, which are downstream of Forest City dam, a sizable minority of the GCM projections plot (pink shading), show that there is reason for concern in the 2036-2065 timeframe of the GCM projections. The action taken was to consider what would be needed to proceed along two pathways. First, the board could study how to develop alternative management strategies that reduced the risk of minimum instream flow failures. Second, additional monitoring of precipitation and temperature data, as well as pertinent climate research, could produce a changed assessment of risk. The "flash drought" beginning in spring 2020 that lasted through the summer and into fall 2020 has stimulated board discussions about revisiting the analysis to consider operational alternatives.

Lake Champlain-Richelieu River

The Lake Champlain-Richelieu River (LCRR) Study Board appointed by the IJC is conducting an ambitious climate change analysis that follows the CCGF methods but, because it is part of a larger flood study, provides unique insights that could be valuable to other boards. The LCRR Study Board was formed in response to a reference from the Canadian and American governments to study what could be done to address Lake Champlain and Richelieu River flooding, after a flood in 2011 exceeded flood levels in the preceding 150 years by a wide margin.

The LCRR study is unusual in that there is no existing regulation structure for Lake Champlain and the study is considering non-structural measures designed to increase resilience without reducing water levels. The study has developed a structure-by-structure flood damage model that is consciously designed to produce relatively high accuracy, and the model has shown that damages increase at a much steeper rate when flood levels exceed the 20th century levels used to formulate floodplain delineations and development regulations.

The study uses the decision-scaling approach described in the CCGF, but with more perspectives on future climate risk than were applied in the St. Croix River study. A complete report on the decision-scaling effort is expected by February 2022. This Highlights Report will describe the issues in the LCRR report that other boards might be interested in.

Using multiple tests of plausibility

In the St. Croix study, a generated weather pattern was considered more plausible if it had been generated based on a change in precipitation and temperature predicted by a GCM. However, there are other ways to consider whether an extreme event is

plausible. LCRR climate experts pursued decision scaling from four perspectives, applying those perspectives individually for some purposes and considering them simultaneously for others. They included net basin supplies generated:

1. Stochastically
2. Using Probable Maximum Flood (PMF) generation methods.
3. Using a weather generator
4. Using specific Global Climate Model (GCM) and Regional Climate Model (RCM) projections over time

Insights from estimating damages by property

The Integrated Social, Ecological and Economic (ISEE) model and the damage reported in the 2011 flood make it clear that damages increase non-linearly as water levels rise above the 100-year recurrence interval. Floodplain management has greatly reduced vulnerability to flooding within the 100-year floodplain. Damage in 2011 along the Richelieu River was sustained mostly by buildings erected fifty years ago or those built just outside the regulated floodplain.

Stress testing, plausibility, and long-term forecasting

In the LCRR study, a weather generator drives a hydrologic model of the basin which produces net basin supplies for a water balance model, which in turn calculates Lake Champlain water surface elevations and releases. Each simulation of the hydrologic model steps through the transient states of the basin including snowfall and snowpack in the winter, a particular warming regime, snow melt and spring rains later in the year. Researchers are considering whether these transient data can address two different issues that have been understood but not quantified for use in planning deliberations, long term (three month) forecasting and creating a deeper understanding of the plausibility of extreme events.

The value of inter-Board communication on climate issues

Computer models can simulate future conditions and help any board attempting to assess the risk posed by climate change. While there are common issues that arise with models, boards could use each other's experiences to determine how to manage these issues. A study on the St. Mary-Milk shed some light on a related issue facing the Lake Champlain-Richelieu River study regarding evapotranspiration. Climate change is expected to increase temperature and precipitation, but whether that drives lake levels up or down depends on how much the higher temperatures offset the higher precipitation. This is part of a broader topic of the estimation of factors that drive models, the broader topic covered in a new study (Van Beusekom, 2021) that investigated the sensitivity of different hydrologic model configurations to temporal variations of seven forcing variables (precipitation rate, air temperature, longwave radiation, specific humidity, shortwave radiation, wind speed, and air pressure).

In the course of speaking with different IJC boards for this report, a United States Geological Survey (USGS) modeler with the Earth Resources Observation and Science (EROS) Center conducting an evapo-transpiration measuring effort for St. Mary-Milk provided a dataset not known to the Canadian researchers on the LCRR study,

called gridMET, and that helped validate the LCRR work.

The climate experts involved in this study have agreed to share some of their internal debates on technical issues, assumptions, and modeling choices. The final LCRR climate report due in late 2021 will have short summaries of the four perspectives so that readers, including researchers on other climate studies, can benefit from the debate and deliberations. *The value of inter-Board communication on climate issues* informed the same debate for the Lake Champlain basin. This illustrates the value of inter-Board communication.

Lake Ontario-St. Lawrence River

The Great Lakes - St. Lawrence River Adaptive Management Committee (GLAM), which reports to all three Great Lakes Control Boards, is conducting an expedited review of Plan 2014. Phase 1 deals with high water deviations from Plan rules. Phase 2, which began in the fall of 2021, will study the effectiveness of the plan rules themselves. Phase 1 included some climate related work to develop net basin supplies that could be used in the newly developed Decision Support Tool, however work assessing potential climate change scenarios and related vulnerabilities to the regulation plan will primarily occur during Phase 2. The decision-scaling approach will also be applied in Phase 2 which is expected to take three to five years to complete.

Rainy-Lake of the Woods

The Water Levels Committee of the International Rainy - Lake of the Woods Watershed Board is considering conducting a climate change stakeholder workshop to be held in person over an afternoon and morning in International Falls in March 2022. The goal of the workshop would be to increase confidence that the board is prepared for climate change impacts. The objectives of the workshop are to:

- summarize climate related planning completed under the rule curve study
- share recent insights into the region's climate change studies
- report on whether the adaptive management program is working as hoped
- brainstorm and prioritize a list of climate influenced management concerns (flooding, hydropower production, water quality, etc.)
- formulate a group consensus on next steps, including public findings, changes in the adaptive management program, additional IWI studies, or broader actions

The facilitator would work with participants to develop the agenda and would orchestrate the brainstorming sessions for best results.

St. Mary River-Milk River

The Accredited Officers of the St. Mary and Milk Rivers oversee the measurement and apportionment of the waters of the St. Mary and Milk Rivers in accordance with a 1921 IJC Order. Both rivers flow from Montana into Alberta, but the Milk crosses the border a second time, flowing back into Montana and emptying into the Missouri River. The Milk River flows rely on spring snowmelt and rainfall and are less dependable than St. Mary River flows. The St. Mary Canal was built in 1917 to divert water from St. Mary to the Milk, increasing the dependability of water supply in the southern part of the Milk River basin. There it is used by farmers to irrigate 110,000 acres of farmland and for

municipal water for 13,000 people in Havre, Chinook, and Harlem, Montana.

The recently initiated St. Mary-Milk River apportionment study will include an analysis of impacts of climate change in the basin. Separate components of climate change may conspire to alter the amount of water available for the environment and human use. The components of climate change include potential changes in the amount of snowpack in the upper part of the basin, changes in timing of spring melt and runoff, and hotter temperatures. These components are being examined in many basins in western North America; of particular interest to IJC boards may be the study's use of satellite imagery as a method to measure evapotranspiration.

The USGS EROS Center is leading the related IWI funded study to assess the effectiveness of remote sensing to estimate evapotranspiration (ET) , and an agency news report provides a useful description of the process. Gabriel Senay (USGS) leads the effort and has co-authored a paper that provides a deeper understanding and context. There are several aspects to the study that water managers in other boundary waters might be interested in.

First, it features the use of Landsat images to estimate historic ET rates for use in climate change studies. Although Landsat images were first captured in 1975, thermal infrared sensors that support remote ET estimates were added in 1985. The use of these data in operational management is routine, but this paper describes using the images to construct historical ET databases to provide a statistical basis for correlating ET with driving factors, such as air temperature, and for detecting trends in ET losses.

Second, the data derived showed the impact of land management choices, and that raises the question of how changes in land use could affect water supply, whether linked to climate change or not. Crops were fallowed in 2011 causing a decline in ET measured at 107,000 acre-feet. According to a Bureau of Reclamation study, that is about half the water used for agriculture. Over the measurement period, ET declined even though the atmospheric demand went up; this was ascribed to more efficient irrigation. In this basin, with very dry summers, a substantial portion of the water moving from terrestrial to atmospheric was applied by farmers. It is a well-known phenomenon that the conversion of farm and forest to built landscapes can increase the area of impervious surfaces, increasing runoff and aggravating flood risk. However, if forests transfer more water into the atmosphere than rainfed farms (one European study shows forest produce 491 mm of evapotranspiration annually versus 398 mm for agricultural cropland), then in areas where farm acreage is declining and not being converted to development, that conversion could contribute to a reduced risk of flooding.

Osoyoos Lake

The IJC's International Osoyoos Lake Board of Control (IOLBC) will participate in a climate change preparedness study in concert with the Okanagan Basin Water Board and the B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD), which controls water entering Osoyoos Lake (Figure 3). The Okanagan Basin Water Board and MFLNRORD have developed a sweeping plan of study for modernizing the province of British Columbia's Okanagan

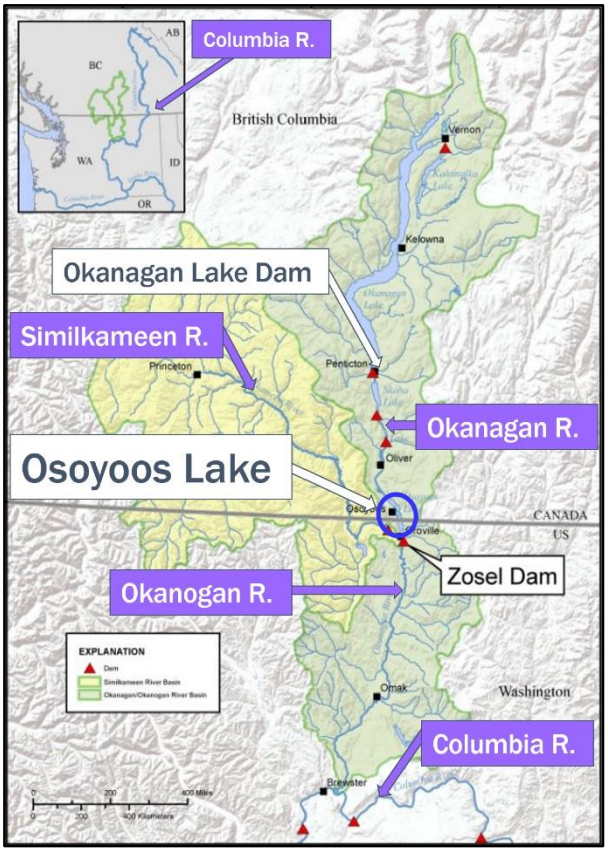

Figure 3: The Okanagan Lake Regulation System

Lake Regulation System (OLRS). The OLRS includes a series of dams and other structures on major lakes and the Okanagan River which flows into Osoyoos Lake. The IJC's Board of Control monitors the regulation of Osoyoos Lake levels. IWI funding was used to develop a hydrologic model of the Similkameen River and to link that model with a basin wide hydrologic model that also incorporates the upstream Okanagan Lake system.

The climate study complements other ongoing regulation and climate related studies planned for the larger system shown in Figure 3. Climate change is expected to have a significant impact on the timing of snowmelt in western North America and could reduce the safe yield of systems like the Okanagan. The climate study will produce estimated mid-century hydrologic input to a new linked Okanagan-Similkameen hydrology model, and the model will be used to compare new regulation plans to the ones in place now.

The OLRS plan of study may be the most sweeping for transboundary systems to date in the 21st century because it examines the need for new or rebuilt structures. This in turn makes the stakes for the climate analysis higher because projections about climate may shape major long-lasting investments in physical structures.

Red River

The Red River basin is a classic example of a "feast or famine" scenario wherein wet decades with common Spring floods oscillate with dry decades of extended droughts. In addition to this climatic variation and uncertainty in October of 2019 a rare fall flood necessitated the first-ever opening of the Winnipeg Floodway. Potential changes in hydrology associated with climate change could further affect magnitude and frequency of extreme flooding events in the Red River basin. To date the board has not completed a vertical CCGF analysis. It has a current IWI project entitled Red River Drought Risk study which utilizes historical records and stochastic (random) modelling of low flows to generate future scenarios. In anticipation of severe droughts in future, the North Dakota state-led Red River Valley Water Supply Project (RRVWSP) is proposing to provide a supplemental water supply from the Missouri River to the central and eastern part of North Dakota. The ND Department of Environmental Quality (DEQ) has issued a discharge permit for the proposed

RRVWSP project. Further information can be found at: http://rrvwsp.com/

The Garrison Diversion Conservancy District (GDCD) is the State sponsor for the project and the GDCD has provided updates on the project to the International Red River Watershed Board (IRRWB). To date the board has not yet formally engaged in discussions on the project.

The USGS is also conducting a study of the impact of climate change on Red River flows.

Souris River

This basin is deeply affected by climate variability; changes in spring peak runoff associated with early snow melt, and changes in the frequency and magnitude of spring and early summer extreme precipitation events could impact streamflow in the basin. The Souris Study Board recently completed their climate investigation subtask. The main report has been published and is available on the IJC's website. Highlights from the report can also be accessed online.

The next update of the Highlights Report will cover activities on the Kootenay, Red and Souris Boards.

Conclusions, Recommendations, and Next Steps

Conclusions

The urgency to assess basin vulnerabilities must be considered in the context of boards' competing priorities and limited resources. With volunteer board members working diligently to carry our normal board responsibilities and activities, more resources are needed if the CCGF is to be

conducted across the entire transboundary within the next five years.

The CCGF was intended as a "living document," able to change and adapt to new information about the changing climate, as well as new methods and best practices. The IJC should consider revisiting the framework as more boards and study boards utilize the CCGF and its principles like decision scaling to incorporate lessons learned and new approaches in an adaptive manner.

The linkages between the CCGF and the developing IJC Climate Resiliency Strategy need to be explored, explained and exploited. The National Research Council describes resilience as "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events." Resiliency improving measures include those that reduce hazard, exposure, and vulnerability, as well as policies in place before an event that speed post event recovery" (NRC, 2012). Broadly speaking, IJC boards may have some influence on reducing hazard (for instance, flood stages) but rarely have direct influence on exposure (for example, the presence of a structure in the floodplain) or vulnerability (for example, the lack of flood insurance or immediate post-flood assistance). Collaboration among

multiple entities is essential, so in applying the CCGF, IJC boards may need to consider how their stress testing informs not only the management of board performance targets but also management of exposure and vulnerability managed by others.

Recommendations

1. Increase internal communal awareness of IJC's work and build on it

IJC control, watershed, and pilot watershed boards have been leading and collaborating in work designed to help the IJC meet performance expectations despite the challenges of changing climate. Individual IJC staff members in both countries monitor these activities, creating an opportunity for comparative analysis and learning through the Commission, but how does a board member know what other boards are doing? How is a staff member alerted to relevant work on a project she is not monitoring? How can we draw lessons learned and strategize when almost no one is aware of the totality of experience we could draw on?

This Highlights Report has been designed to partially address that challenge in two ways. First, by collecting relevant work experience across the boundary and reporting it informally and succinctly. Second, this edition of the Highlights Report will be published and frozen in the time of its publication, but it will also serve as the basis for an online space where stories will be updated as important milestones are met. This means the dynamic report will have nearly current information on projects. Dynamic highlights could begin with fixed, printed documents that change over time. If desired, the IJC could freeze the dynamic report and publish it as a standard dated and fixed report on regular intervals.

2. Develop a centralized IJC on-line space that contains all the IJC board climate change work

The brevity of a Highlights Report makes it easier to capture the essence of the full range of climate change related work, but it does not provide the details and the data that would help an analyst develop tasks for a new project. The notion of a "Hub" has been discussed, defined as a central IJC online space that contain all relevant IJC work products, accessible not just through a search engine, but also through hyperlinked references in summary reports. A board's four step CCGF effort might be presented in a 20-page online pdf file, for example, but hyperlinked references within that 20-page report would link to more detailed reports on hydrology or in-stream flow requirements reviewed by the study team, and other hyperlinks would lead to large data files or models used in the study.

3. Hold regular events where boards could present and discuss their climate change work

The IJC and its basins would benefit from working events every other year presenting and contrasting climate change activities across the border. The event would provide each board with informal peer review and advice for shaping future activities.

Strategy

By implementing these three recommendations, a board member, Commissioner or staff member associated with any of the control, watershed or pilot watershed boards could better understand the totality of the relevant IJC experience and research on climate change resiliency efforts. The IJC climate change hub would

be a virtual library of accessible research and experience easily explored from any part of the organization, that covers work done by Ottawa, Washington, Windsor and the boards. However, just because knowledge is collected does not mean it is shared. The challenge will be to institute practices that make sharing more likely. The use of simple devices, such as a documentation page, could make searches more productive. Hyperlinks on the documentation page could make them more useful.

Standard operating procedures, academic papers and books on the IJC, satellite and GIS data, lessons learned from past studies, past news clippings could all be included in the hub. The construction of the site could be gradual, with newer information structured for easy addition.

Consistent with Commissioner priorities (2019-2023), Indigenous collaboration is an important mission for IJC boards. Boards should look strive to collaborate with and involve Indigenous communities in their basins, and incorporate Indigenous ecological knowledge where appropriate, as they utilize the CCGF going forward.

Next Steps

As work proceeds on the compilation of information and development of the hub, the next Highlights Report could introduce and describe a hub/mechanism by which IJC boards can collaborate, share information and lessons learned. It could also include a periodic "Progress Report" on what's happened on the boards presented in this 2021 report. The Progress Report will also cover activities on the Kootenay, Red and Souris Boards.

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