Water Levels Committee of the International Rainy-Lake of the Woods Watershed Board

2022 Post Flood Report

A Report on High Water Levels in the Rainy River Basin

Public Comment Period
March 10, 2023

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List of Acronyms

CA- Canada

CoCoRaHS- Community Collaborative Rain, Hail & Snow Network

CN Rail- Canadian National Railway

ENSO- El Niño- Southern Oscillation

FEMA- Federal Emergency Management Agency

FFCS- Flow Forecasting and Communications Subcommittee

IJC- International Joint Commission

HFRRC- High Flood Risk Rule Curve

ILWCB- International Lake of the Woods Control Board

IRLWWB- International Rainy-Lake of the Woods Watershed Board

LWCB- Lake of the Woods Control Board

MNDNR- Minnesota Department of Natural Resources

NCRFC- North Central River Forecast Center

NOAA- U.S. National Oceanic and Atmospheric Administration

NWS- National Weather Service

ON- Ontario

OPG- Ontario Power Generation

SWE- Snow water equivalent

U.S.- United States

USACE- U.S. Army Corps of Engineers

USGS- U.S. Geological Survey

WLC- Water Levels Committee

Executive Summary

In the spring and summer of 2022, the Namakan Chain of Lakes and Rainy Lake reached the highest water levels on record. The flood was a natural disaster that lasted for many weeks. Rainy Lake reached record-breaking water levels, and Namakan Lake ranked as the third highest on record. Since 1949, the International Joint Commission (IJC) has employed rule curves to regulate water levels on Rainy and Namakan Chain of Lakes. The Water Levels Committee (WLC) of the International Rainy-Lake of the Woods Watershed Board (IRLWWB), monitors hydrologic conditions throughout the year and provides dam operators, which are currently H2O Power in Canada and Boise Paper in the United States, with directions for the operation of their discharge facilities to ensure the rule curves are followed.

This report provides a review of the conditions which led to the high-water event in 2022, a summary of WLC actions, and answers questions raised by the public. Additionally, the report includes an analysis of what would have happened if the High Flood Risk Rule Curve (HFRRC) had been employed starting March 10, 2022.

The following points highlight the most significant details in this report:

- The 2022 high water event was caused by continuous above normal precipitation events through April and May. All available storage space across the region were filled. From April 1 to the end of May, the Rainy River basin, on average, received a total of 257 mm (10.1 in) of rainfall, more than twice the average for April and May.
- On March 10, 2022 the WLC determined that the standard rule curve would be used in spring 2022. As discussed during the 2022 Pre-Spring Engagement, current and forecasted conditions did not support the use of the high flood risk rule curve (HFRRC) at the time. By March 31, the WLC provided a target range for Namakan Lake water levels to be between 339.65 m (1,114.3 ft) and 339.8 m (1,114.8 ft) on March 31. The Rainy Lake target range was for water levels to be between 336.90 (1,105.3 ft) and 337.0 m (1,105.6 ft) on March 31; a level within the upper range of the HFRRC.
- In response to the rising water levels following the April 22-23 precipitation event, dam operators pulled all logs from the sluices at the two dams at the outlet of Namakan Lake on April 26. As the lake levels rose, the gates at the International Falls/Fort Frances Dam were continually opened to maximize outflow. Since May 5, all gates were open at the International Falls/Fort Frances dam.
- Inflows for April through July were second highest only to the year 1950. As a result, the level of Namakan Lake rose to a maximum level of 342.18 m (1,122.69 ft), the third highest on record and only 7 cm (2.8 in) lower than the record level set in 1916. The level of Rainy Lake rose to 339.31 m (1,113.28 ft), setting a new record 8 cm (3.1 in) higher than the previous level record set in 1950.
- After the flood event, computer simulation modeling was completed to investigate the effect of what operating under the HFRRC would have had. The results were compared with the 2018 standard rule curve that was employed in 2022, as well as the effect of operating at the bottom 25 percent of the Namakan 2018 rule curve would have made. It was further compared to the spring operations as they were directed in 2022. The

simulation found that the difference in peak level on Namakan Lake would have been one cm less than what was experienced, and the level would have returned below the All-Gates Open level one day sooner. As for Rainy Lake, the reduction in peak level would have been four cm and the level would have returned below the All-Gates Open level two days sooner.

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1 Introduction

The 2022 flooding in the Rainy River basin was a disaster of historic proportions. Rainy Lake reached record- breaking water levels, and Namakan Lake ranked as the third highest levels on record. Losses from the flood were widespread and included severe damages to homes, docks, boathouses, shoreline erosion, tree loss, infrastructure, and roads. Thousands of hours were spent on flood protection and mitigation such as sandbagging, berming, and water pumping, as well as recovery and remediation efforts as water levels lowered to normal ranges. Many recreational tourism operators across the region lost business and or had to close due to flooding. In all the economic, financial, and emotional toll on the entire community was significant.

This report aims to address the following questions and topics:

- The roles and responsibilities shared by the IJC, IRLWWB, and WLC within the watershed;
- Hydrologic conditions that led to the extreme flooding;
- Activities and decisions of the WLC in 2022;
- The role of rule curves during flood events and what would have happened if the HFRRC on Rainy Lake was implemented in 2022; and
- A summary of public engagement and what the WLC heard throughout the flood event and August 2022 Public Listening Sessions in Fort Frances, Ontario and International Falls, Minnesota.

2 IJC, IRLWWB, and WLC: Authorities, Roles, and Responsibilities

The dams at International Falls/ Fort Frances and Kettle Falls have been in basin for over 100 years. The day-to-day operations of the dams are determined by the owners, which are currently H2O Power in Canada and PCA in the United States. Dam operators seek to maintain water levels in the lakes within specific ranges., as defined by the International Joint Commission Orders.

The IJC is an independent, objective, and binational body established by Canada and the United States (U.S.) to prevent and/or resolve disputes under the 1909 Boundary Waters Treaty. The 1938 Rainy Lake Convention gave the IJC responsibilities to control water levels under emergency conditions. To do this, the IJC has employed rule curves, beginning in 1949, to regulate water levels and update them to reflect current science and stakeholder benefits. The rule curves were last updated in 2018, following the release of the Rainy and Namakan Lakes Rule Curve Study report of 2017. The current IJC Order consists of a rule curve band for Rainy Lake and the Namakan Chain of Lakes. The rule curve band provides an upper and lower limit for the water elevation in the reservoir on any day of the year (lower in the winter, higher in the summer). The rule curves also establish minimum releases during low inflows and All-Gates Open levels during high inflows.

In 2013, the IJC established the IIRLWWB to assist with binational coordination of watershed management. The Board is comprised of federal, provincial, state, municipal and Indigenous representatives. Its activities are supported by an Industry Advisory Group, a Community

Advisory Group, and four committees. The WLC monitors hydrologic conditions and may provide dam operators with directions for the operation of their discharge facilities to ensure that the rule curves are followed. The Adaptive Management Committee was established in 2020 to monitor whether the latest rule curves perform as expected.

3 Hydrology Review: Winter-Summer 2022

This section provides an overview of the hydrological and meteorological conditions which contributed to the high-water conditions in the Rainy River watershed in 2022. A glossary of technical terms is provided in Appendix C.

These conditions provide important context for the rule curve operations and activities undertaken by the WLC (see Section 4). All precipitation, water level, and flow data provided in this report were obtained from the Lake of the Woods Control Board Secretariat database. The database collects the information from various U.S. and Canadian government agencies for the full Winnipeg River watershed. At the time of preparation of this report, this data was provisional and subject to revision. Refer to Appendix A for a map of the Rainy River basin and Appendix D for graphs of the water levels and flows of the Namakan and Rainy Lakes, Rainy River, and all contributing tributaries of the basin. Appendix D also includes an annual summary of precipitation across the entire basin.

3.1 Review of Drought Conditions through 2020 and 2021

The Rainy River basin experienced severe drought conditions between the spring of 2020 and the fall of 2021 due to lack of precipitation (**Error! Reference source not found.**). Although conditions over the winter of 2020 were normal, with average snow accumulation, precipitation from April to June was at less than 5^{th} percentile[1] and ranked the lowest in the last 30 years. Very little precipitation in the summer of 2020 exacerbated the dry conditions, and by the end of August 2020, many parts of the basin were classified as abnormally dry, or in a moderate drought, on the North American Drought Monitor (Figure 1).

Table 1: Seasonal Cumulative Precipitation Statistics for the Rainy-Namakan Basin from Spring 2020 to Fall 2021

Period	Precipitation (mm)	Precipitation (in)	Percentile	30 Year Rank
Spring 2020 (Apr-Jun)	120.8	4.8	<5%	30
Summer 2020 (Jul-Sep)	214	8.4	19%	26
Fall 2020 (Oct-Dec)	138.7	5.5	47%	15
Winter 2021 (Jan-Mar)	56.4	2.2	8%	28

[1] In statistics, denotes the relative position of a value in a set of ranked values. In this report, percentiles for water levels and flows are relative to values for a specific time of year recorded in the 30-year period from 1981-2010. See Appendix C for more information.

Spring 2021 (Apr-Jun)	173.8	6.8	16%	26
Summer 2021 (Jul-Sep)	205.6	8.1	14%	27
Fall 2021 (Oct-Dec)	166.3	6.5	60%	12

Source: for data 1981 – 2022 Environment Canada Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

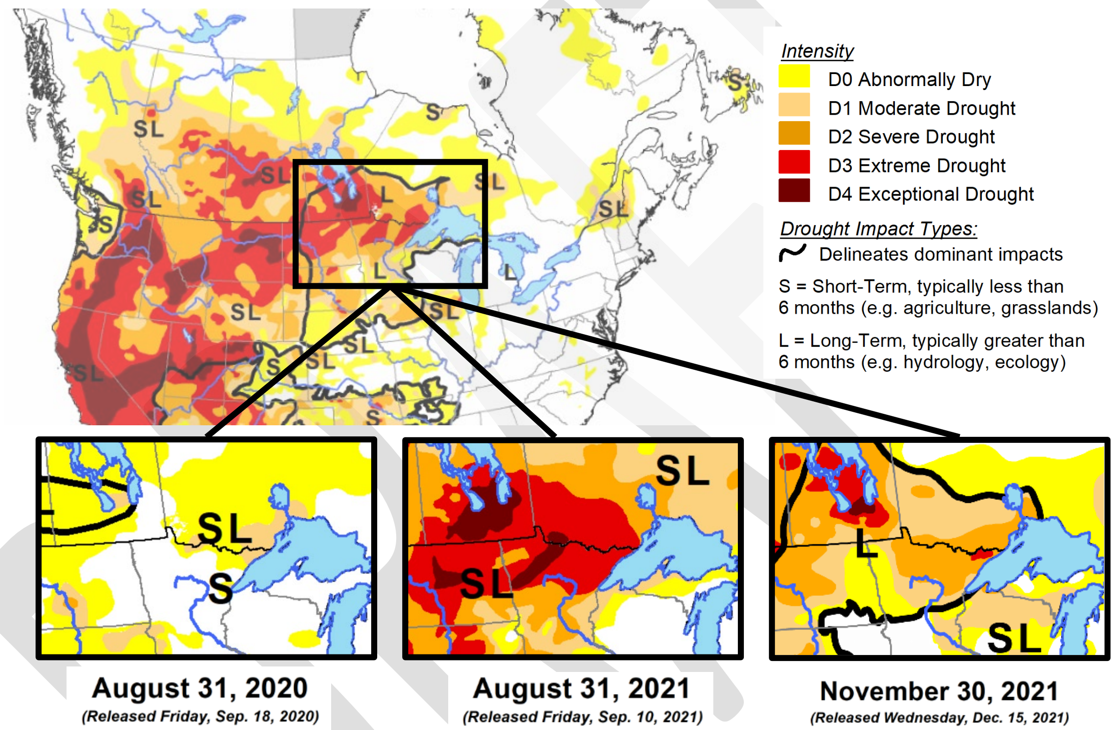


Figure 1: North American Drought Monitor Map of the Rainy River Basin (NCEI-NOAA)

Drought conditions improved slightly in the fall of 2020 when cumulative precipitation for the season ranked close to normal. However, drier conditions returned in the winter of 2021, with snow accumulation at less than 25th percentile. Another weak freshet occurred in the spring of 2021 with cumulative precipitation values dropping to below the 20th percentile. The dry conditions persisted into the summer months with declining cumulative precipitation, to the extent that the basin had been categorized as being in an extreme drought by the end of August (Figure 1). Precipitation maps (Figure 2 and Figure 3) for the period of January 1 to July 31, 2021, show the precipitation totals ranged from 200 to 350 mm (8 to 14 in). These ranges corresponded to precipitation deficit of 100 to 200 mm (4 to 8 in) in comparison to normal precipitation totals for this period.

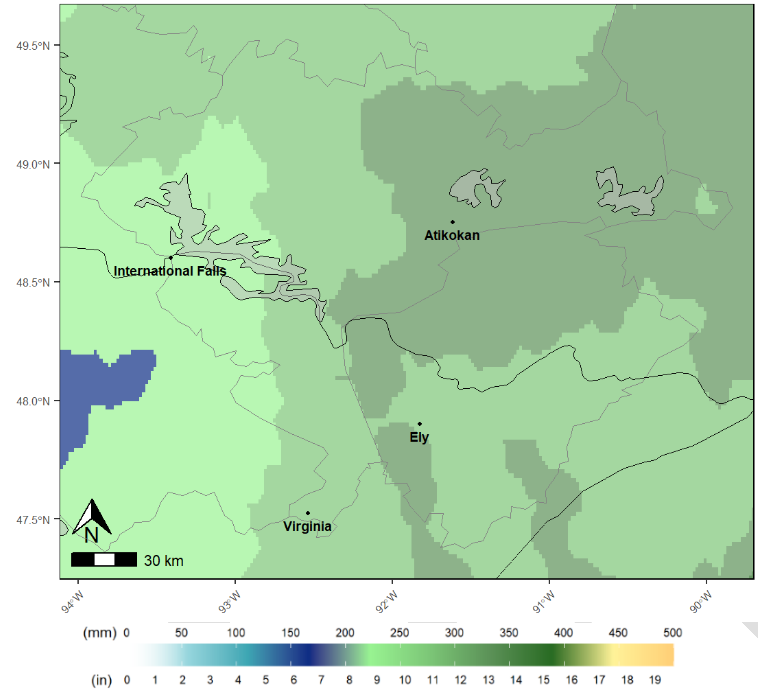


Figure 2. Total Precipitation for January 1 to July 31, 2021 (Canadian Precipitation Analysis)

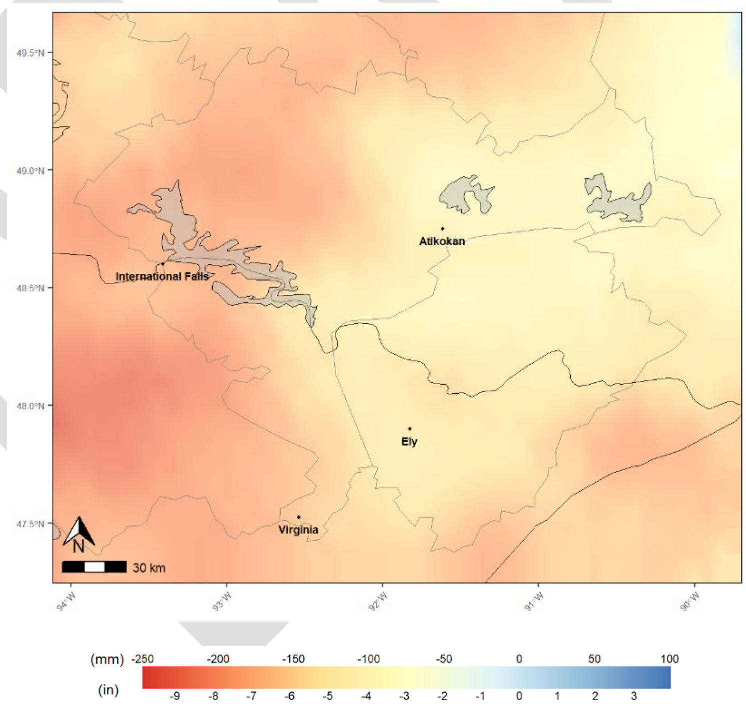


Figure 3. Difference from Normal Precipitation for January 1 to July 31, 2021 (Canadian Precipitation Analysis)

The tributaries throughout the Rainy River basin set low flow records due to the lack of precipitation in August 2021 (see Table 2). Most notable was the Atikokan River, which had the

5th lowest flow on record in October 2020 and recorded zero flows in August 2021. The latter record tied to the previous low flow record from August 1998.

Table 2: Daily Low Flow Records for Natural Tributaries in the Rainy River Basin

Rank	Atikokan River (since 1978)			Vermilion River (since 1979)		
	Date	Flow (m^3/s)	Flow (ft^3/s)	Date	Flow (m^3/s)	Flow (ft^3/s)
1	2021-08-26 & 1998-08-01	0	0	2021-08-26	0.19	6.8
2	2006-12-29	0.24	8.5	2006-10-09	0.31	10.8
3	2012-10-14	0.24	8.6	2012-01-22	0.44	15.7
4	2007-03-09	0.30	10.4	2007-02-16	0.53	18.6
5	2020-10-11	0.33	11.6	2011-10-07	0.56	19.9
Rank	Turtle River (since 1914)			Little Fork River (since 1909)		
	Date	Flow (m^3/s)	Flow (ft^3/s)	Date	Flow (m^3/s)	Flow (ft^3/s)
1	1918-03-17	1.42	50.2	1936-08-26	0.59	21.0
2	1998-09-18	1.88	66.4	1976-09-21	0.65	23.0
3	1940-10-25	4.28	151.2	2021-08-27	0.66	23.2
4	2021-08-25	4.50	158.9	2007-08-26	0.87	30.9
5	1937-02-18	4.84	170.9	2006-09-15	0.99	34.9

Source: Water Survey of Canada

Inflows to Rainy and Namakan Lakes were exceptionally low over the summer of 2020 and only got worse the following year. Inflow statistics in Table 3 show the severity and longevity of the drought experienced in 2020 and 2021. The very small freshet in the spring of 2020 resulted in average inflows to Rainy and Namakan Lakes ranking in the bottom third of spring inflows for the past 30 years. As the summer progressed, the lack of precipitation caused inflow to the lakes to drop considerably, with Namakan Lake inflows ranking the second lowest in the past 30 years and Rainy Lake inflows also ranking low, at 27th percentile. The following seasons, namely the fall of 2020 and the winter and spring of 2021, only saw minor improvements, with inflows to both lakes remaining at or below the 25th percentile. Conditions worsened in the summer of 2021 again due to the lack of precipitation and Rainy and Namakan Lakes inflows fell to the 29th and 28th rank, respectively, for that season.

Table 3: Seasonal Average Inflow Statistics for Namakan and Rainy Lakes from Spring 2020 to Fall 2021

Period	Basin	Inflow (m^3/s)	Inflow (ft^3/s)	Percentile	30 Year Rank
Spring 2020 (Apr-Jun)	Namakan Lake	197.7	6,982	35%	21
	Rainy Lake	287.6	10,157	26%	24
Summer 2020 (Jul-Sep)	Namakan Lake	63.0	2,225	7%	29
	Rainy Lake	107.1	3,782	9%	27
Fall 2020 (Oct-Dec)	Namakan Lake	49.5	1,748	21%	26
	Rainy Lake	101.5	3,584	18%	25
Winter 2021 (Jan-Mar)	Namakan Lake	53.8	1,900	25%	25
	Rainy Lake	108.5	3,832	11%	28

Period	Basin	Inflow (m^3/s)	Inflow (ft^3/s)	Percentile	30 Year Rank
Spring 2021 (Apr-Jun)	Namakan Lake	175.7	6,205	32%	21
	Rainy Lake	264.3	9,334	25%	24
Summer 2021 (Jul-Sep)	Namakan Lake	33.7	1,190	<5%	29
	Rainy Lake	61.1	2,158	6%	28
Fall 2021 (Oct-Dec)	Namakan Lake	29.7	1,049	11%	27
	Rainy Lake	117.5	4,150	24%	24

Source: Lake of the Woods Secretariat

The Rainy and Namakan Lake levels were affected by prolonged drought conditions. The levels on both lakes remained within their respective rule curves throughout 2020. The level of Namakan Lake dropped slightly below the lower rule curve from August through October 2021. The lake levels recorded for this period were the lowest since the 2000 Rule Curves implementation for Namakan Lake. At Rainy Lake, the level dropped below the lower rule curve in July 2021, continued to decline to levels below the Drought Line by September 2021, and finally returned to the rule curve range in mid-October (Figure 4). The lake level in August was the second lowest since the implementation of the 2000 Rule Curves, the lowest being in 2003.

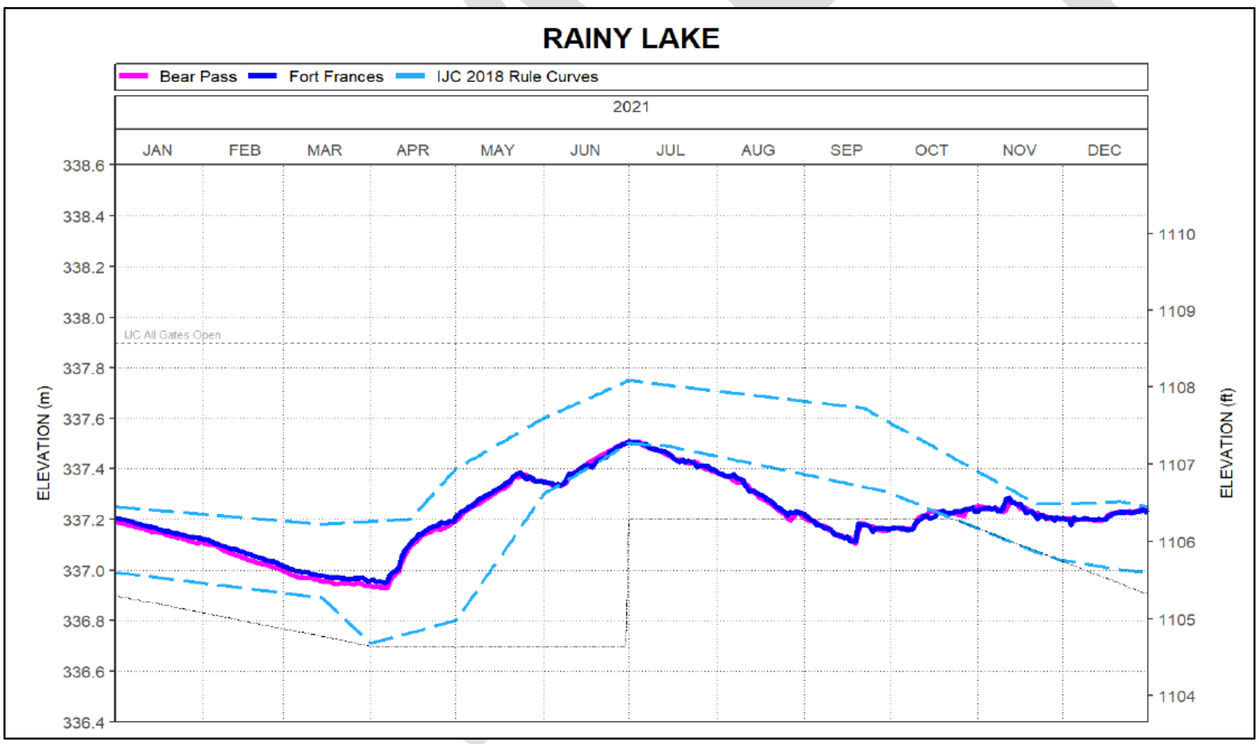


Figure 4: Rainy Lake Level from January 1 to December 31, 2021 (LWCB)

3.2 Watershed Conditions in Fall 2021 and Drought Improvement

In November, the Rainy River basin was still classified as being under a moderate to severe drought despite slight improvement in the fall of 2021(Figure 1). Cumulative precipitation values () indicated the precipitation was slightly above what is normally expected in September.

Despite this, the drought's intensity ranged from severe to extreme. The conditions improved in October, and by November most of the pockets of severe drought had disappeared. with precipitation just above normal at 53rd percentile. The precipitation deficit, which reached a peak at the end of the summer, had resolved by the end of the year, with minor exceedances of 50 millimeters above normal (2 in) in the Eastern portions of the Rainy River basin. Figure 5 shows precipitation totals were very close to normal for the remainder of the basin.

Table 4: Monthly Cumulative Precipitation Statistics for the Rainy-Namakan Basin for Fall 2021

Period	Precipitation (mm)	Precipitation (in)	Percentile	30 Year Rank
September 2021	103.1	4.1	67%	13
October 2021	53.7	2.1	41%	21
November 2021	48.4	1.9	53%	13

Source: for data 1981 – 2022 Environment Canada Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

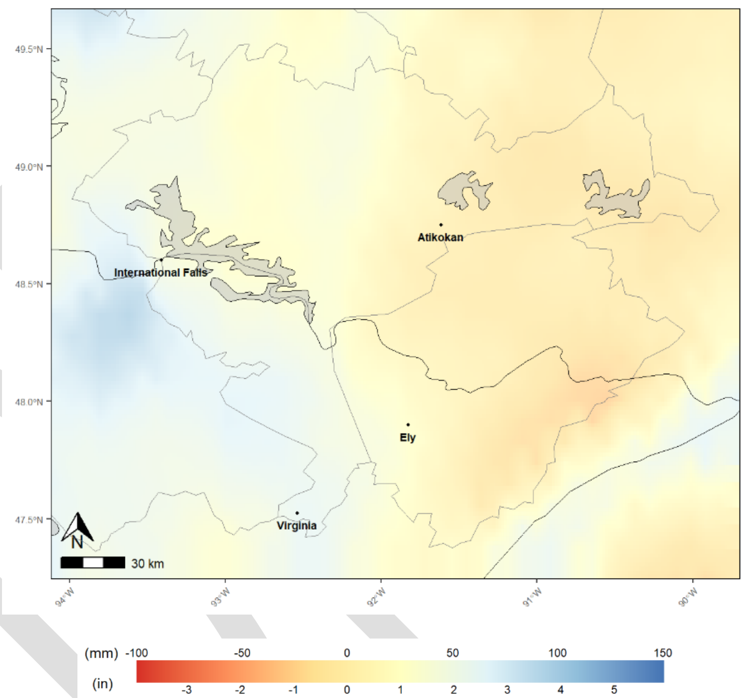


Figure 5: Difference from Normal Precipitation for October 1 to December 31, 2021 (Canadian Precipitation Analysis)

Although cumulative precipitation over the fall increased to normal, inflows to the lakes remained low. On the tail end of some of the lowest summer inflows in 30 years (see Table 3), the inflows from October to December 2021 only improved moderately. The average inflow to Namakan Lake over that period was at the 11th percentile and still ranked 27th of 30 years. Rainy Lake saw the most improvement, with inflow reaching the 24th percentile.

3.3 Snowpack Conditions in Winter 2021-2022

From mid-February to the end of March 2022, there was above normal snow depth and snow water equivalent[2] (SWE) measured across the Rainy River basin. On February 22, the U.S. Army Corps of Engineers (USACE) in St. Paul, Minnesota completed the annual snow survey, results shown in Figure 6. On March 1, an additional measurement was conducted at Atikokan by Ontario Power Generation (OPG). The measurements are listed in Figure 5. The actual measured values of SWE ranged from 100 mm (4 in) at the Crane Lake measurement location, to as high as 147.5 mm (5.9 in) at the Ray location. Compared to the average SWE for this time of year, the measurements in 2022 ranged from 117 to 193 percent of normal. The Minnesota Department of Natural Resources (MNDNR) reported similar results in their snow depth maps of February 24 (Figure 7). The results showed the snow depth range of 24 to 30 inches (60 to 76 cm) for most of the Rainy River basin, translating to a snow depth ranking over the 80th percentile.

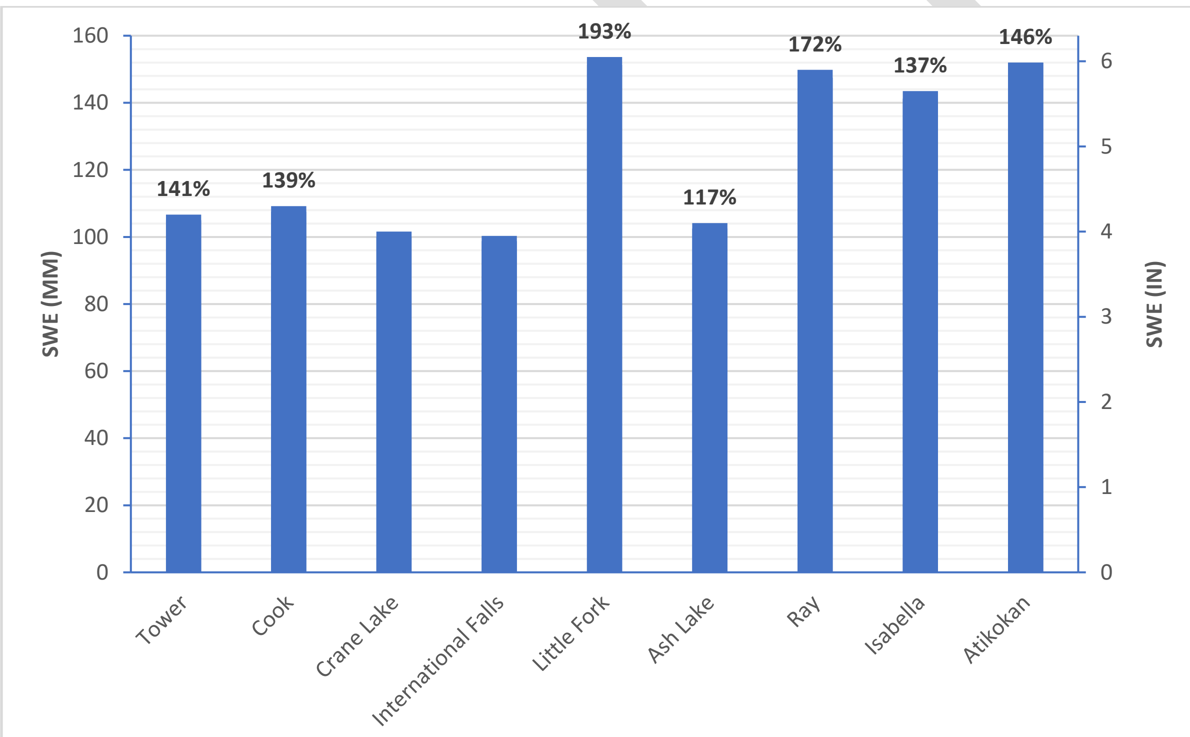


Figure 6: USACE and OPG Snow Water Equivalent Measurements in February 2022 and Percent of Normal for Locations Referenced in Figure 7 (USACE and OPG)

[2] Snow Water Equivalent (SWE) is the amount of liquid water stored in the snowpack. It is measured in millimeters or inches of water or melted snow.

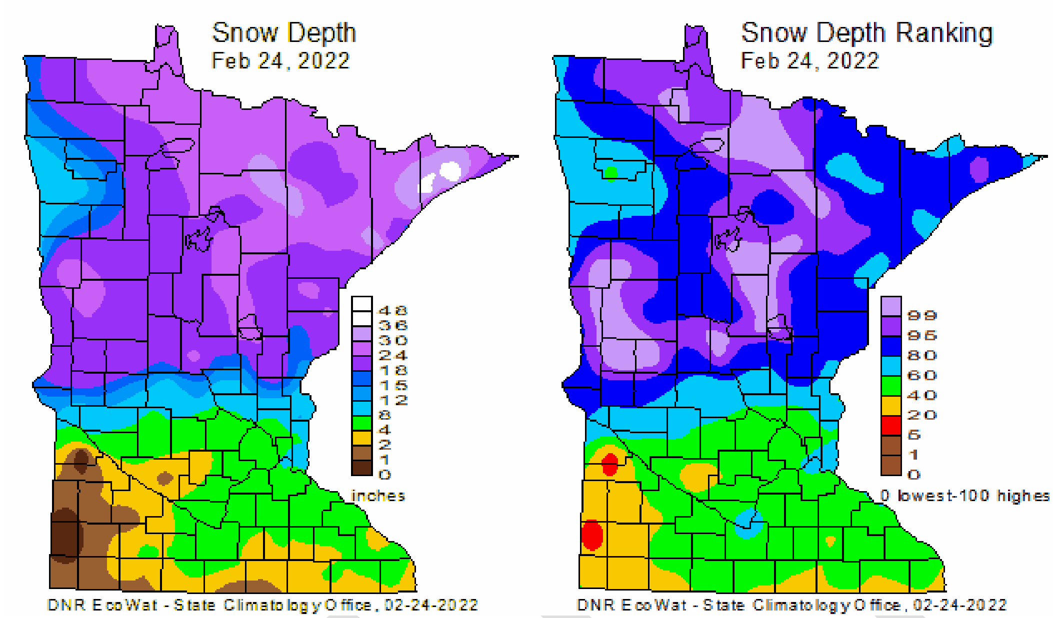


Figure 7: Minnesota Snow Depth and Rank Maps for the week of February 24, 2022 (Minnesota Department of Natural Resources)

Modeled SWE estimates completed in mid-February by the U.S. National Weather Service (NWS) were consistent with the USACE measurements in Minnesota, but under-estimated in comparison to measurements in Canada. These estimates are developed through a physically-based snow model which is calibrated using ground-based measurements, satellite snow observations, and, for the first time in this basin, airborne gamma surveys made in January 2022 [https://www.nohrsc.noaa.gov/snowsurvey/]. Figure 8 through Figure 10 show maps of the modeled SWE for February 22, March 15, and April 15. Furthermore, the maps show a ripening of the snowpack by mid-March, meaning the snowpack reaches a state where it can produce meltwater, with SWE appearing to reach its high for the season. In a typical year, once the snowpack has ripened and temperatures start to increase above the freezing mark, the snowpack melts relatively quickly. However, one month later, on April 15, the SWE estimates in the basin remained the same. This was caused by a shift in weather patterns that occurred mid-April when air temperatures fell below freezing, stalling the typical snowmelt pattern.

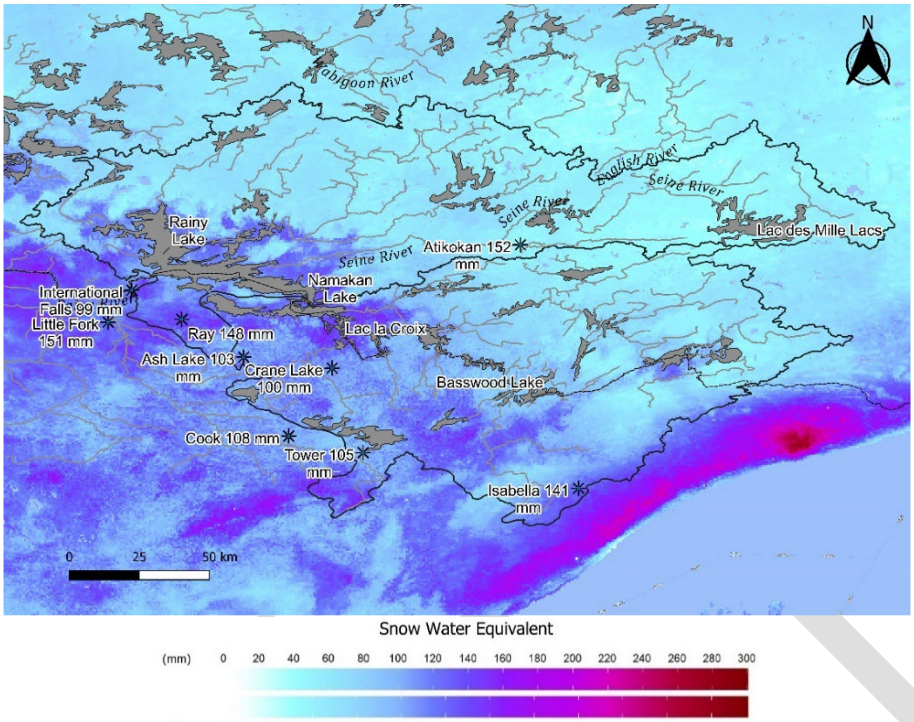


Figure 8: Estimated Distributed and Measured Point Snow Water Equivalent on February 22, 2022 (NOHRSC [NOAA])

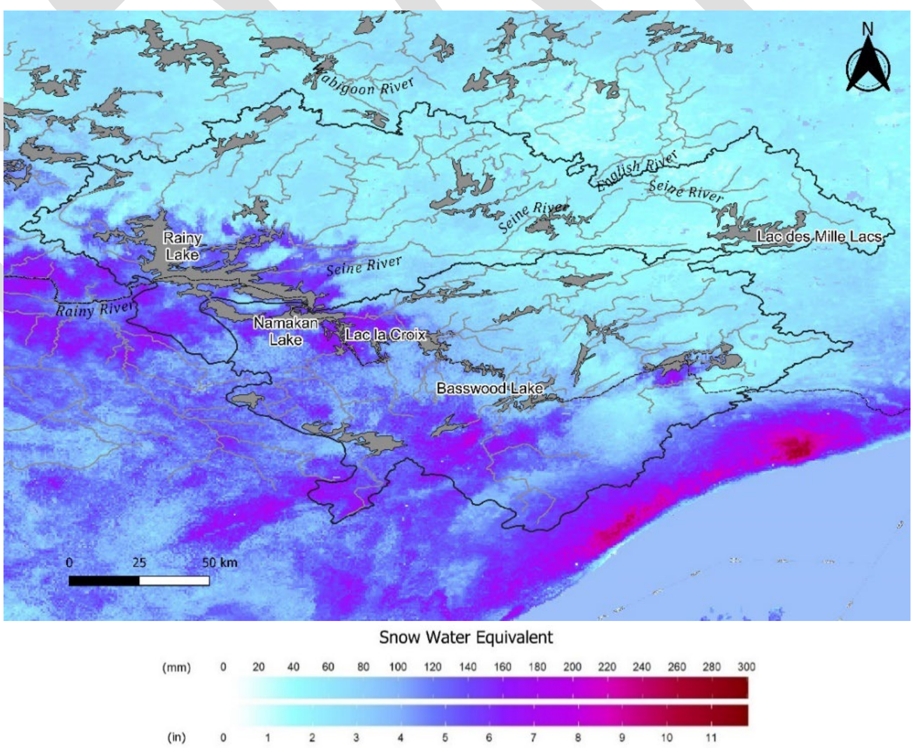


Figure 9: Estimated Distributed Snow Water Equivalent on March 15, 2022 (NOHRSC [NOAA])

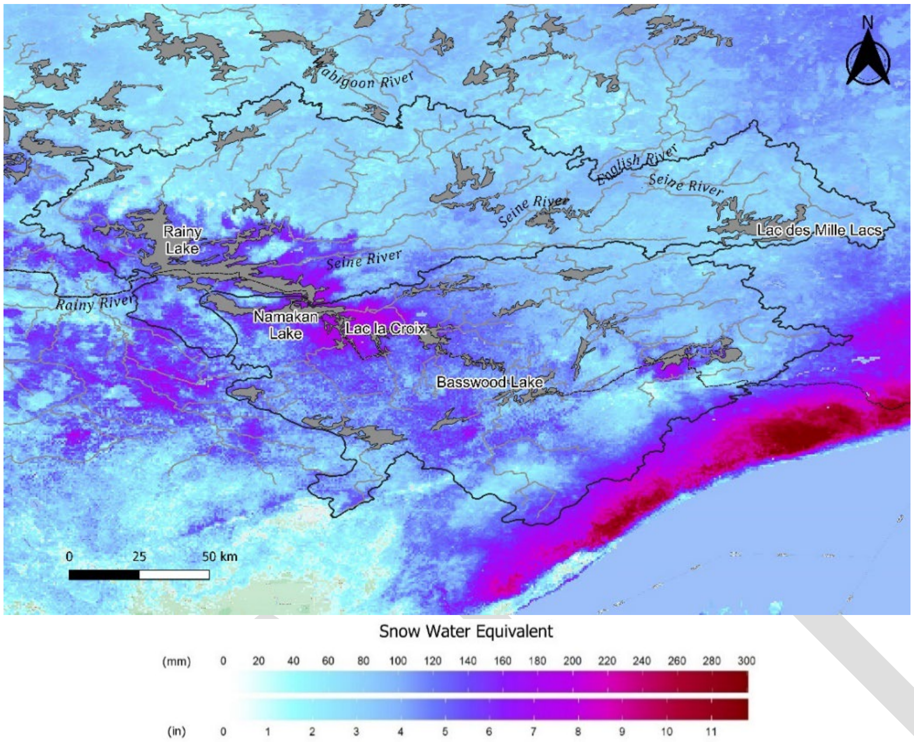


Figure 10: Estimated Distributed Snow Water Equivalent on April 15, 2022 (NOHRSC [NOAA])

The extension of the winter-like conditions and stalling of the melting snowpack is also evident in the plot of SWE over time at the Atikokan measurement location (see Figure 11). The blue bands reflect the percentiles of SWE from January through May, and the lightest blue section reflects the normal trend. In this case, the trend is for SWE to continue increasing until April, after which melt occurs, and drops off very quickly. The graph also indicates that, in extreme cases in dark blue, SWE can climb steadily over the winter and reach significant levels by April. The black line shows the evolution of SWE in 2022. From January to March, the line trended within the normal or high-normal range. In mid-March, with warmer temperatures, there was even a slight decline in SWE. But over the course of late March and early April, the SWE at Atikokan did not drop off as expected. Instead, it continued to climb and reached a high outside the range of measurement on April 15 before finally dropping off in the latter half of April.

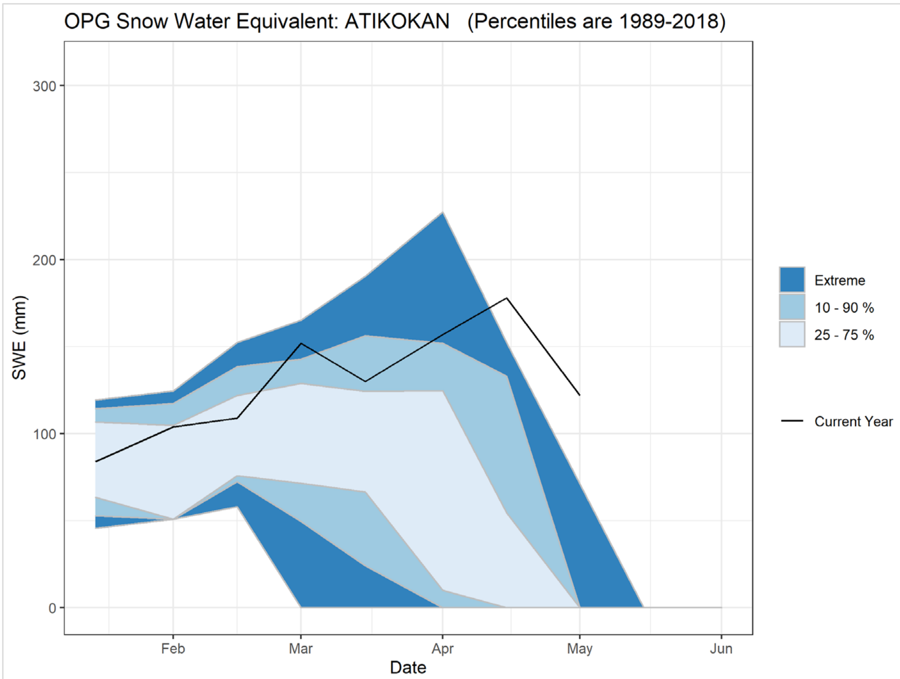


Figure 11: Measured (2022) and Historic Snow Water Equivalent at Atikokan, ON (OPG)

3.4 Summary of Precipitation for April to July 2022

Conditions changed dramatically in April and May 2022 and abruptly ended the two-year drought. Precipitation was abundant and regular through the spring. In April, a series of Colorado Low[3] systems crossed the basin. Although air temperatures in the first few days were above freezing, an additional 10 cm (4 in) of snow fell over the Rainy River watershed by the end of the first week of April. Conditions in the second week of April did not improve; air temperatures continued plummeting and the Colorado Low brought widespread, heavy snowfall to the basin. Snowfall totals ranged from 30 to 70 cm (12 to 28 in). The highest amounts of snow accumulated directly over the Namakan sub-basin. In the third week of April, the next Colorado Low struck, causing a rain-on-snow event that resulted in an almost instant depletion of the snowpack. Wet conditions continued into May, with precipitation in the form of rain. The largest single-day precipitation event so far that year occurred at the end of the month.

From April 1 to the end of May, the Rainy River basin had an average of 257 mm (10.1 in) of rainfall. This equated to more than twice the average for April and May (see Figure 13. Difference from Normal Precipitation for April 1 to May 31, 2022 (CaPA)

). Weekly precipitation totals consecutively outranked average precipitation (see Figure 14).

[3] A Colorado Low is a low pressure storm system that forms in winter in southeastern Colorado or northeastern New Mexico and tracks northeastward across the central plains of the U.S. over a period of several days, producing blizzards and hazardous winter weather (NOAA).

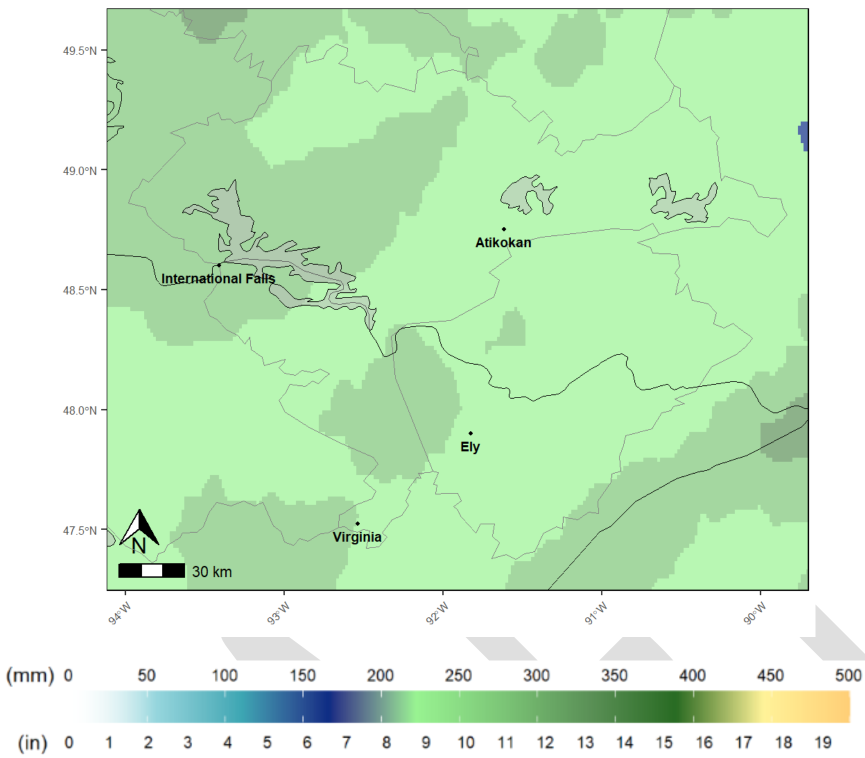


Figure 12. Total Precipitation for April 1 to May 31, 2022 (CaPA)

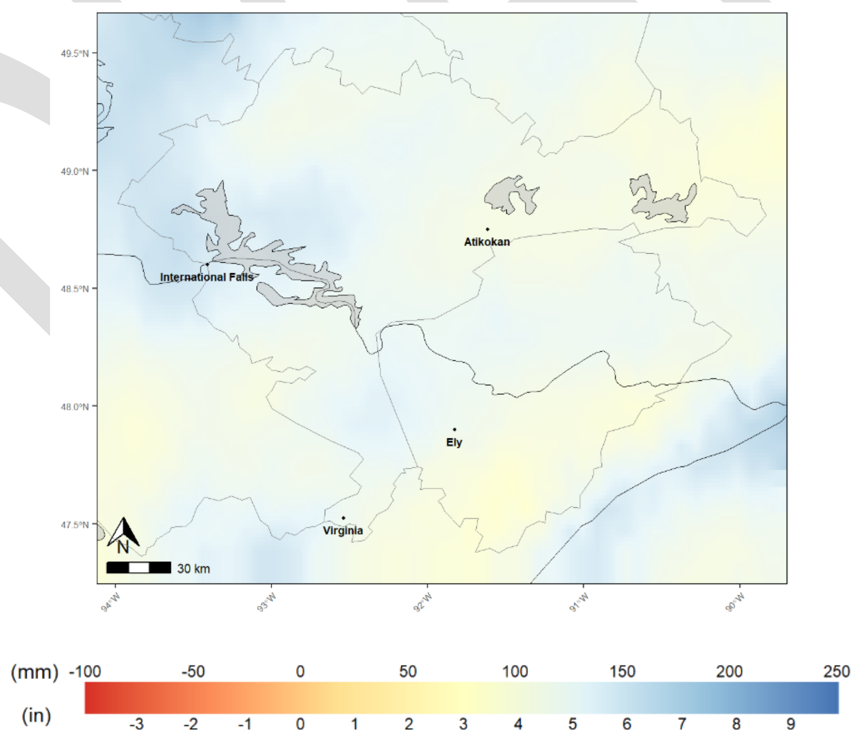


Figure 13. Difference from Normal Precipitation for April 1 to May 31, 2022 (CaPA)

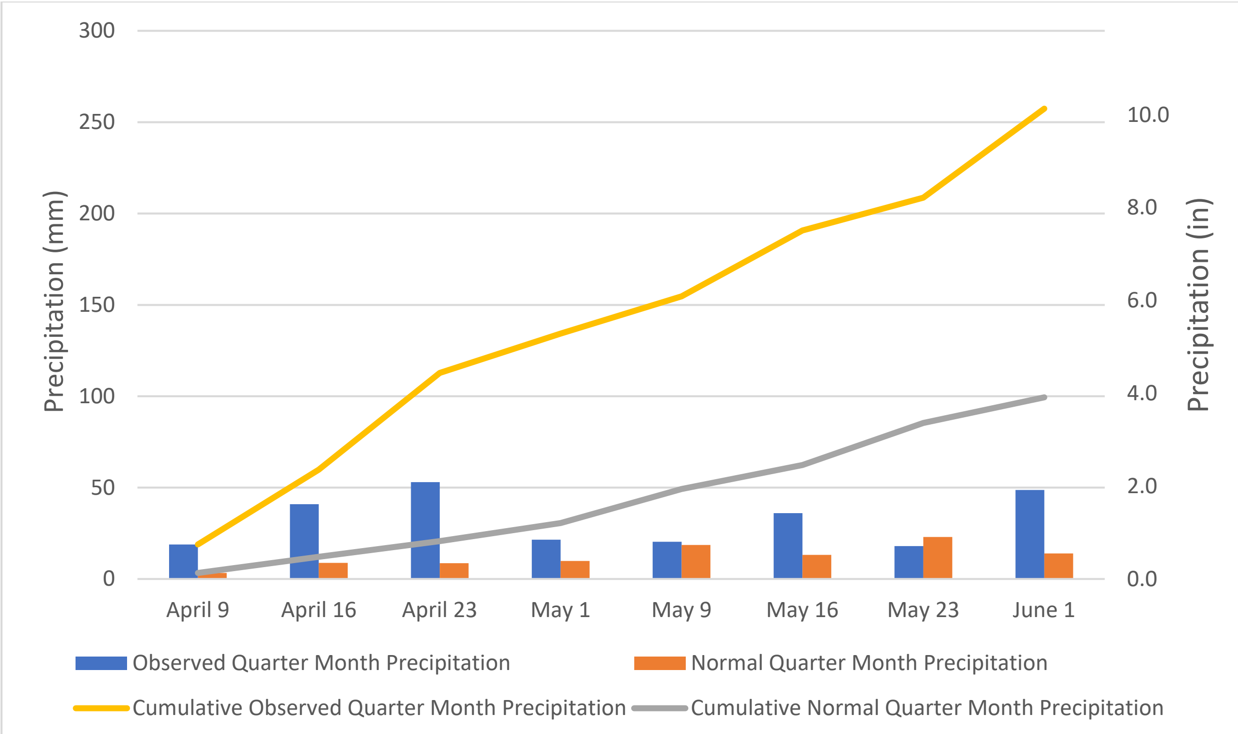


Figure 14: Rainy River Basin Mean Cumulative Precipitation for April 1 to May 31, 2022 from Environment Canada's Regional Deterministic Precipitation Analysis

Source: for data 1981 – 2022 Environment Canada's Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

The months of April and May ranking near the top of cumulative precipitation in the last 30 years (Table 5). In June, a reversal of conditions occurred. The Rainy River basin received half as much rainfall in June as it had the two previous months, and cumulative precipitation fell to the11th percentile of precipitation for the basin. Despite the much-needed relief from the wet conditions, the above-average precipitation returned to the basin in the last three weeks of July. The precipitation for July came in at the 86th percentile and ranked the fifth highest in the last 30 years.

Table 5: Monthly Cumulative Precipitation Statistics for the Rainy-Namakan Basin for April to July 2022

Period	Precipitation (mm)	Precipitation (in)	Percentile	30 Year Rank
April 2022	123.1	4.9	>95%	2
May 2022	134.3	5.3	89%	4
June 2022	68.8	2.7	11%	25
July 2022	157.4	6.2	86%	5

Source: for data 1981 – 2022 Environment Canada Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

3.5 Summary of Flows and Levels in Spring and Summer 2022

The intensity and longevity of the spring precipitation caused flows in the tributaries of the Rainy River watershed to remain at high or close to peak levels from late April to mid-June. The Vermilion River set a new peak flow record, and many other tributaries ranked second or third for all-time high flows. The long duration of these high flows fed the inflows to the lakes and ultimately became the driving force behind the flooding.

The average inflow to Namakan and Rainy Lakes was the highest on record for April and May combined (see Table 6).The inflows for April through July 2022 were second highest only to 1950. As a result, the water level of Namakan Lake rose to a maximum level of 342.18 meters (1,122.69 feet), the third highest on record, and only 7 centimeters (2.8 inches) lower than the record level set in 1916. The water level of Rainy Lake rose to 339.31 meters (1,113.28 feet) and set a new record 8 centimeters (3.1 inches) higher than the previous level record set in 1950.

The graphs of water levels and flows throughout the basin are included in Appendix D and illustrate the magnitude of the tributary flows and lake inflows. The graphs also provide previous level records shown in comparison to levels reached in 2022 on Namakan and Rainy Lakes.

Table 6: Namakan and Rainy Lake Record Inflows for Various Periods

	April 1 - May 31					
	Namakan Lake			Rainy Lake		
Rank	**Year**	**Inflow (m^3/s)**	**Inflow (ft^3/s)**	**Year**	**Inflow (m^3/s)**	**Inflow (ft^3/s)**
1	2022	542	19,141	2022	1098	38,776
2	1950	540	19,070	1950	877	30,971
3	1966	511	18,046	1966	865	30,547
4	2001	504	17,799	2001	864	30,512
5	1969	457	16,139	1927	860	30,371
	April 1 - July 31					
	Namakan Lake			**Rainy Lake**		
Rank	**Year**	**Inflow (m^3/s)**	**Inflow (ft^3/s)**	**Year**	**Inflow (m^3/s)**	**Inflow (ft^3/s)**
1	1950	583	20,589	1950	1,101	38,882
2	2022	499	17,622	2022	1,044	36,869
3	2014	462	16,316	1927	892	31,501
4	1968	444	15,680	2014	869	30,689
5	1966	441	15,574	2001	766	27,051

Source: LWCB

Table 7: Namakan and Rainy Lake All Time Record Levels

	Namakan Lake			Rainy Lake		
Rank	**Date**	**Level (m)**	**Level (ft)**	**Date**	**Level (m)**	**Level (ft)**
1	1916-05-23	342.25	1,122.92	2022-06-14	339.31	1,113.28
2	1950-06-07	342.2	1,122.76	1950-07-05	339.23	1,113.01
3	2022-05-31	342.18	1,122.69	1916-06-08	339.09	1,112.55
4	1927-05-19	341.97	1,122.00	2014-07-01	338.74	1,111.41

5	1938-05-22	341.84	1,121.58	1941-10-18	338.6	1,110.95

Source: LWCB

4 Rule Curve Operations and Water Levels Committee Activities Winter-Summer 2022

The following section provides a summary and timeline of the WLC activities and rule curve operations from February 2022 to when Rainy and Namakan lakes returned to their rule curves in August.

4.1 U.S. Agency Winter Planning Meeting and February Water Levels Committee Meeting with Flow Forecasting and Communications Subcommittee

The WLC and Flow Forecast and Communications Subcommittee (FFCS) participated in an Annual Winter Planning Meeting on February 3, 2022, hosted by the USACE, St. Paul District. The NWS, U.S. Geological Survey (USGS), MNDNR, and other U.S. agencies also attended. Discussions circled around the current hydrologic and meteorologic conditions and available forecasts going into spring.

In late February, the WLC met with the FFCS to discuss current conditions and review the presentation for the Pre-Spring Engagement which would take place on March 3, 2022. The FFCS membership includes U.S. and Canadian WLC Engineering Advisors, Lake of the Woods Control Board Secretariat, U.S. National Weather Service – River Forecast Center, Boise Cascade, Packaging Corporation of America, H2O Power, and the Ontario Surface Water Monitoring Centre.

4.2 Pre-Spring Engagement

The WLC sent a calendar invitation via email to the distribution list of 87 representatives of basin interests 12 days in advance of the Pre-Spring Engagement Webinar on March 3, 2022. The WLC hosted the Webinar where the Engineering Advisors provided a summary of basin conditions and seasonal forecast information to approximately 37 participants. Participants included dam operators, IRLWWB members, U.S. and Canadian forecasting agencies, government staff at the municipal and county level, Indigenous communities and organizations, and property owner associations within the basin, to include resort and recreation organizations. Webinar participants were encouraged to provide their knowledge, subject-matter expertise, and share any concerns or additional information for consideration in advance of the freshet season.

During the Pre-Spring Engagement, the basin was in a drought condition. Base flows were in the low to normal range for that time of the year. The average winter temperatures were colder than in recent years, but warmer than during the previous high-water event in 2014. In the beginning of March, the accumulated snowpack was between 80th and 95th percentile range, based on historic records. The basin was in a La Niña condition, projected to continue through spring (March to May), and then a chance transition to El Niño- Southern Oscillation (ENSO) neutral. Data since 1970 show high water years occur most often when La Niña conditions are present are likely during neutral conditions. National Oceanic and Atmospheric Administration (NOAA) long-term forecasts of temperature indicated a 33 to 40 percent chance of above normal temperature for spring and equal chances of low, normal, or above normal precipitation.

Feedback from basin interests obtained at the Pre-Spring Engagement were consistent with the information provided by the WLC. Following the engagement, the Rainy Lake Property Owners Association wrote to the WLC, stating the WLC should operate on the side of caution based on the following points:

1. Temperatures are expected to remain well below freezing at night during the extended forecast. This may potentially push the ice-out date into mid-May, creating the potential for freshet and spring rains to enter the basin at the same time;
2. It is reported the lakes have as much as 32 in of ice at this time;
3. Area forestry experts have indicated higher than normal precipitation rates follow a drought year; and
4. Basin wide combination of rain and heavy wet snow (according to the National Weather Service, 6 in of water in early November were retained in the bush and will enter the watershed this spring.

4.3 Decision on Spring Target

On March 10, the WLC, in accordance with the IJC 2018 Supplementary Order, determined that the standard rule curve will be used in spring of 2022 to direct the operation of the International Falls/Fort Frances dam. The current and forecasted conditions, discussed during the Pre-Spring Engagement, did not support the use of the high flood risk rule curve at the time. In the recent years (discussed in Section 3.1), the water level conditions had been low. To balance the needs of the fisheries in the lakes, the lake levels were to be held in the middle range (25 to 75 percent) of the band. For the Namakan Lake, the March 31 target range was between 339.65 m (1,114.3 ft) and 339.8 m (1,114.8 ft). The Rainy Lake March 31 target range was 336.90 m (1,105.3 ft) and 337.0 m (1,105.6 ft), and within the upper range of the HFRRC (Figure 15). The red dashed lines are the upper and lower limits of the HFRRC, the black solid lines are the upper and lower limits of the standard rule curve, and the blue dotted lines are emergency water levels; the upper blue dotted line when all gates at the dam are required to be opened and the lower blue dotted line at which point outflow from the dams is prescribed to a minimum allowable discharge.

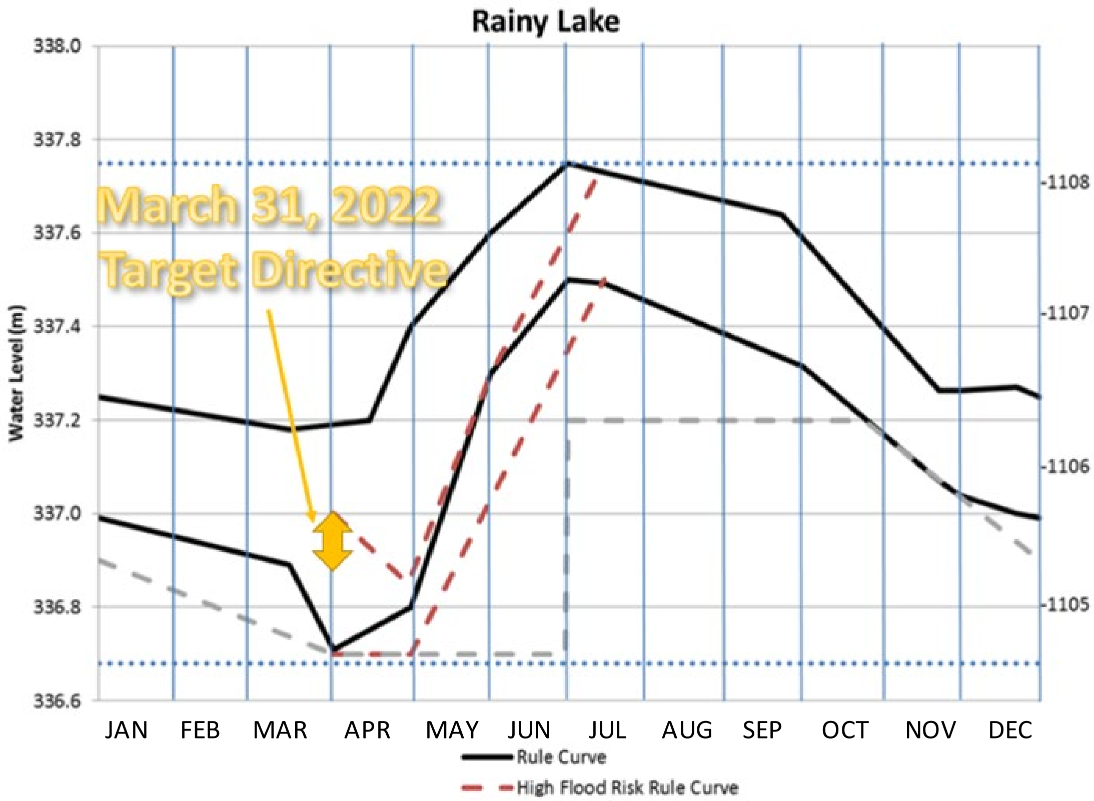


Figure 15. March 31, 2022, Rainy Lake Target Range under Standard Rule Curve

4.4 March 31: WLC Review of Conditions

On March 31, 2022, the WLC reconvened to review basin conditions. The drought condition improved to a moderate drought on the U.S. side of the basin, and the Canadian drought index indicated similar conditions. The base flows were still low to normal range, and snow depth in late March ranked within the 60 to 80 percentiles (less than 2014 and comparable to 2018). Some precipitation had occurred the week prior, but the tributary flows exhibited a minimal response to the precipitation. The Rainy Lake level was within the targeted middle of the standard rule curve and at the top of the High Flood Risk Rule Curve. The WLC decided to inform operators to continue targeting the middle of the band for both lakes.

4.5 April-May Operations

In response to the extreme precipitation which occurred on April 22-23, the Namakan Lake outflow was increased to approximately 280 m^3/s (9,888 cfs), and the Rainy Lake outflow increased to approximately 740 m^3/s (26,133 cfs) on April 25. All logs were pulled from sluices at Namakan dams on April 26 and gates at the International Falls-Fort Frances Dam were opened to maximize outflow as lake levels rose. For more information on the limitations of outflow from Rainy Lake, see a factsheet and a series of three educational videos on the IRLWWB website. The timeline of gate and log openings at both Rainy and Namakan Lakes is demonstrated in Figure 16. Timeline of Namakan Lake Gate Openings (LWCB)

and Figure 17. For specific timeline of gate openings for Rainy Lake see Table 8. The graphs within the figures show the inflow, outflow, and maximum theoretical outflow for each lake

April 1 through June 15, 2022. Maximum theoretical outflow (the red dashed line) represents outflow if all gates were always open and lake elevations were high enough to be able to pass the maximum amount of flow possible out of the dams. The two dams at the outlet of Namakan Lake consist of five stop-log controlled sluices. Logs are stacked on top of each other in each sluice and water flows over the top of the stacked logs. There are 125 total logs between the two dams and Figure 16. Timeline of Namakan Lake Gate Openings (LWCB)

provides the total number of logs in the dams at the correlating date. The dam between International Falls and Fort Frances with 15 total gate-controlled openings.

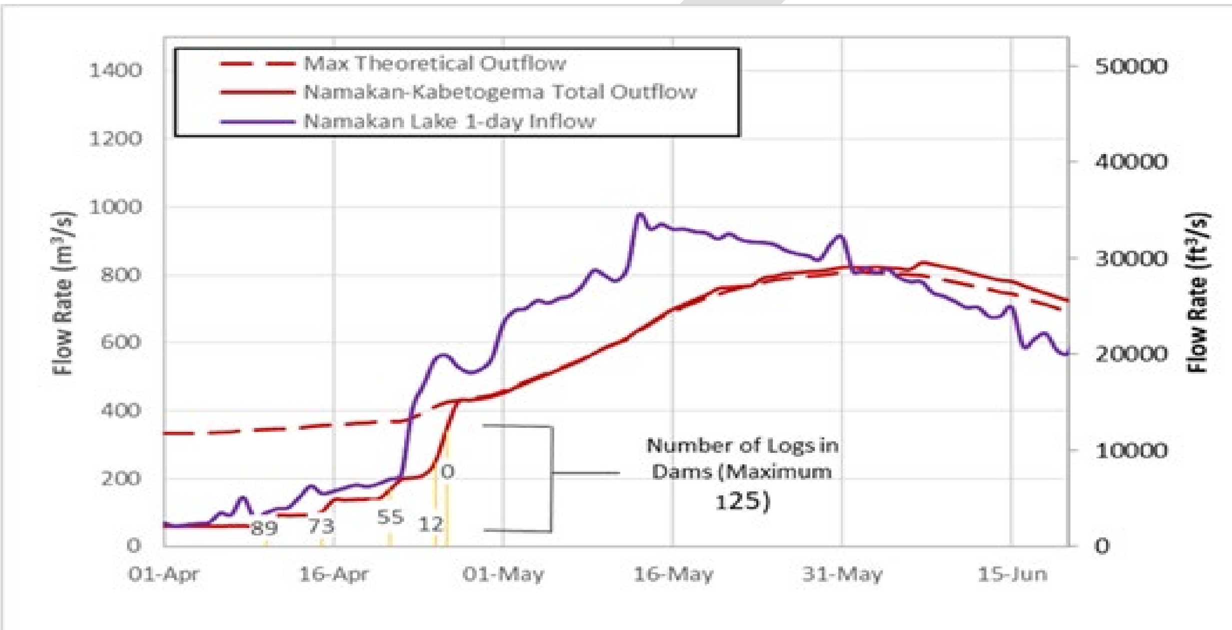


Figure 16. Timeline of Namakan Lake Gate Openings (LWCB)

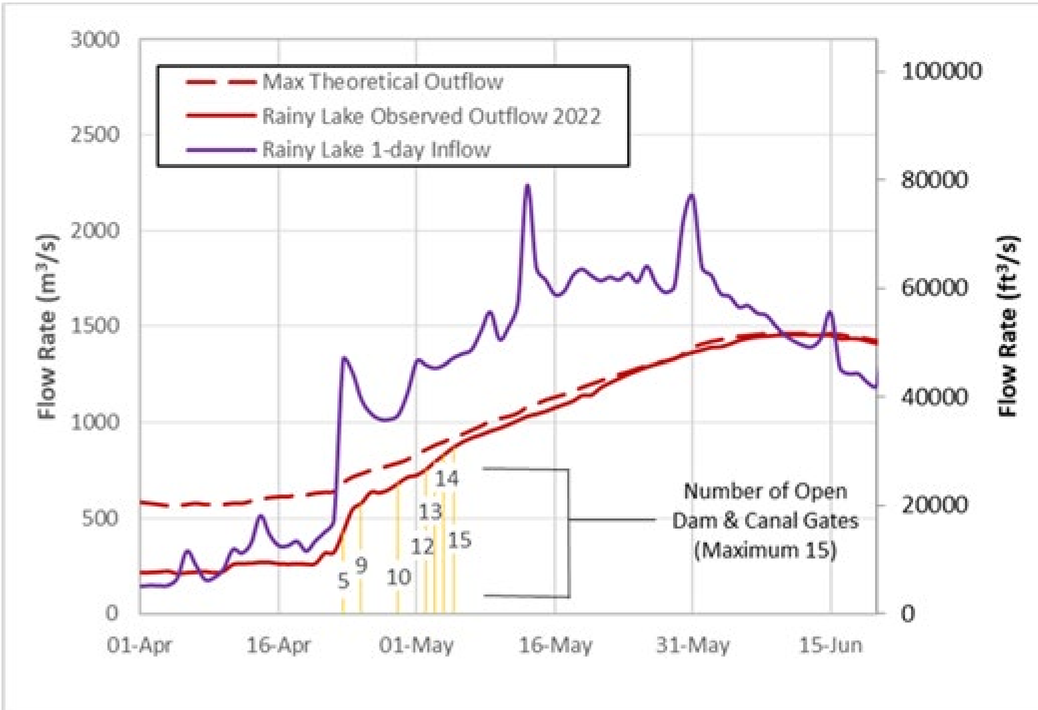


Figure 17. Timeline of Rainy Lake Inflows, Outflows, and International Falls/ Fort Frances Dam Gate Openings (LWCB)

Table 8. Timeline of gate openings for the dam at International Falls/ Fort Frances (15 total gates)

Date (2022)	Gates Open
April 27	9
May 2	12
May 4	14
May 5	All Gates Open

4.6 WLC Activities after All Gates Open

Once all sluices and gates were open at Namakan and Rainy Lake dams, there were no additional actions that the dam operators or the WLC could take to pass additional water . The rate of water released from both lakes steadily rose as the water levels of the lakes increased but remained well below the inflow rates as week after week of above-average precipitation continued to fall. The WLC Engineering Advisors worked closely with Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry and the U.S. NWS to provide guidance three days a week on forecasts for the levels of both lakes. The Lake of the Woods Control Board provided the level forecasts and communicated them through the NWS's Rainy River Basin webpage, which housed current water level and flow observations, precipitation, river level, and lake level forecasts. The NWS also conducted a weekly webinar for agencies and public members to attend. The forecast and basin conditions updates and weekly meetings continued until the end of the flood event.

At the end of May, the U.S. Co-Chair of the WLC and the public U.S. WLC member met with local officials and community members from around the International Falls. During the week of June 6, 2022, the WLC and IJC representatives, including a U.S. Commissioner, traveled through the larger basin to meet with the affected residents and community officials. Local WLC members have been consistently communicating with affected residents, providing information, and answering questions.

On June 14, water was discovered overflowing from Namakan Lake into Rainy Lake through an area north of the Kettle Falls hotel and Namakan dams. High water found an overflow channel from the bay just north of the Kettle Falls Hotel to the American Channel of Rainy Lake. Although some soil erosion occurred, and bedrock was visible, there was no concern of further erosion of the overflow channel.. Both Kettle and Squirrel Falls dams were visually inspected and there was no concern with either dam structure. An area resident indicated that the overflow channel acted as a historic water passage for the Namakan Lake's summer levels in the 1970s. It is believed the water flow has ceased in the recent years as a result of the beaversand fallen trees. To better under the total outflow into Rainy Lake, the USGS crew took flow measurements of the developed channel and upstream of the dams. The overflow channel did not impact normal operations at Namakan and Rainy Lakes since measured outflow was small compared to total inflow to the lake.

4.7 Return to Band

The Rainy Lake Property Owners Association sent a request to WLC when the Namakan Lake water level fell below its prescribed All-Gates Open level on June 30. The request detailed that when Namakan Lake water level recedes to 1,118.8 feet (top of 1970 Rule Curve) operations on the lake should follow the 1970 rule curve temporarily to speed up the decline of the Rainy Lake. In the hope that residents have access to damages and start on restoration activities. The WLC had concerns over the risk of holding a steady Namakan Lake water level should an unforecasted precipitation event occur; however, no precipitation was forecasted for the period that Namakan Lake would be held at the 1970 Rule Curve. The WLC also wanted to ensure residents on Namakan Lake agreed with the recommendation to hold Namakan Lake water levels steady rather than continuing to keep the water level within the 2018 Rule Curve.. Following a discussion amongst the WLC and Namakan Lake residents, the WLC requested a Temporary Order from the IJC to hold the lake at the upper limit of the 1970 Rule Curve.

On July 5, the WLC received the Temporary Order from the IJC.The dam operators were directed to make the minor adjustment from the standard Namakan Lake water level target to a temporarily target range from 340.90 m to 341.0 m. The target was a 10 cm (4 in) range centered on the upper level of the 1970 Rule Curves, 340.95 m (1,118.6 ft). This level also follows the top of the 2018 Rule Curve in early June, but the 2018 Rule Curves drops gradually over the summer rather than holding flat per the 1970 Rule Curves (see Figure 18). The temporary target resulted in Namakan Lake being approximately 5-15 cm higher (2-6 in) than it would have been following the 2018 Upper Rule Curve.

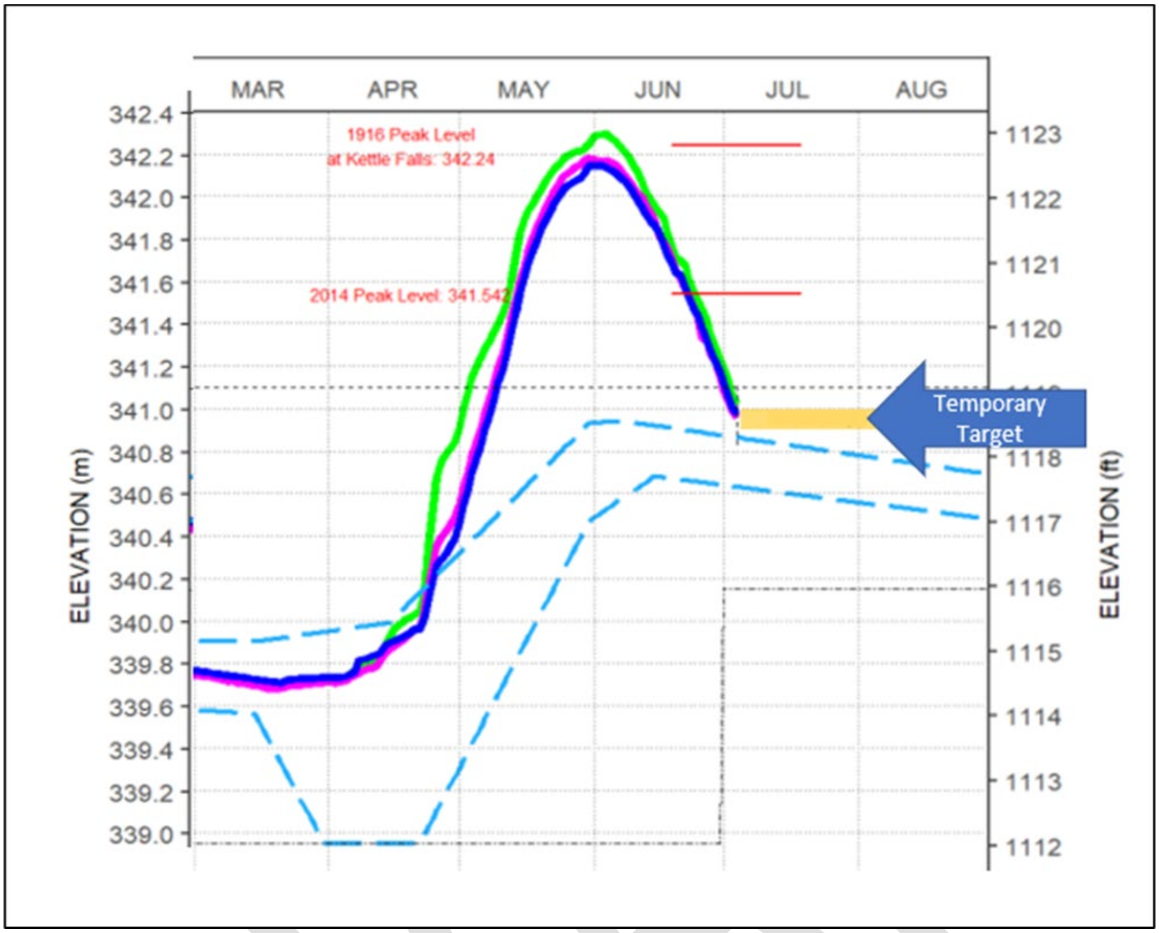


Figure 18. Temporary Target for Namakan Lake under the July 5 IJC Supplementary Order, the blue dashed lines outline the 2018 rule curve, dark blue line indicates the Namakan Lake level at Kettle Falls, green lake indicates the Crane Lake level, and pink line indicates the Lake Kabetogama at Gold Portage.

On July 26, as Rainy Lake fell below the IJC All- Gates Open lake level, the WLC advised operators to set outflows from Namakan and Rainy lakes to target the middle 50 percent of their rule curve bands. The Namakan and Rainy Lakes returned to their standard rule curves on August 3, 2022.

5 Public Engagement

5.1 Basin Visits, Communications and Listening Sessions

In 2022, the WLC engagement with the public began with the Pre-Spring Engagement Webinar, hosted on March 3, 2022. Further information about the Pre-spring Engagement session is included in this report under section 4b. Following the webinar, the WLC received correspondence from and followed up on, input from the Rainy Lake Properties Association.

On March 9, 2022, the IRLWWB presented during the Annual Rainy-Lake of the Woods Watershed Forum on water level information including a 2021 Conditions Recap and a high-level overview of the 2022 conditions. The presentation highlighted that information on current water level and flow conditions in the basin can be found on the Lake of the Woods Control

Board website, and that details of Water Levels Committee decisions regarding the implementation of rule curves on Rainy and Namakan Lakes are posted on the IJC website. The Annual Rainy-Lake of the Woods Watershed Forum was held virtually in 2021 due to public health concerns. There were over 144 people in attendance for the day-and-a-half event.

On March 10, the Water Levels Committee posted a press release on the International Rainy Lake of the Woods Watershed Board website. It was further distributed to the local media to inform the public about the decision to target the standard rule curve for spring 2021 to guide the International Falls/Fort Frances dam operation for Rainy Lake, as well as rule curve targets to guide operations at outlets of Namakan Lake. The WLC also informed stakeholders of the rule curve decision and targets through the WLC's email distribution list. Further information about the 2021 decision on the spring target can be found in this report under Section 4.3.

The sudden onset of the extreme precipitation occurred between April 22 and 23 rising water levels in Namakan Lake. On May 5th, a High Water and Flow Bulletin was posted to the IRLWWB website detailing the extreme conditions, with links to access updated flood risk information via the National Weather Service and the Province of Ontario. The WLC collaborated with the NWS to share information with residents about the NWS webpage specific to Rainy River Basin conditions and their weekly webinar for agencies and public members.

The WLC visited the Rainy River basin twice during the 2022 flood event. On May 24 through 26, 2022, the U.S. WLC members toured the U.S. portion of the basin with Koochiching County Sherriff and Engineer to assess the effects of high-water conditions. The U.S. WLC team also visited resort owners on Rainy and Kabetogama Lakes to answer questions and hear their concerns as water levels were still rising.

June 7 though 11, WLC members from both sides of the border, an IJC Commissioner, and staff from the IJC toured the full RainyLake of the Woods watershed. Given the extensive flooding throughout the region, the tour was coordinated with members of the Lake of the Woods Control Board and the International Lake of the Woods Control Board and included visits to parts of the watershed outside the regulatory mandate of the WLC.

As part of the tour, the WLC met with Chiefs and members of Big Grassy on Lake of the Woods, Nigigoonsiminikaaning, and Couchiching First Nations. There was also engagement with town officials in Fort Frances and International Falls. The WLC observed flood damage, listened to the concerns and questions from the communities, and provided information about the flood, water regulation, and the role of the IJC.

In International Falls, the WLC met with Koochiching County Emergency Operations personnel and participated in the daily brief with the Minnesota Department of Homeland Security and Emergency Management. A media availability session was held in Ranier, Minnesota, for, with local newspaper outlets from both sides of the border and member from the Border Lakes Association to answer questions regarding the flooding in the basin.

Throughout the summer, the WLC members and the IRLWWB responded to phone calls and emails with inquiries from residents about the flooding. The Water Levels Committee continued participating in and sharing information about the National Weather Service's weekly webinars.

During the IRLWWB annual basin meeting the second week of August, the IRLWWB and WLC hosted two Public Listening Sessions: one in Fort Frances, Ontario, and the other in International Falls, Minnesota. A press release was posted on the IRLWWB webpage to inform the residents about the listening sessions. The goal for each session was to provide an opportunity for the community members to share their views and concerns with the Board and its Committees. Participants were asked to register in advance and submit questions. The WLC developed a video presentation about the 2022 flood. The video played at the beginning of each listening session, and is available on the IRLWWB website. The video followed a facilitated session for participants to ask questions and express concerns.

The IRLWWB also received a letter with recommendations from its Community Advisory Group (CAG) after the flood event, which is included in Appendix G. The letter noted improvements in emergency response compared to the 2014 flood event but also noted challenges in communications during the 2022 flood event. The CAG's recommendations to the IRLWWB included:

1) an establishment of multi-agency information officer role and a potential development of an app that provides easy access to watershed-related information,
2) investigating emergency regulation where Rainy and Namakan Lakes levels are more balanced,
3) investigation of a floodway on either side of the border, and
4) coordination with NWS on added capacity in basin forecasting of future flood events.

Additionally the IRLWWB asked the IJC to urge governments to ensure that any plans to replace the Ranier rail bridge are designed to minimize impacts on flows (5), and for the WLC to consider reviewing rule curve decision process to allow for approval of a HFRRC later in spring or provide additional public updates as the spring freshet develops (6).

While establishing a multi-agency information officer (1) and developing an app is outside the scope of the WLC, the WLC is supporting multi-agency communication by providing links to water level data and emergency information on its website. Section 8 of this report provides more background information on basin conditions and water management in the basin, both in general as well as in times of flood.

Regarding coordination with the NWS (4), the WLC sent a letter to the North Central River Forecasting Center (NCRFC) on October 31, 2022 requesting additional forecasting support for the full Rainy River basin and building modeling capacity and support for snow water equivalent measurements to accurately quantify snow observations within the basin. Since the request, NCRFC has been actively working on additional river forecast modeling points within the basin, as well as adding the Rainy-Lake of the Woods watershed flight paths for aerial snow surveys. Another WLC effort related to the recommendations was to address misunderstandings around the role the HFRRC plays in water level management (6). On January 3, 2023, the WLC sent a letter to IJC Secretariats requesting an amendment to the 2018 Supplementary Order eliminating the distinction between the regular and high flood risk rule curves for Rainy Lake, combining them into one rule curve through the spring period. In response to feedback that invoking the HFRRC in March was being misinterpreted by the public that the WLC was able to manage High Risk Floods with this curve to avoid damages, it was also recommended to remove all references to a high flood risk rule curve from the Order. The March 10th decision would then be the date by which the WLC establishes a 'Spring Regulation Plan'. In response to the request, on March 3, 2023, the IJC issued a Temporary Order to the 2018 Supplementary Order allowing for the temporary implementation of the recommendation. After the 2023 freshet, a permanent change would be considered with input from the public and a summary report from the the WLC of its experience with the single rule curve.

The recommendation to investigate a balanced approach of emergency regulation for Rainy and Namkan Lakes stems from the July 2022 Temporary Order to hold Namakan Lake at the top of the 1970 Rule Curve to allow Rainy Lake to recede to its All-Gates Open level sooner (Section 4.7). To target outside the current rule curves, the WLC may request a Temporary Order from the IJC in times it is advisable to do so. In the event that a Temporary Order can be implemented in an emergency situation, impacts and interests of both lakes need to be considered.

The recommendation to investigate a floodway within the basin (3) is currently outside the mandate of the IRLWWB and WLC. Any major structural solutions, like a floodway or a diversion, would have to consider downstream impacts. Solutions in one area of the basin may not be a solution for another area of the basin and may have impacts that exceed those of the pre-project conditions.

5.2 What We Observed and What We Heard

This section provides a summary of key observations, questions, and concerns, based on the opportunities to engage with the public through basin visits, correspondence, and the August Listening Sessions.

Damage to Properties, Infrastructure, and Economic Loss

The impacts on properties and infrastructure varied depending on the location within the Rainy River basin. Given the overwhelming amount of water that entered the basin quickly, the infrastructure was submerged in some areas and resulted in significant damage to the shoreline properties. There was extensive damage to homes and docks. In some places, the roads and harbors with berms were no longer visible. Resort owners and other small businesses suffered significant economic loss due to infrastructure damage. Some resorts had to shut down entirely due to their location on the lake, while others had to reduce summer reservation numbers. Tourism is a crucial economic driver for the region, and the financial hardship from the flooding occurred after two exceptionally lean tourism years due to the global pandemic.

Figure 19. Flood mitigation efforts at Thunderbird Lodge in International Falls, MN (Photo Credit: Abigail Moore)

Sandbagging and Community Support

As water levels rose, states of emergency were declared at the state, provincial, and Federal levels. The State of Minnesota issued an Executive Order declaring a peacetime emergency on May 19 to provide on-site state assistance to the local governments. The U.S. Federal Emergency Management Agency declared a disaster in the basin on July 15 to provide Federal funding to the state, tribal, and local governments. Residents, with the help of various agencies, mounted a tremendous sandbagging effort to mitigate the impacts of the flood. The WLC and Board members observed and heard from the local community that the number of sandbags available improved compared to previous flood events. In addition to agency help, community members on both sides of the border made exceptional efforts to support each other, whether volunteering to fill sandbags or helping neighbors place sandbags around homes.

Figure 20. Koochiching County sandbagging station at International Falls, MN (Photo Credit: Rebecca Seal-Soileau)

Snow and Ice

The Board heard from multiple community members that there were concerns over the accuracy of snow data in the basin. There were questions about why the SWE data modeled and shown in the forecasting presentations did not reflect what individuals observed locally, especially in the more remote areas. There is an opportunity to build awareness about how a single observation of snow depth or ice thickness can vary from one location within the watershed and differ from broader averages for forecasting. The NWS identified that participation of citizens throughout the basin in their Community Collaborative Rain, Hail & Snow Network (CocoRaHS) would be of value to by providing additional data points to ground truth precipitation observations, which would support improved forecasts of lake and river levels. More information on CoCoRaHS is available at https://cocorahs.org/.

Water Level Committee Decisions

There were many questions about the significance of making a regulatory decision by March 10. Despite ongoing work by the WLC to monitor conditions in real-time during the spring, some public members held the misperception that the WLC was no longer engaged following the March 10th rule curve decision.

There were several comments related to concerns about the timing of gate openings at Rainy Lake as water levels rose and a general sentiment that the WLC could have done more to minimize the impacts of the flooding. A minority of people believed that the rule curves were designed to prevent floods or perceived it as an "emergency rule curve." It became evident that the term "High Flood Risk Rule Curve" is misleading as the high flood risk rule curve is only intended to provide modest mitigation under minor to moderate spring flood risk scenarios

A key question that arose several times throughout the 2022 flood event and during the August Listening Sessions regarded the implementation of rule curves and what would have happened if the HFRRC had been used instead of the standard Rule Curve. Many of the community members felt that following the HFRRC could have ‘taken the edge off’ the impacts they were experiencing from the flood, while acknowledging the flooding could not have been prevented. Analysis of “what-if” scenarios regarding rule curves is covered in Section 6 of this report.

Outflow of Rainy Lake at the CN Railway Bridge Crossing

There is a restriction point that limits the outflow of water out of Rainy Lake into the Rainy River at the rail crossing between Fort Frances, Ontario, and Rainer, Minnesota, at the Southwest corner of Rainy Lake. Some community members understand that the dams need complete control of the outflow. There were several questions about whether changes could be made at this location to let more water out of Rainy Lake to reduce the effects of flooding. This line of inquiry, however, did not take into account the impacts this would have on downstream communities There were other questions about whether infrastructure changes, such as an emergency floodway to increase Rainy Lake outflows, would be a viable option to mitigate the severity of flooding. The Board was reminded that the restriction at this location is natural and existed before Koochiching Falls and Couchiching First Nation land was flooded with the building of the dams.

Community members also highlighted growing concern over the potential modification of the Canadian National (CN) Railway railroad bridge[4]. Many asked how structural changes at the bridge crossings would impact water levels and flows, especially when the basin is experiencing a flood. The lack of information about the scope of the potential work was noted as a key concern. No official project information was available at the time of the August Listening Sessions; however, the WLC brought the CN Rail bridge modification project to the attention of the IRLWWB and IJC.

Debris and Environmental Spill Concerns

There was a concern about hazards to boaters caused by the significant number of large debris floating downstream. The hazard was in a form ofThis trees, branches, docks, and other infrastructure detached from the shore. The potential for an environmental emergency from propane or other hazardous materials displaced due to the flood was also identified as a significant risk. The IRLWWB notified agencies on both sides of the border about these concerns.

Communications, Roles and Responsibilities

There were multiple reports that residents struggled to understand where to go for help and who was responsible for what during a flooding emergency. This included questions about where to find information on water levels and lake level forecasts. First Nation communities on Rainy

[4] The CN Rail was proposing a partial replacement of the CN Railroad Bridge, Mile 85.0 over Rainy River at Fort Frances, Ontario, and Ranier, Minnesota. The bridge’s movable span on the U.S. side was nearing its end of reliable service life, and CN Rail was proposing a replacement of the movable span.

Lake noted the lack of timely and local forecast information during the flooding. Among those who were aware of the NWS webpage and webinars, they were seen as effective and central hubs for information. Section 8 of this report provides additional detail, resources, and sources of information within the basin.

Many residents expected the IRLWWB and the WLC to be more active during the flooding. Although the WLC and IJC were actively working in the background during the flood event, the WLC's involvement was not made clear to the public. During the 2022 flood event, it was evident that the scope and limitations of the Board and Committee's mandate, compared to that of government agencies, were not well-understood. Section 2 covers the roles and responsibilities of the IJC, IRLWWB, and WLC for Namakan and Rainy Lakes.

The Lake of the Woods community members asked about who is responsible for water level decision-making in part of the basin. Many appeared surprised to learn that the mandate for the WLC of the IRLWWB is limited to Rainy and Namakan Lakes and that the separate Lake of the Woods Control Board (LWCB) is responsible for water level decisions on Lake of the Woods, as per the Canada-U.S. 1925 Lake of the Woods Convention and Protocol. Many were unaware that the aquatic ecosystem health mandate of the IRLWWB extends further to include Lake of the Woods and felt these governance arrangements needed to be clearer and were not developed with community interests as a priority.

There was an interest in understanding what kind of communication was taking place to coordinate between the various Boards and Committees and whether anyone was looking at water level issues throughout the system more holistically. The perceived disconnects between the upstream and downstream regulators exacerbated concerns that opportunities were missed to reduce or balance flood impacts.

The IJC has since developed an infographic, available on the IRLWWB website (https://www.ijc.org/en/rlwwb/key-roles-and-responsibilities-binational-management-water-levels-rainy-lake-woods-watershed) to better identify the key organizations involved in binational management of water levels in the Rainy-Lake of the Woods watershed and distinguish their roles and responsibilities.

Misinformation throughout and after the flooding, amplified by social media, worked against the IJC and the public interest. In general, community members and governments have appreciated IJC engagement since 2014; however, there was a desire for more information and inclusion. The community and local media also appreciated IJC basin visits and public information sessions.

Flood resilience and climate change adaptation

Other key topics identified in public feedback were plans for avoiding another catastrophic flood and climate change. Some raised concerns about the changing frequency of flood events and wanted to know what could be done if larger floods occurred more often. There were calls to help the community increase shoreline resiliency, and questions about if and how water regulation would change for future floods at the same or greater scale as the 2022 event.

Accounts from individuals and businesses that had invested in enhancing or moving infrastructure further away from high water marks, based on lessons learned from past flooding, were also shared; unfortunately, in some cases, the scale of flooding in 2022 was so significant that flood damages were experienced even with adaptation and resiliency attempts.

One way the IJC assesses the impacts of regulatory changes is through adaptive management. Adaptive management can ensure that improved future knowledge can be translated into informed lake-level and flow-release decisions. The Adaptive Management Committee (AMC) was established in June 2020 with an overall objective to monitor and understand how the 2018 Rule Curves affect water levels and flows of Namakan and Rainy Lakes, and Rainy River. Their work will support an objective review of the rule curves in the future.

Ecological impacts

High water levels can have positive and negative ecological impacts. The high-water levels in the spring and summer negatively impacted the wild rice harvest in 2022. Coochiching First Nation stated that the annual traditional wild rice roast was impacted by the poor harvest on Rainy and Namakan Lakes. A potential benefit is that invasive cattail species were choked out by the high-water levels, which may provide more habitat for other species, like wild rice, in the future. Some fish species benefited from the high-water levels, with an increase in spawning habitat. However nesting bird habitats were flooded by the high-water levels.

6 Role of the 2018 Rule Curves

6.1 Purpose of High Flood Risk Curve

After the 2018 Rule Curves for Rainy Lake were developed, an additional HFRRC was created as a second option to the standard rule curve. This second curve, as outlined in the IJC 2018 Supplementary Order, is designed to be used in the event that forecasts predict the start of March indicators of high inflows in the upcoming spring are prevalent. During the development of the HFRRC, model simulations indicated that peak levels for moderately large inflow events could be slightly reduced by providing additional drawdown capacity on Rainy Lake in April. For extreme inflow events, the High Flood Risk Rule Curve was shown not to have the capacity to prevent extremely high levels on Rainy Lake and, therefore, cannot prevent flooding.

6.2 Rule Curve "What-If Modeling"

In the spring of 2022, the WLC directed the dam operators to target the middle of the standard rule curve for both Namakan and Rainy Lakes rather than targeting the HFRRC for Rainy Lake. As flood conditions developed and worsened in the following months, many were left wondering if the flooding may have been avoided had the HFRRC been targeted in the spring. To answer this question, the Shared Vision Model (SVM) of the 2000 Rule Curve Review was used to explore what-if scenarios on Namakan and Rainy Lakes.

Four scenarios were modeled to determine if different regulation strategies in the spring would have influenced the peak levels at Namakan Lake and Rainy Lake. The strategies considered were:

- Operating to the middle of the 1970 Rule Curves
- Operating to the bottom 25% of the 2000 Rule Curves
- Operating to the bottom 25% of the 2018 Rule Curves for Namakan Lake and using the High Flood Risk Rule Curve on Rainy Lake
- State of Nature (no dam operations)

These scenarios were modeled for the three largest flood events available in the datasets: 1950, 2014, and 2022. The resulting peak levels and the number of days the level remained above the All- Gates Open level for each lake are presented in Table 9. The results indicate that regardless of which Rule Curve was used, or if no dams existed at all, the level of each lake rises above the All- Gates Open level during these flood events. Furthermore, using one set of rule curves over another has very little influence on the peak level attained by each lake. For all of these extreme flood events, using the 2018 Rule Curves, including the HFRRC, over the 2000 Rule Curves might have resulted in peak levels approximately 1 cm lower, or up to 3 cm lower on Rainy Lake in 2014. The number of days above All Gates Open also saw a reduction of 1 day at the most.

A similar difference in peak levels was achieved using the 1970 Rule Curves, where the difference in peak level compared to the implementation of the 2018 Rule Curves would have again been 1 to 3 cm on either lake. A somewhat larger difference in peak level compared to the 2018 Rule Curves are seen when simulating the State of Nature. In this case, levels on Namakan Lake may have been as much as 5 cm lower in 2022, and the level on Rainy Lake may have been up to 7 cm lower in 2022.

Table 9. Simulated Peak Levels on Namakan Lake and Rainy Lake in 1950, 2014 and 2022 under various Regulation Strategies

	Namakan Lake Peak Levels in meters (number of days above all gates open)		
Regulation Strategy	**1950**	**2014**	**2022**
1970 RC (middle)	342.19 (65)	341.51 (40)	342.07 (40)
2000 RC (bottom 25%)	342.23 (67)	341.52 (41)	342.11 (42)
2018 RC (bottom 25% Nam, high risk Rainy)	342.22 (66)	341.52 (40)	342.10 (41)
State of Nature	342.19	341.51	342.05
	Rainy Lake Peak Levels in meters (number of days above all gates open)		
Regulation Strategy	**1950 Peak Level (m)**	**2014 Peak Level (m)**	**2022 Peak Level (m)**
1970 RC (middle)	339.10 (103)	338.59 (53)	339.16 (64)
2000 RC (bottom 25%)	339.11 (101)	338.60 (51)	339.19 (65)
2018 RC (bottom 25% Nam, high risk Rainy)	339.10 (101)	338.57 (51)	339.17 (64)
State of Nature	339.09	338.62	339.10

In the spring of 2022, the WLC directed the dam operators to target within the 25 to 75 percent of the 2018 Rule Curve band on Rainy Lake. A simulation of this regulation strategy was completed, and these results can be compared to the other simulations using the 2018 Rule Curves, as shown in Table 10. The difference in peak level on Namakan Lake would have been only 1 cm, and the level would have returned below the All-Gates Open level one day sooner. As for Rainy Lake, the reduction in peak level would have been 4 cm and the level would have returned below the All-Gates Open level two days sooner.

Table 10. Simulated Peak Levels on Namakan Lake and Rainy Lake in 2022 under Regulation Strategies using the 2018 Rule Curves

	Namakan Lake Peak Levels in meters
Regulation Strategy	**2022**
2018 RC (between 25% and 75%) ***- used in 2022***	342.11 (42)
2018 RC (bottom 25% Nam, high risk Rainy) ***- alternative***	342.10 (41)
	Rainy Lake Peak Levels in meters
Regulation Strategy	**2022 Peak Level (m)**
2018 RC (between 25% and 75%) ***- used in 2022***	339.21 (66)
2018 RC (bottom 25% Nam, high risk Rainy) ***- alternative***	339.17 (64)

For those impacted by flooding it is understandable that every centimeter of flood level and every day above the All-Gates Open level is meaningful, and therefore even these relatively small reductions in lake level and time are significant. However, it is key to recognize that implementing the High Flood Risk Rule Curve comes with significant risks. In the early spring the prospect of flooding is judged only based on indicators of potential, while the main driver of flooding, spring precipitation, cannot be forecasted out more than a few days. Drawing down the lakes to the bottom of their rule curves based on the possibility of reducing a flood by centimeters and days in anything but the most exceptional case of potential risk is irresponsible, as the negative consequences of that action (i.e. when flood inflows do not develop) cannot be taken lightly.

7 Hazard Management and Resiliency

2022 is the fourth year since 2000 where very high-water levels occurred, with the last high-water event in 2014. Rainy Lake hit record-setting water levels that were 8 cm (3.1 in) above the previous record set in 1950. Namakan Lake experienced the third highest water levels on record, just 7 cm (2.8 in) lower than the record level set in 1916. Flooding has always occurred in the Rainy River watershed and will continue to do so in the future. As discussed in Section 6, no rule curve changes will prevent high water levels in the face of extreme precipitation in the future.

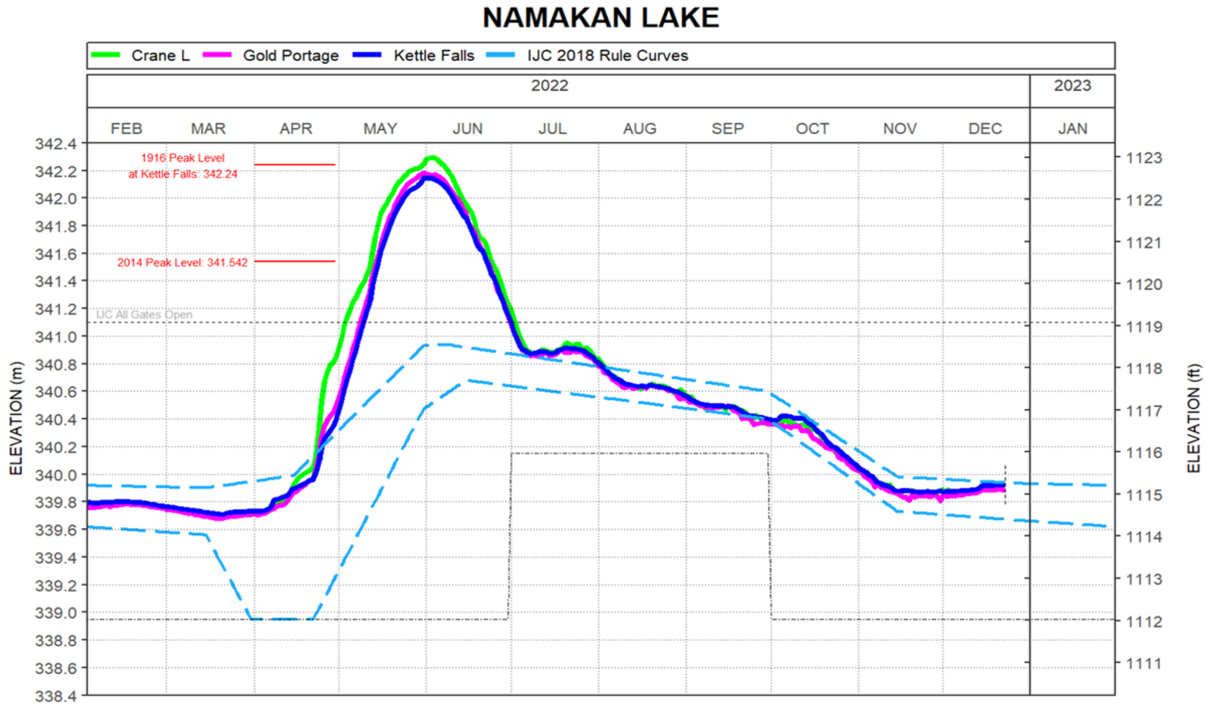


Figure 21. Namakan Lake levels in 2022 with 1916 and 2014 peak water levels marked for comparison.

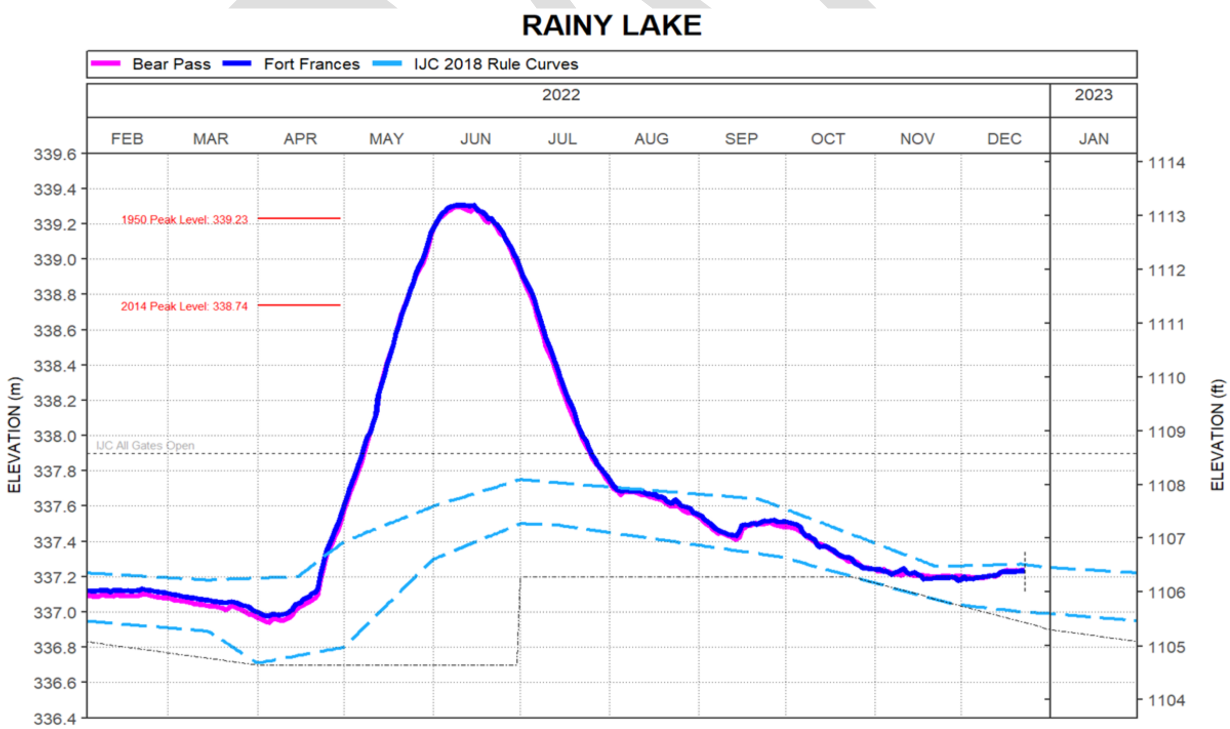


Figure 22. Rainy Lake levels in 2022 with 1950 and 2014 peak water levels marked for comparison.

It is imperative that the community focuses on resiliency and develops capabilities to persist through the next flood (or drought). For shoreline structures such as docks and boathouses, there is an inherent compromise between not only building the structures at a level that is suitable during normal water level years, but also building them high enough to ensure minimal damage is sustained in times of moderately high water levels. For example, the town of Rainy River, Ontario, rebuilt a road along Rainy River to the elevation of the sand berms used in 2014 flood fighting efforts. The mitigation minimized the flood damages in 2022 though there was still visible shoreline infrastructure damage. Unless such structures are built above the historic high-water levels, which would likely limit their usefulness in most years, they will inevitably be inundated and suffer some damage in years of extremely high inflow. When building or repairing structures that are not designed to withstand some degree of inundation, such as cabins or homes, local regulations that define hazard land elevations should be followed.

8 Resources and Sources of Information

During many of the public meeting sessions held in response to the 2022 flooding, members of the public indicated a keen interest in obtaining more information on basin conditions and water management in the basin, both in general as well as in times of flood.

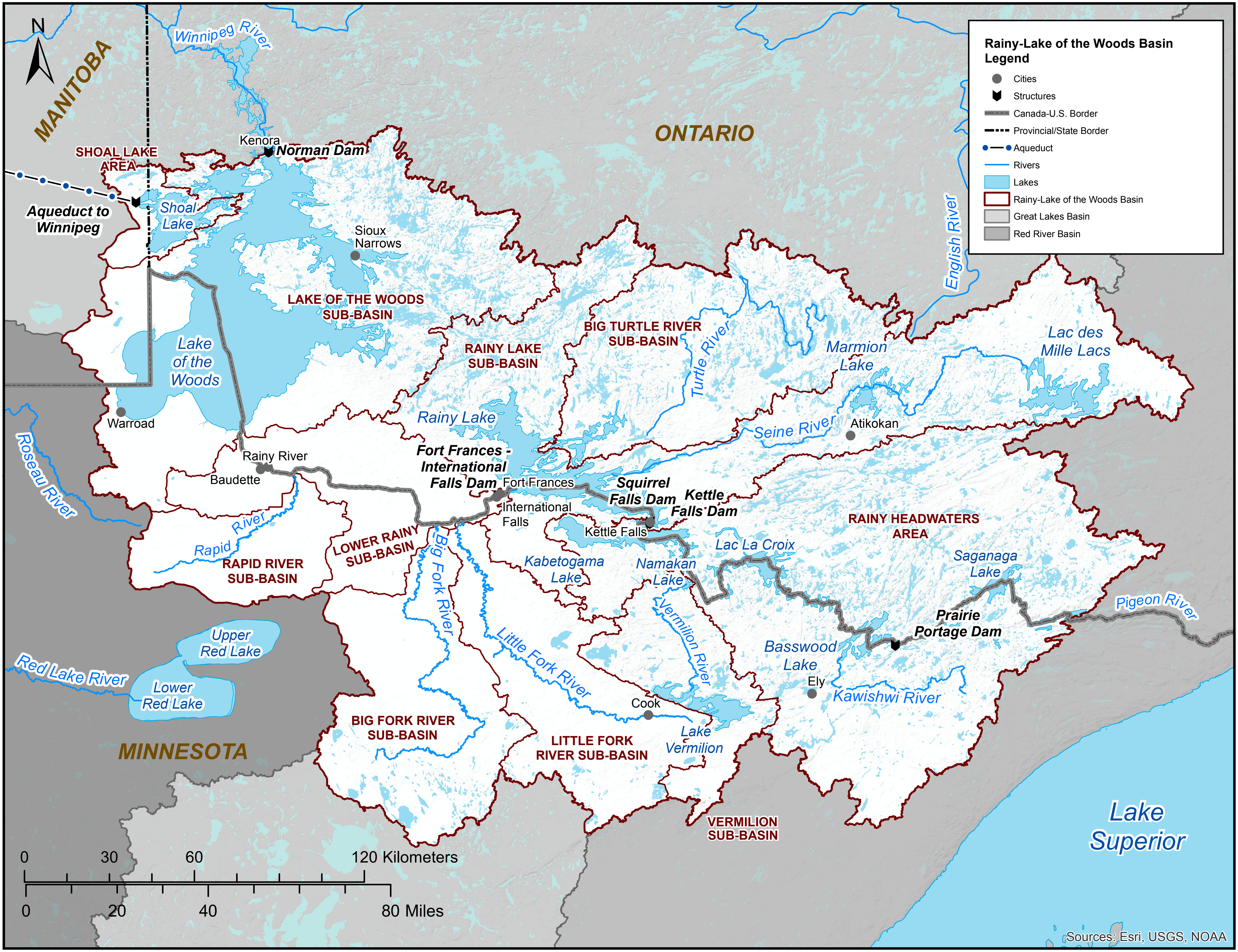
Information about the IJC and the IRLWWB, including the Water Levels Committee can be found on the IJC website https://www.ijc.org/en/rlwwb. Of special interest on the website are a series of three videos that explain the hydraulic limitations at the outlet of Rainy Lake that govern what water management is achievable during years such as 2022 (https://www.ijc.org/en/rlwwb/watershed/simulation). On the IRLWWB website, the public can also see notifications of public meetings and webinars, such as the Pre-Spring Engagement session hosted by the WLC each spring, as well as announcements of decisions and other activity by the Board and its committees. The website also has links to explore in detail the Orders provided to the IRLWWB and WLC by the IJC Commissioners, which include direction on the application of the rule curves for Rainy and Namakan Lakes.

For current and historical information on conditions in the basin, such as water levels in the lakes, outflow from the lakes, and flow at key points throughout the basin, the Lake of the Woods Control Board is one source (https://www.lwcb.ca/waterflowdata.html). Alternatively real time and historical water data can also be obtained from the Water Survey of Canada (https://wateroffice.ec.gc.ca/) and the United States Geological Survey (https://waterdata.usgs.gov/nwis).

As explained in this report, the IRLWWB and WLC only monitor for compliance with the IJC rule curves and issue instructions and targets to the operators of the dams at the outlets of Rainy and Namakan Lakes only under limited circumstances. While day to day decision making about operations of the dams, to achieve specified targets and overall compliance with the rule curves, is up to the operators, H2O Power and Boise Paper, with H2O Power being principally in charge of operations. The H2O Power website (https://www.h2opower.com/water-management/) provides a summary table of lake levels and scheduled gate and log operations, for those interested in having a more in depth understanding of actions that are occurring to regulate water in the basin.

Finally, the IRLWWB WLC, although responsible for overseeing regulation of this transboundary basin, is not a flow-forecasting agency. Rather, those responsibilities, along with associated public safety responsibilities, lie with governments on either side of the border. In Ontario, the Ministry of Natural Resources and Forestry, Surface Water Monitoring Centre, operates the provincial Flood Forecasting and Warning Program (https://www.lioapplications.lrc.gov.on.ca/webapps/swmc/flood-forecasting-and-warning-program/#ontarioFloodMap). Included in the information they provide are notices of flood watches and warnings and special watershed conditions statements, as well as local and provincial flood messages and information about states of emergency.

In response to the need to provide increased public information during the 2022 flood event, the United States National Weather Service created a new Rainy River Basin page on their website (https://www.weather.gov/dlh/RainyRiverBasin). The NWS basin page contains information on basin conditions and various information resources related to water level and flow conditions and water management throughout the basin, including flood briefings when flooding is forecasted.



Rainy-Lake of the Woods Basin
Legend
Cities
Structures
Canada-U.S. Border
Provincial/State Border
Aqueduct
Rivers
Lakes
Rainy-Lake of the Woods Basin
Great Lakes Basin
Red River Basin
N
MANITOBA
ONTARIO
MINNESOTA
SHOAL LAKE AREA
Aqueduct to Winnipeg
Shoal Lake
Kenora
Norman Dam
Winnipeg River
Sioux Narrows
LAKE OF THE WOODS SUB-BASIN
Lake of the Woods
Warroad
Rainy River
Baudette
RAINY LAKE SUB-BASIN
Rainy Lake
BIG TURTLE RIVER SUB-BASIN
Turtle River
Marmion Lake
Lac des Mille Lacs
English River
Seine River
Atikokan
Fort Frances - International Falls Dam
Fort Frances
International Falls
Squirrel Falls Dam
Kettle Falls Dam
Kettle Falls
RAINY HEADWATERS AREA
Lac La Croix
Saganaga Lake
Pigeon River
Prairie Portage Dam
Namakan Lake
Kabetogama Lake
Basswood Lake
Ely
Kawishwi River
Roseau River
Rapid River
RAPID RIVER SUB-BASIN
LOWER RAINY SUB-BASIN
Big Fork River
Little Fork River
Vermilion River
Cook
Lake Vermilion
Upper Red Lake
Lower Red Lake
Red Lake River
BIG FORK RIVER SUB-BASIN
LITTLE FORK RIVER SUB-BASIN
VERMILION SUB-BASIN
Lake Superior
0 30 60 120 Kilometers
0 20 40 80 Miles
Sources: Esri, USGS, NOAA

Appendix B- References

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International Rainy and Namakan Lakes Rule Curves Study Board. June 2017. *Managing Water Levels and Flows in the Rainy River Basin.* https://www.ijc.org/sites/default/files/IRNLRCSB_Final_Report_2017l.pdf

IJC. March 2018. *Official Compilation of the Order Prescribing Method of Regulating the Levels of Boundary Waters.* https://www.ijc.org/sites/default/files/2018-11/Docket%2050%20Official%20Compilation%20Rainy-Namakan%20Rule%20Curves%202018%2009%2013.pdf

Lake of the Woods Control Board. *Basin Data*. https://www.lwcb.ca/waterflowdata.html

MN DNR. *Weekly Snow Depth and Rank Maps.* https://www.dnr.state.mn.us/climate/snowmap/index.html

NOAA. *Interactive Snow Information.* National Operational Hydrologic Remote Sensing Center. https://www.nohrsc.noaa.gov/interactive/html/map.html

NOAA. *North American Drought Monitor (NADM).* National Centers for Environmental Information. https://www.ncei.noaa.gov/access/monitoring/nadm/maps

Appendix C – Glossary of Technical Terms

Antecedent Moisture Conditions— in hydrology, the degree of moisture in the soils of a watershed ahead of a precipitation event. The antecedent moisture conditions can significantly affect the flows that develop in a watershed in response to a rain event.

CaPA - The Canadian Precipitation Analysis, an Environment Canada product, is the data source for all precip-itation maps used in this report. CaPA combines different sources of information on precipitation into a sin-gle, near real-time analysis. Sources of information include surface monitoring stations, satellite and radar data, and atmospheric models. CaPA records for the Rainy River basin data back to 2003.

Colorado Low- A low pressure storm system that forms in winter in southeastern Colorado or northeastern New Mexico and tracks northeastward across the central plains of the U.S. over a period of several days, producing blizzards and hazardous winter weather.

Drainage Basin (Basin)– See Watershed.

Freshet—The period in spring when snowmelt contributes to rising flows in a watershed.

Headpond— The area of water directly upstream of a dam where water may be stored.

Hydraulic Head (Head)— In open channel hydraulics, a measure of the energy of water, given as the height of water above a certain elevation. In this report, the head at the outlets of Namakan Lake and Rainy Lake is directly related to the maximum outflow rate that can be achieved, the higher the lake level (head), the high-er the outflow capacity.

Inflow— In this report, inflow refers to the rate of water flowing into a lake. Inflows in the watershed are computed through a simple water balance equation, where known quantities are the change in volume of a lake over a specified time period and the outflow from the lake over the same period.

Median—In statistics, the middle value in a ranked group of values, the 50th percentile. May be different from the average, or mean, of the same group of values.

Normal— In this report, the normal range for a historical data set is considered to be data falling between the 25th and 75th percentile, representing the middle 50 % of historic data.

Outflow— In this report, outflow refers to the rate that water is released from a lake through a dam. Outflow is computed based on the hydraulic characteristics of the control structure and the elevation of the lake sur-face (head).

Percentile— In statistics, denotes the relative position of a value in a set of ranked values. A 75th percentile lake level or river flow is greater than 75 % of all other values recorded at the same time of year but is less than the remaining 25 %. A 25th percentile lake level or river flow is greater than 25% percent of all other values recorded at the same time of year, but less than the

remaining 75%. In this report, percentiles for water levels and flows are relative to values for a specific time of year recorded in the 30-year period from 1981-2010.
Percentiles indicate how often a particular lake level or flow has occurred historically. A 50th percentile value, known as median, indicates that values have been higher than this value 50 % of the time, and lower than this value 50 % of the time. In other words, values have historically been at or above the 50th percentile one year in every two, and lower than this value one year in every two. Similarly, for a 75th percentile lake level value, 75% of the time the values have been lower, and 25% of the time values have been higher. The 75th percentile was reached or exceeded one year in four, on average. A 90th percentile lake level has been reached or exceeded, on average, once every ten years, and a 95th percentile once every twenty years.
A 25th percentile value has been reached or exceeded 75% of the time. In other words, values at or *lower* than the 25th percentile have occurred, on average, once every four years while a 10th percentile or lower has been reached once every ten years.

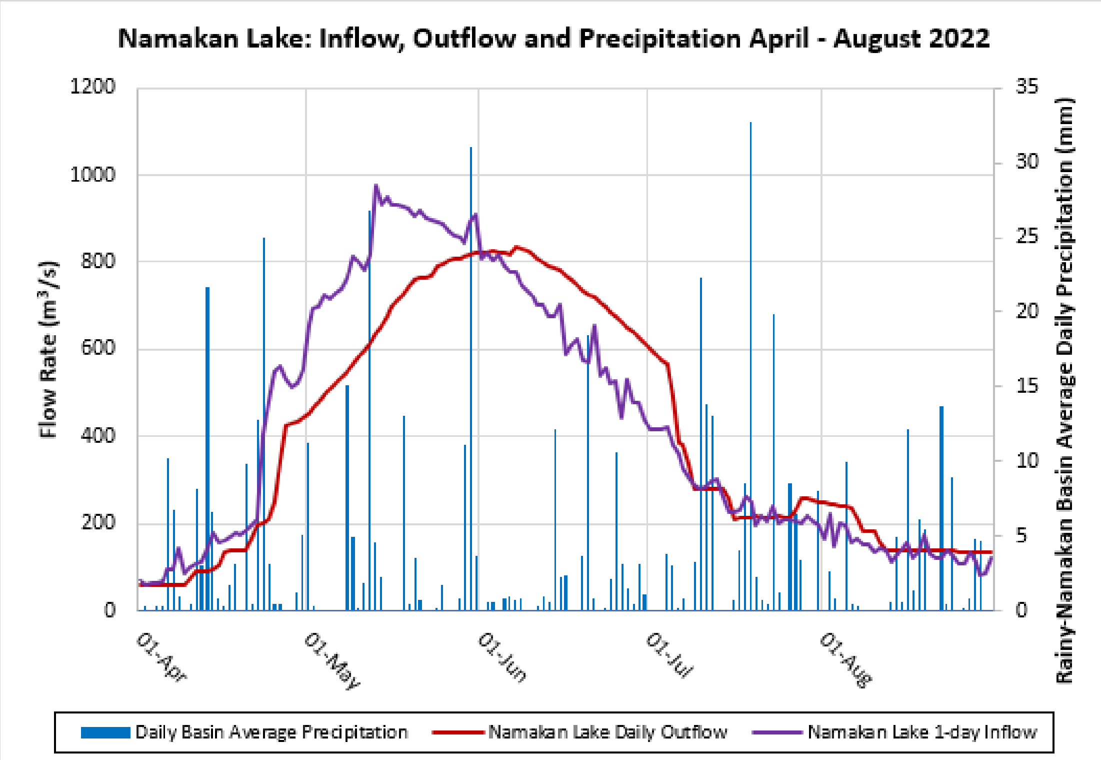
Snow Water Equivalent— The quantity of water contained in the snowpack. It can be thought of as the depth of water that would theoretically result if the snowpack were melted.

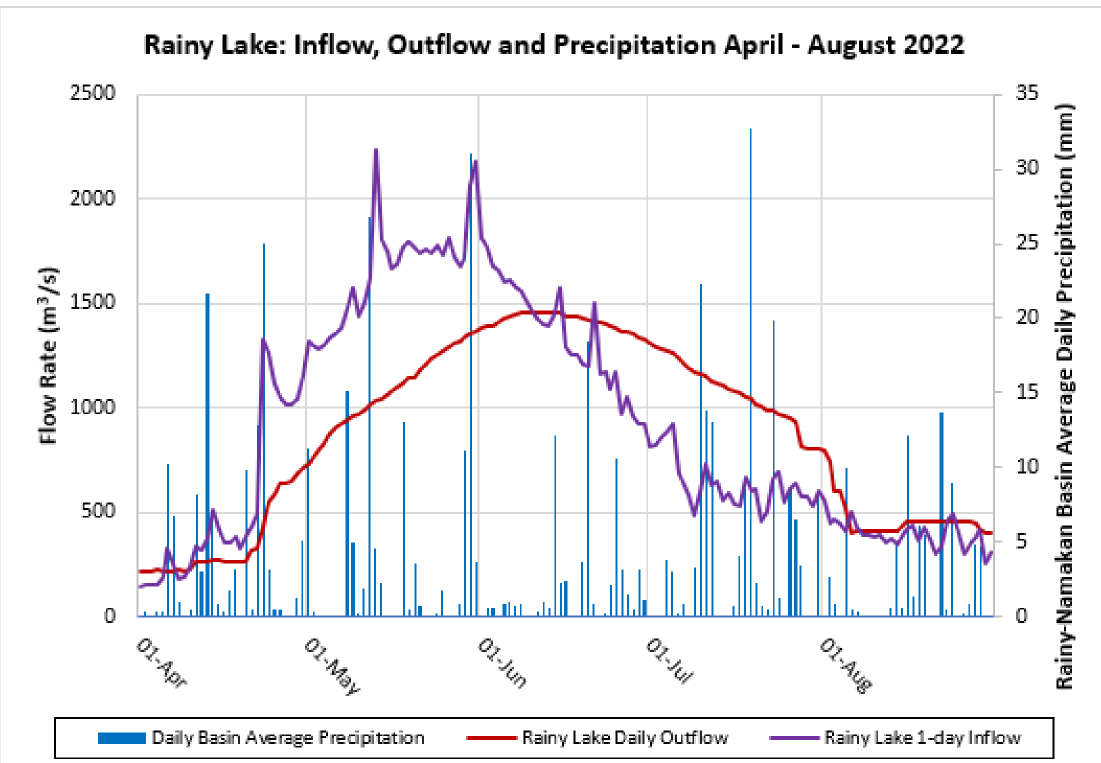
Tailwater– The waters immediately downstream from a dam.

Watershed - In hydrology, the extent of land from which water drains to a given location such as a lake or river.

Appendix D- 2022 Water Level and Flow Graphs

This appendix provides graphs of precipitation, water levels, and flows of key lakes and rivers in the Rainy River basin.





LEGEND - CURRENT DATA GRAPHS

PRECIPITATION

Actual data for year shown, plotted as quarter-month totals (last quarter-month is usually incomplete)

Average - over the years 1986-2015

WATER LEVELS & FLOWS

Actual Data

Actual data for the dates shown
- levels are 1-day means plotted daily
- inflows are 7-day means plotted daily
- outflows are daily values

The most recent data is missing if the actual data line does not extend to this vertical line (on 12-month plots only)

Rule Curves (Namakan & Rainy Lakes)

IJC Upper & Lower Rule Curves

IJC Drought Line

IJC Upper Emergency Level

IJC "All Gates Open" Level

Statistical Data

50 Maximum level/flow recorded and its year of occurrence

Level/flow has been above this line 10% of time.

or

Normal level/flow range
- level/flow has been above this range 25% of time
- level/flow has been within this range 50% of time
- level/flow has been below this range 25% of time

Level/flow has been below this line 10% of time

77 Minimum level/flow recorded and its year of occurrence

All statistical levels are based on 3-day means at month quarter points.

All statistical flows are based on quarter-monthly means.

In general, percent data is based on the period 1986-2015, while maximums and minimums are based on each site's period of record up to 2015. For further information on specific periods used for individual sites, please see the following page.

Datums for water levels are:
- Lake St Joseph - GSC (1923 preliminary) datum
- Lac Seul - GSC (1923 preliminary) datum
- Lac La Croix - USC&GS (1912) datum
- Namakan Lake - USC&GS (1912) datum
- Rainy Lake - USC&GS (1912) datum
- Lake of the Woods - Lake of the Woods datum
- Winnipeg River in Ontario - GSC (1923 Bulletin) datum
- Winnipeg River in Manitoba - GSC datum

Revised: 2020.09.15

LEGEND - CURRENT DATA GRAPHS

WATER LEVELS & FLOWS

Statistical Data

Percent data is based on the period 1986-2015, except for the following:
- Raft Lake Level 1984-2015
- Raft Lake Outflow 1984-2015
- Rainy River Level Below Fort Frances 1988-2015

All maximum/minimum level and flow statistics end in 2015. Start dates for individual sites are provided in the following table.

Site	Minimum	Maximum
Lake St Joseph Level	1958	1958
Lac Seul Level	1935	1935
Ear Falls Tailwater Level	1958	1958
Manitou Falls Forebay Level	1958	1958
Lac La Croix Level	1921	1921
Namakan Lake Level	1949	1912
Rainy Lake Level	1949	1911
Rainy River Fort Frances Tailwater Level	1988	1988
Rainy River Manitou Rapids Level	1928	1928
Lake of the Woods Level	1927	1927
Winnipeg River Level Below Norman Dam	1958	1950
Winnipeg River Level at Minaki Winnipeg	1958	1950
River Outflow at Slave Falls Winnipeg	1927	1927
River Level at Nutimik Lake Winnipeg	1958	1958
River Outflow at Seven Sisters	1958	1958

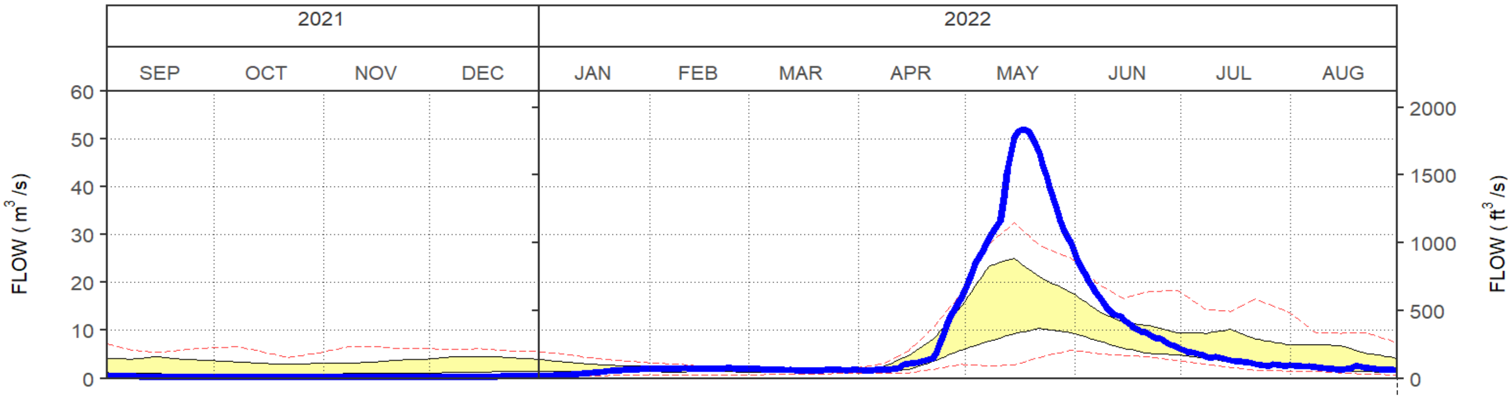
PRECIPITATION

Data Sources

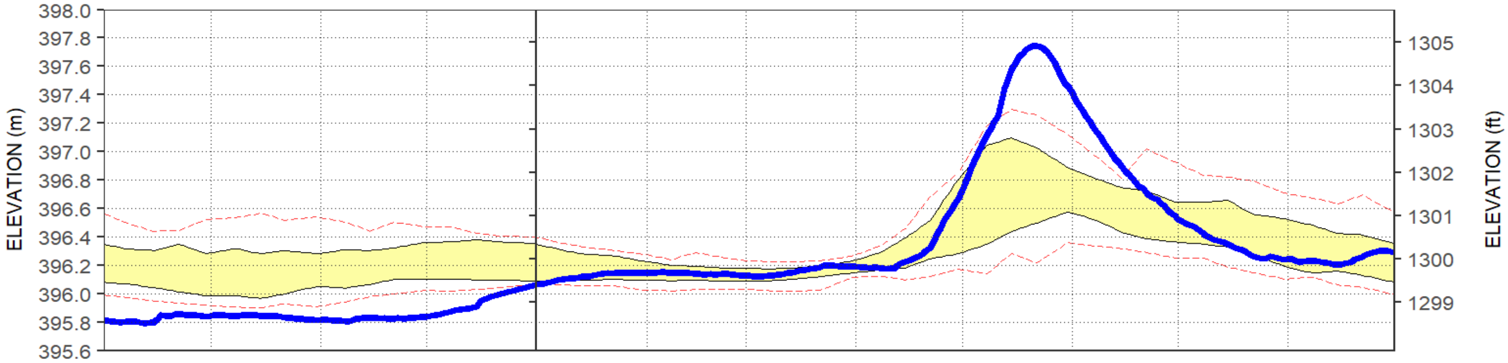
Precipitation data is from the Regional CaPA (Canadian Precipitation Analysis) Analysis of Environment and Climate Change Canada.

Precipitation averages are computed using station data from various sources as reported in the Database Report.

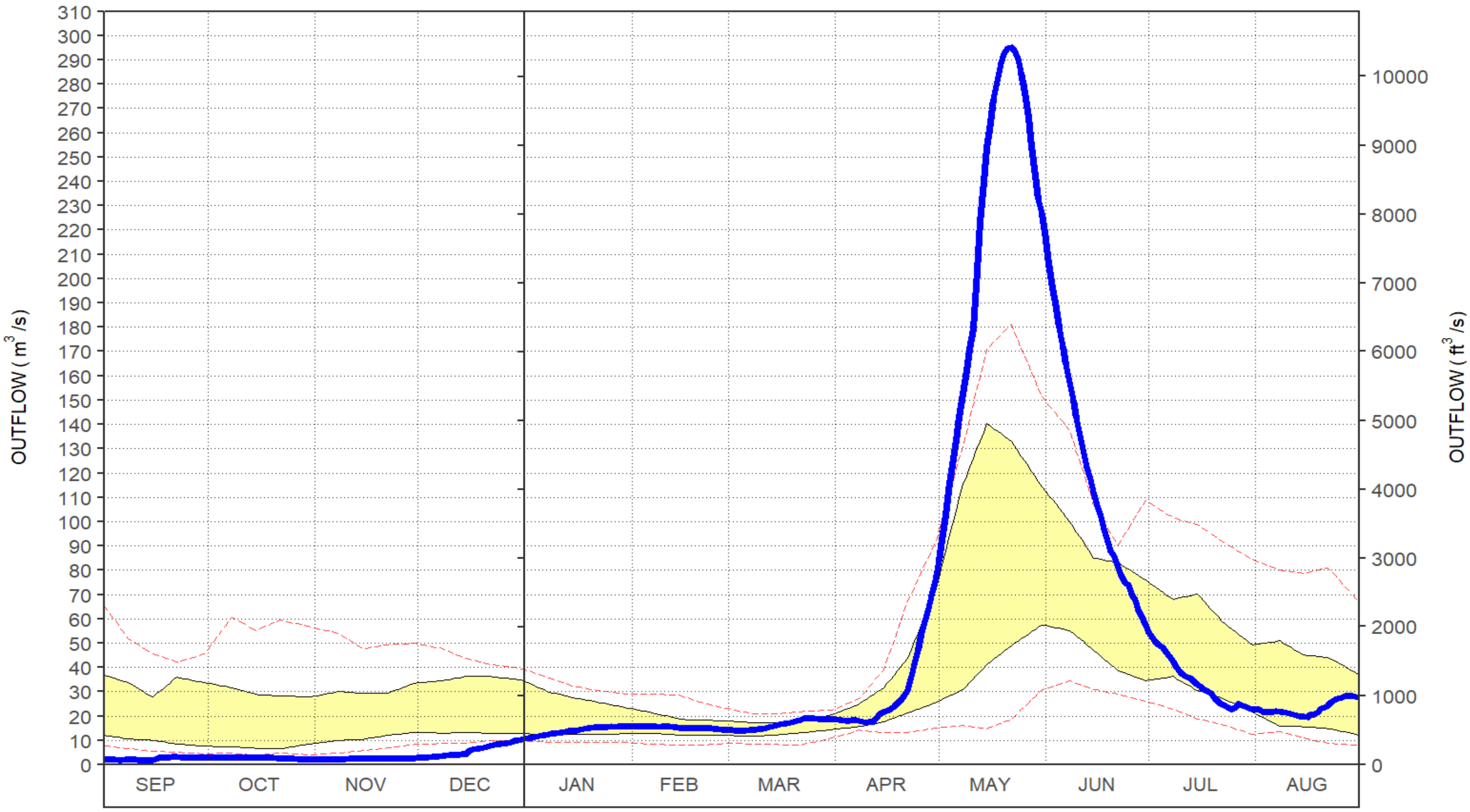
KAWISHIWI RIVER FLOW



BASSWOOD LAKE LEVEL



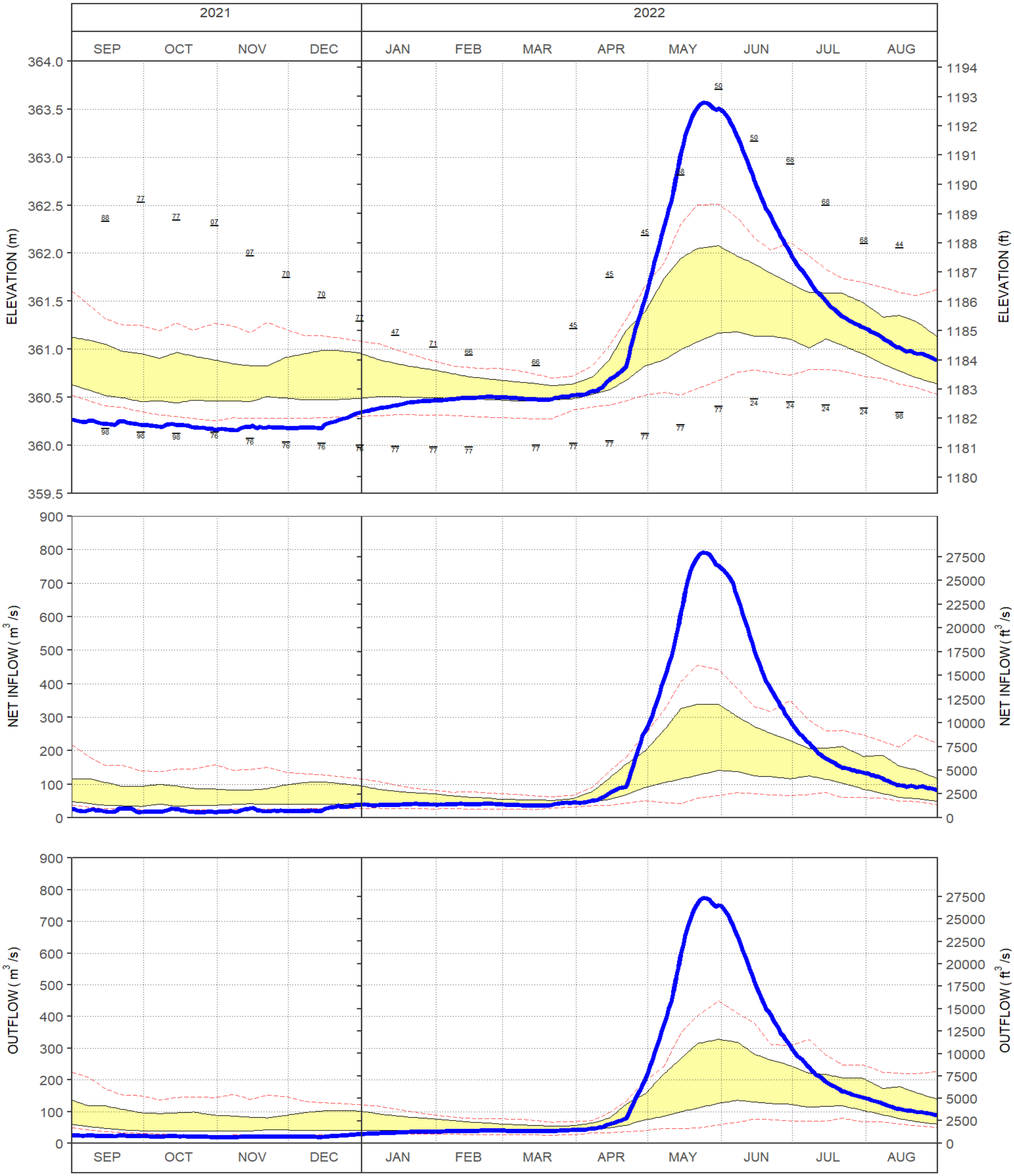
BASSWOOD LAKE OUTFLOW



LWCB
Lake of the Woods Control Board

ISSUED: 2022-08-31
Provisional Data

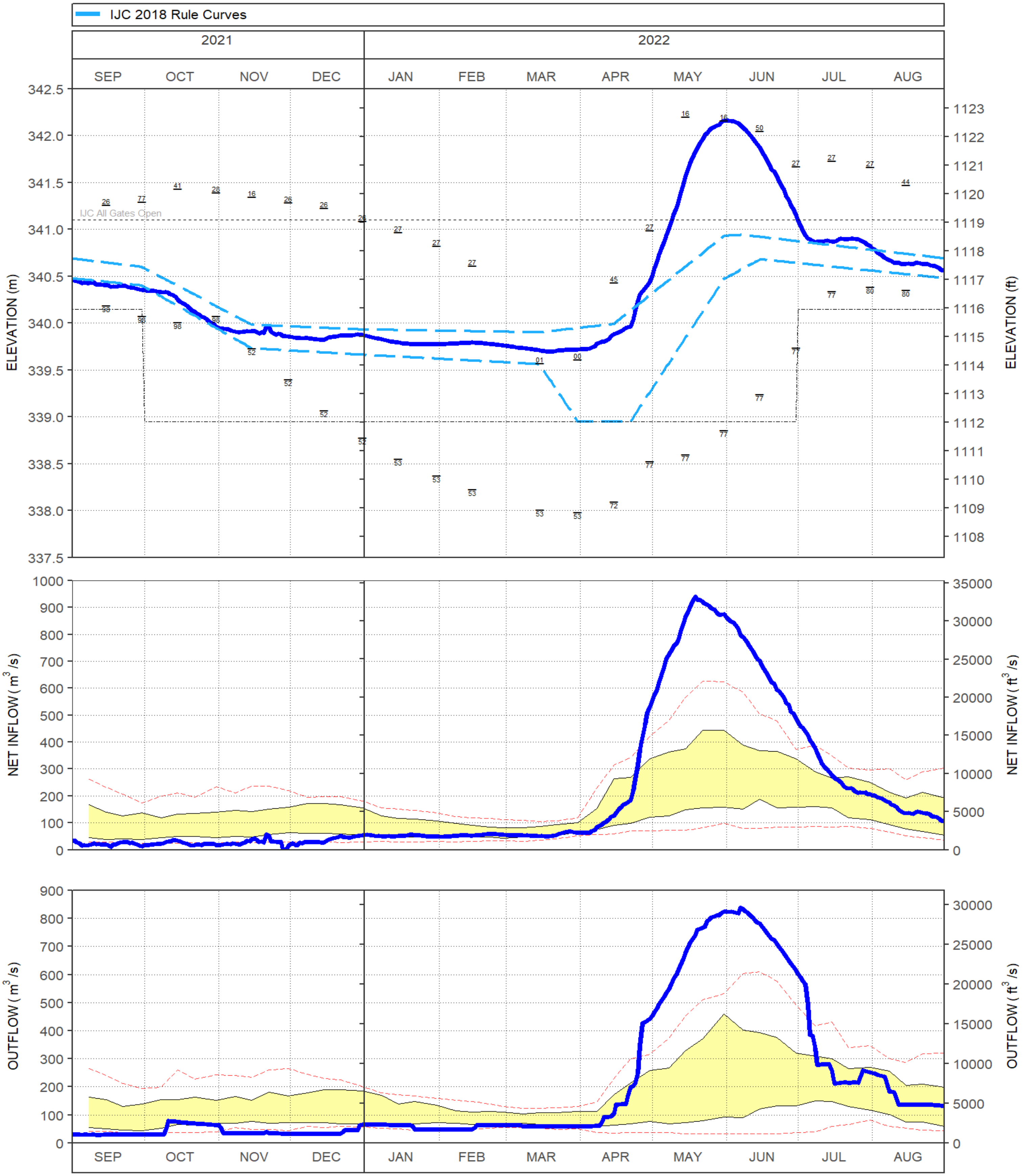
LAC LA CROIX

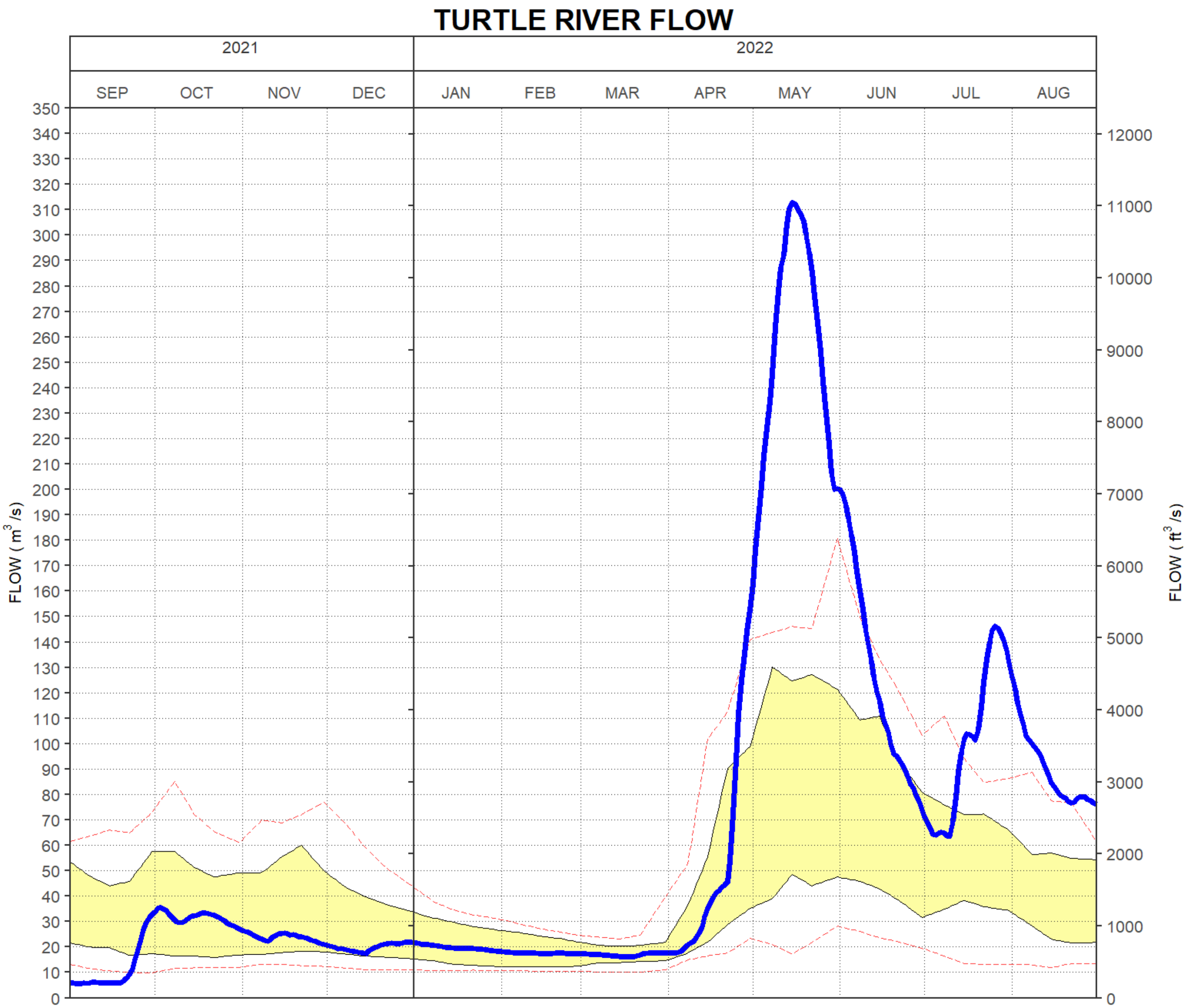


LWCB Lake of the Woods Control Board

ISSUED: 2022-08-31
Provisional Data

NAMAKAN LAKE

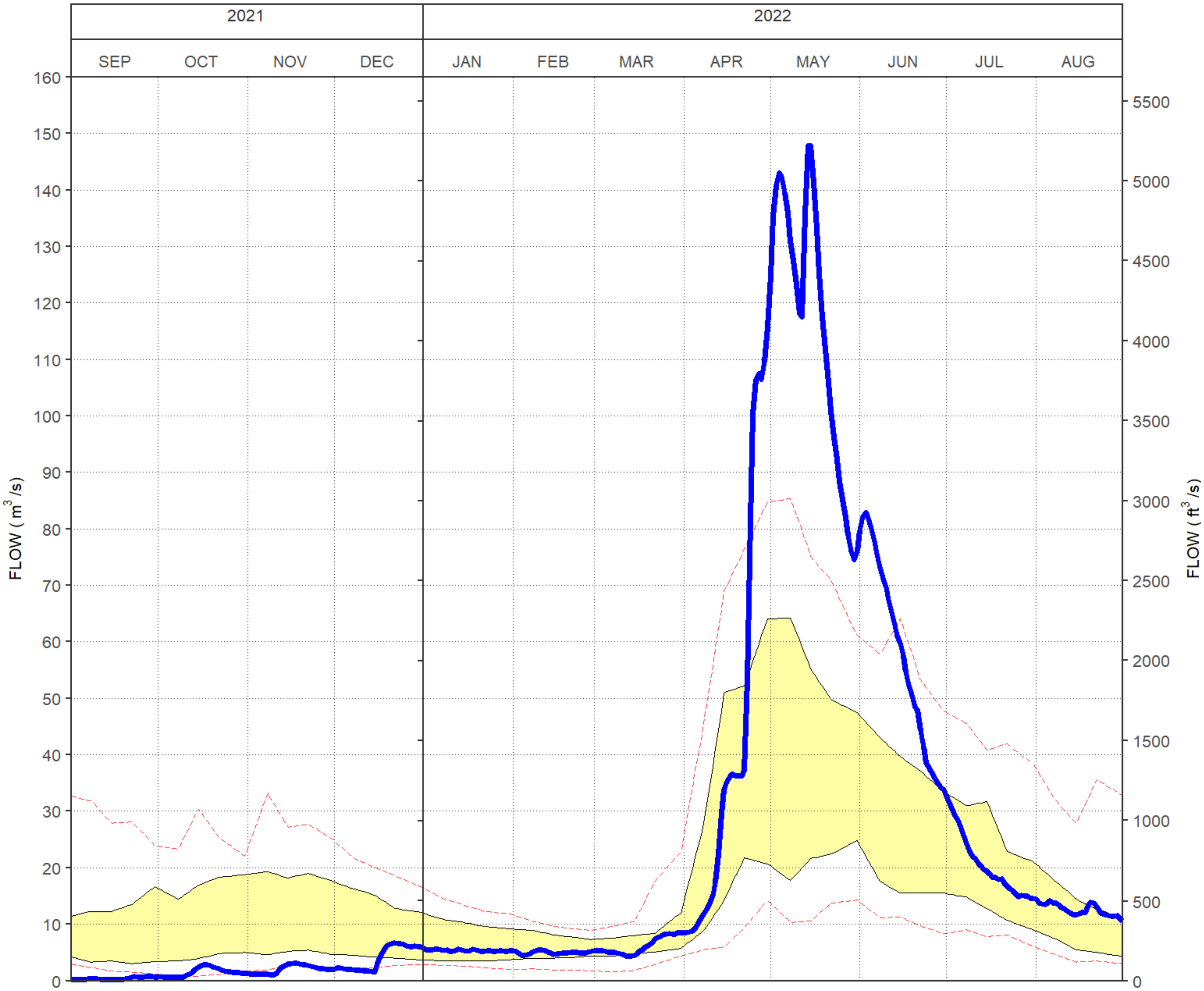



TURTLE RIVER FLOW
2021
2022
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
FLOW (m3/s)
FLOW (ft3/s)
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0

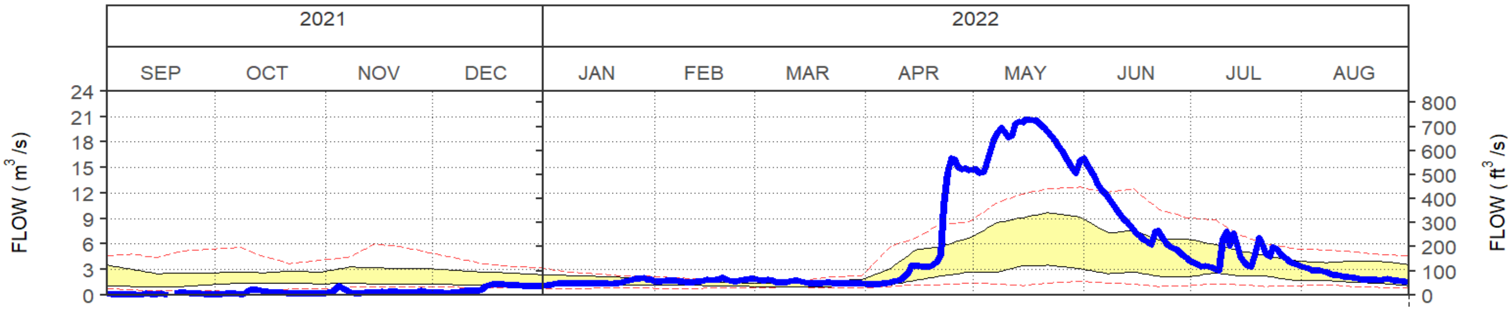
LWCB
Lake of the Woods
Control Board

ISSUED: 2022-08-31
Provisional Data

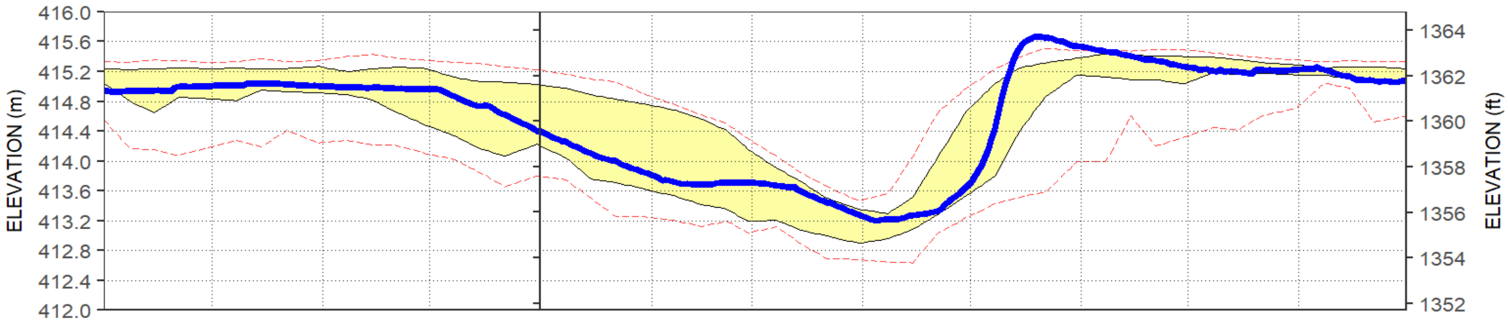
VERMILION RIVER FLOW



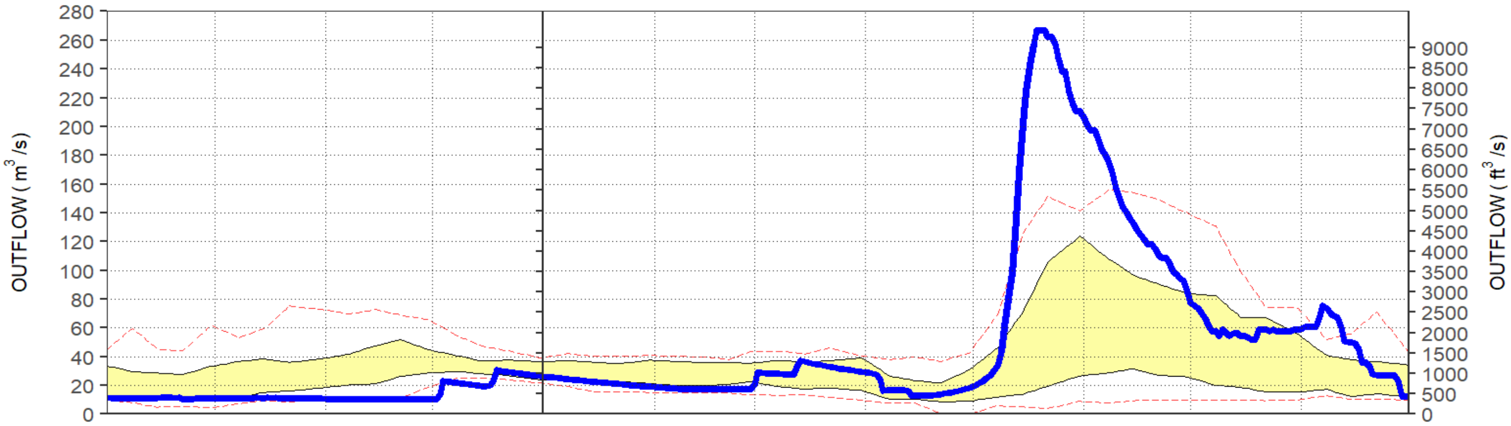
ATIKOKAN RIVER FLOW



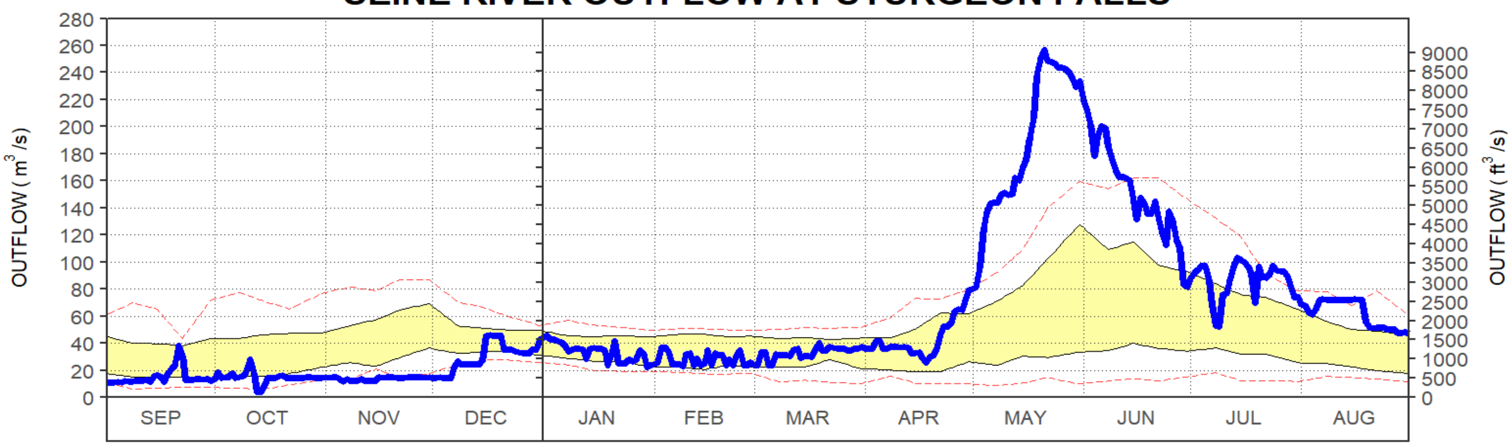
RAFT LAKE LEVEL



RAFT LAKE OUTFLOW

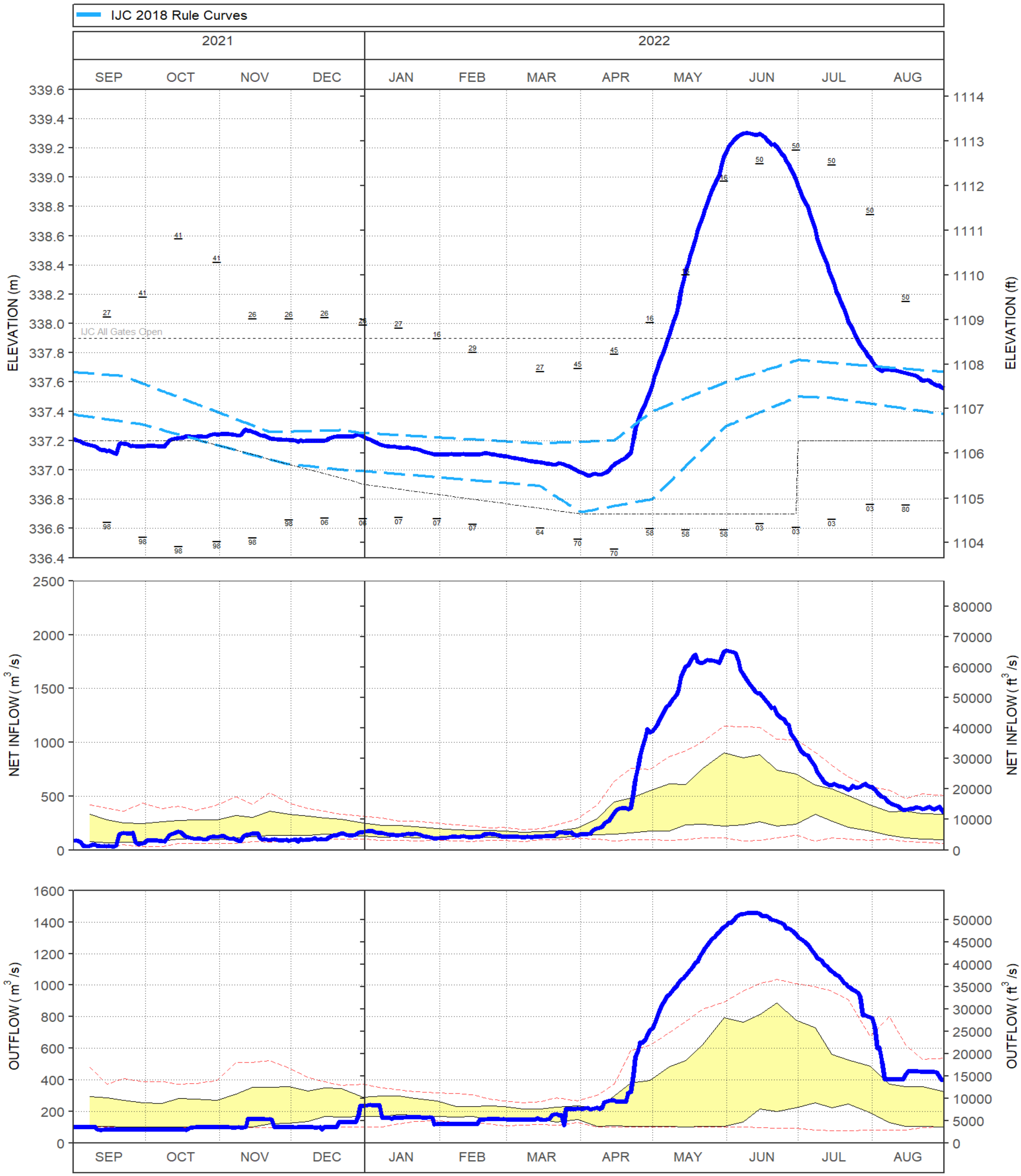


SEINE RIVER OUTFLOW AT STURGEON FALLS

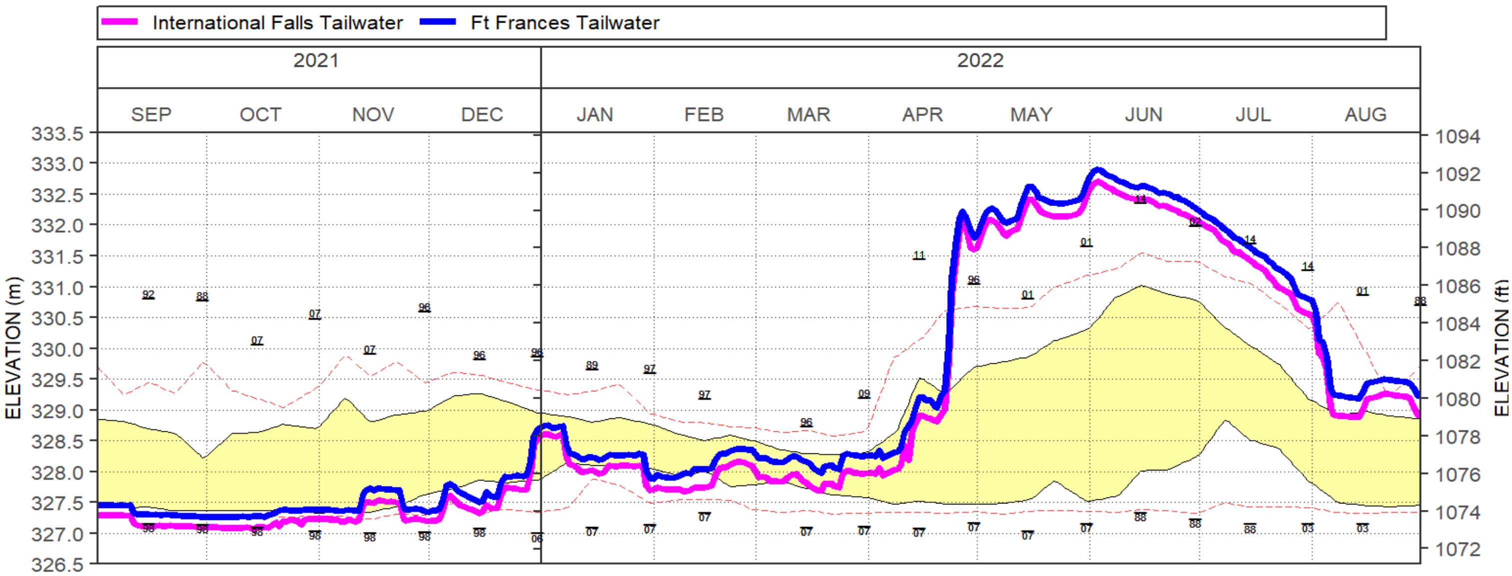


ISSUED: 2022-08-31
Provisional Data

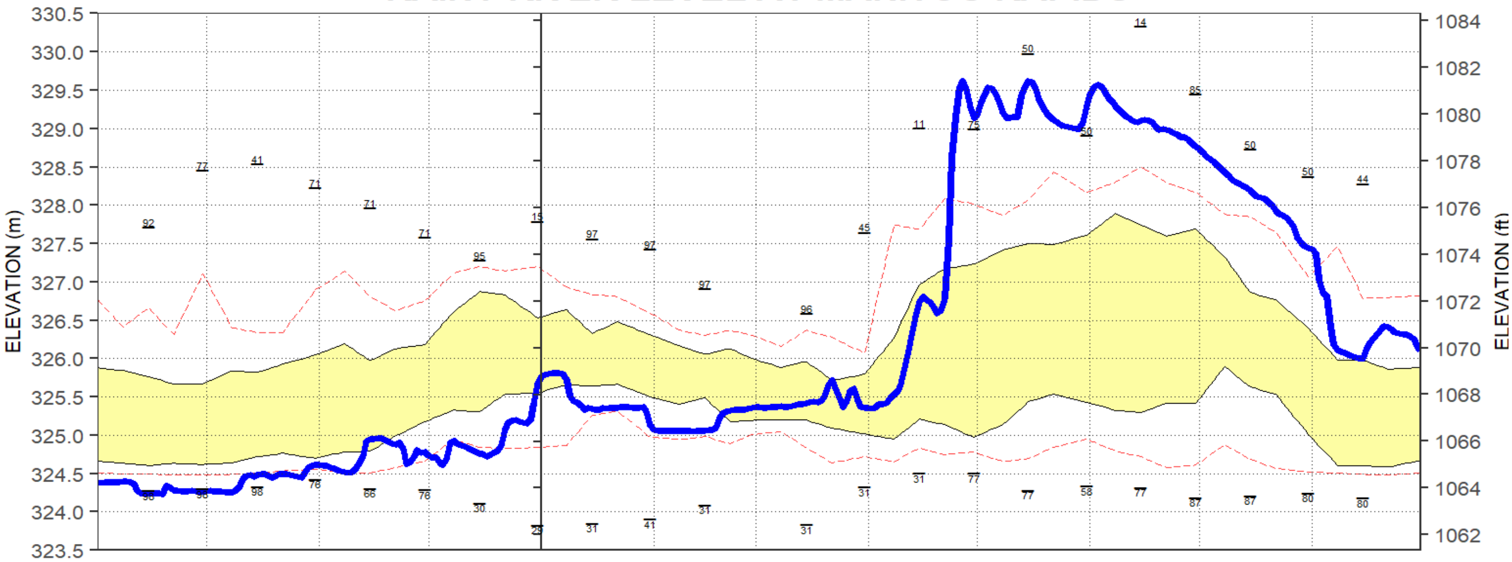
RAINY LAKE



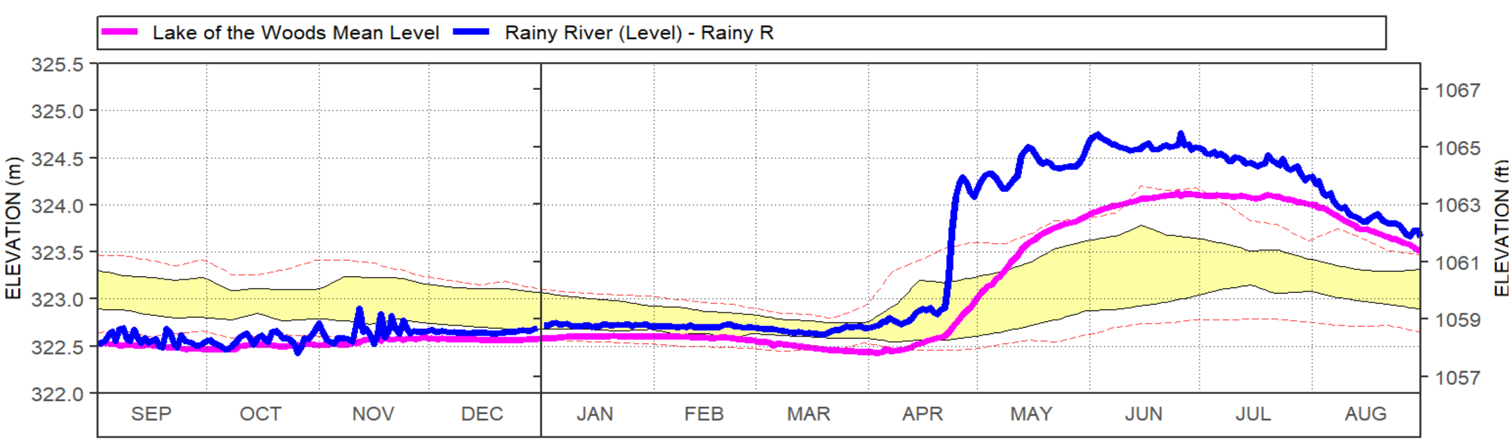
RAINY RIVER BELOW RAINY LAKE DAMS



RAINY RIVER LEVEL AT MANITOU RAPIDS



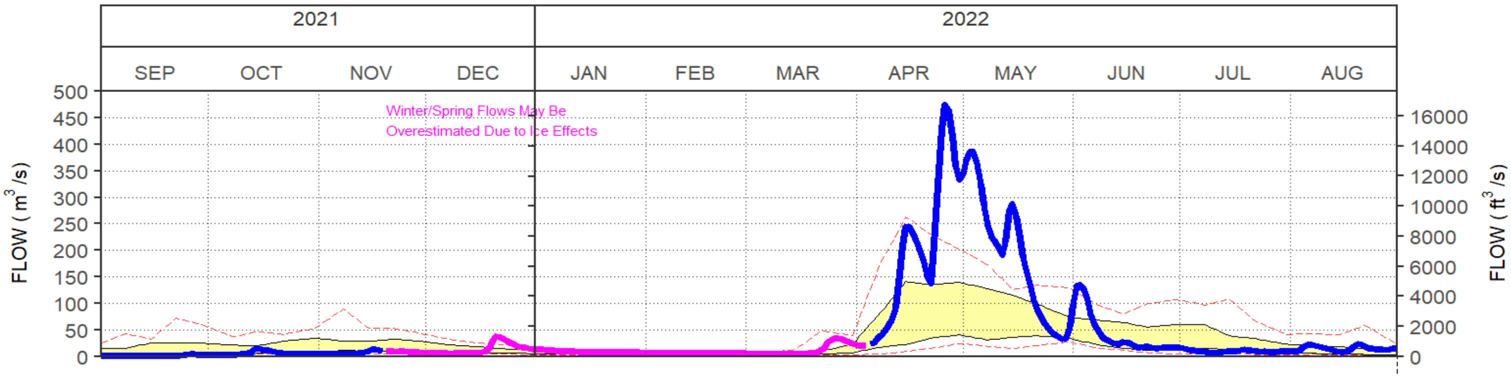
RAINY RIVER LEVEL AT TOWN OF RAINY RIVER



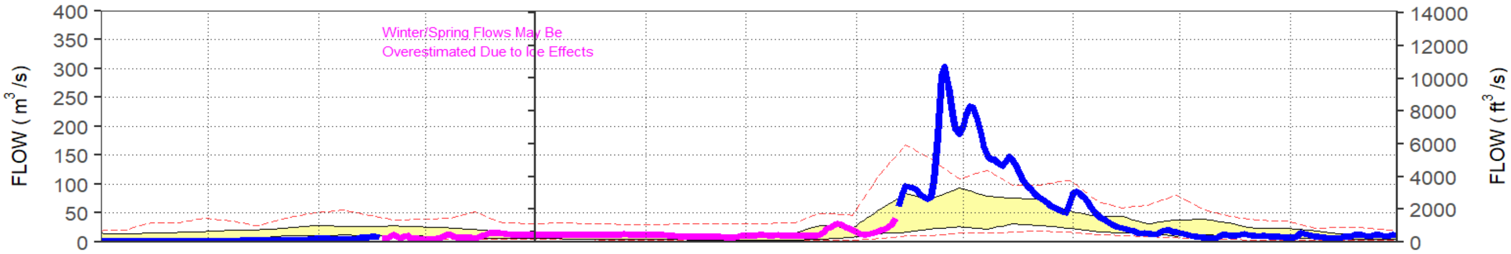
LWCB
Lake of the Woods
Control Board

ISSUED: 2022-08-31
Provisional Data

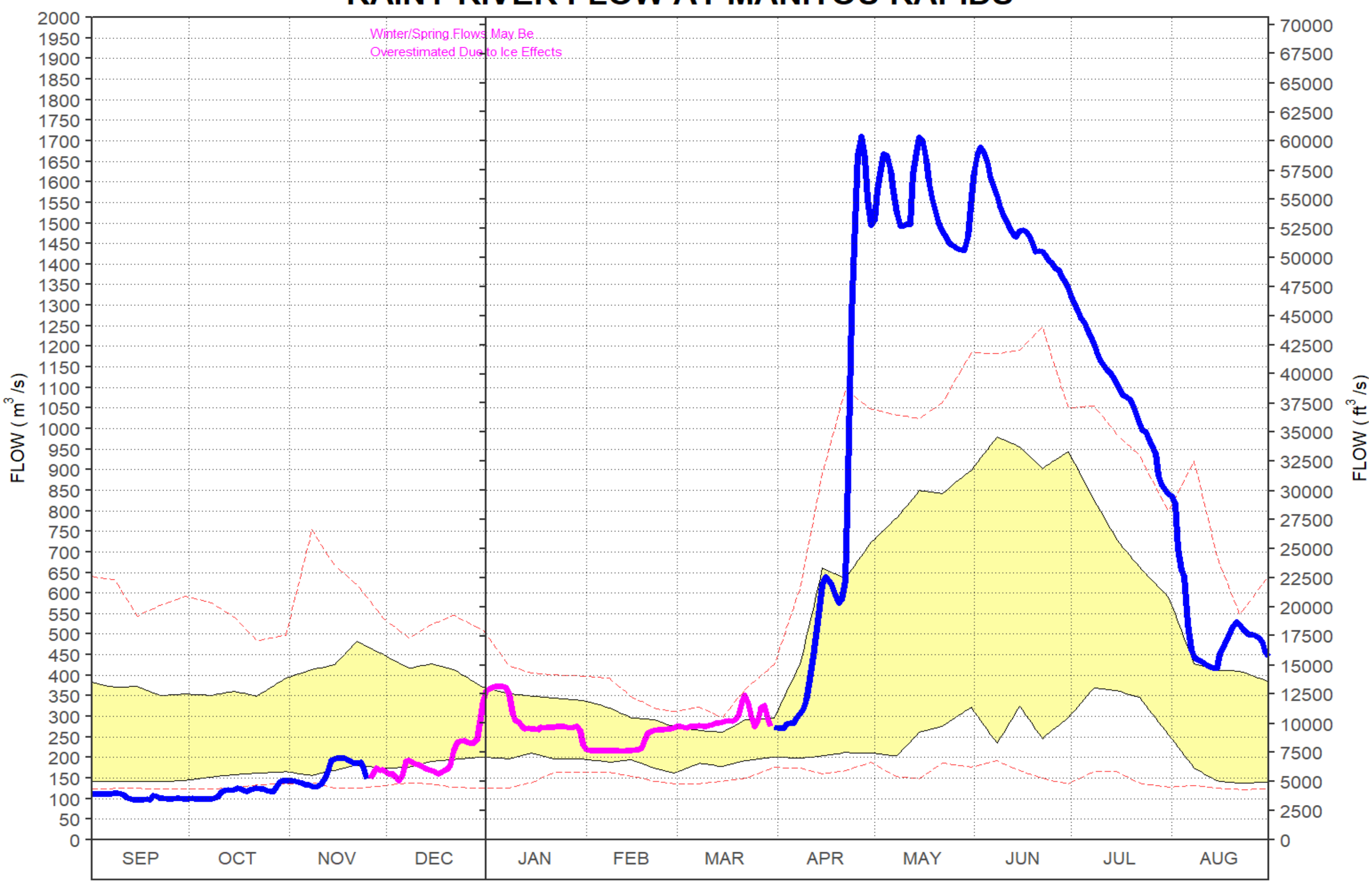
LITTLE FORK RIVER FLOW



BIG FORK RIVER FLOW



RAINY RIVER FLOW AT MANITOU RAPIDS



Key Roles and Responsibilities

Management of Water Levels in the Rainy-Lake of the Woods Watershed

Water Regulation and Control

Dam Operators: The day-to-day operations of the dams at International Falls-Fort Frances and Kettle Falls are directed by the owners: H2O Power (Canada) and Boise Paper (U.S.). Operators maintain water levels in the lakes within specific ranges, as defined by the IJC.

International Joint Commission (IJC): Independent, objective and binational body established by Canada and the U.S. The 1938 Rainy Lake Convention gave the IJC responsibilities to the control of water levels under emergency conditions. Since 1949, the IJC employed rule curves to regulate water levels, updating them to reflect current science and stakeholder benefits. The rule curves were last updated in 2018, following the release of the Rainy and Namakan-Lakes Rule Curve review report of 2017.

Lake of the Woods Control Board (LWCB): Manages levels of the Lake of the Woods, between lower and upper elevations set by the Canada-U.S. *1925 Lake of the Woods Convention and Protocol*. Staff engineers with the LWCB are also members of the Water Levels Committee of the International Rainy-Lake of the Woods Watershed Board.

International Rainy-Lake of the Woods Watershed Board (IRLWWB): Formed by the IJC to assist with binational coordination of watershed management, its members include federal, provincial, state, municipal and Indigenous representatives. Its activities are supported by an Industry Advisory Group, a Community Advisory Group, and four committees, including:

Water Levels Committee (WLC): monitors hydrologic conditions and may provide dam operators with directions for the operation of their discharge facilities to ensure that the rule curves are followed. The WLC regularly hosts public engagement activities to help share information on basin conditions and seasonal forecasts, and solicit public input prior to making rule curve decisions.

Adaptive Management Committee: established in 2020 to monitor whether the latest rule curves perform as expected.

International Lake of the Woods Control Board (ILWCB): Approves the actions of the Lake of the Woods Control Board when the level of Lake of the Woods falls below or rises above prescribed extremes.

U.S. Army Corps of Engineers St. Paul District and Environment and Climate Change Canada officials serve as co-chairs of the IRLWWB, its WLC, and the ILWCB.

The Lake of the Woods, which straddles Minnesota, Manitoba and Ontario. Credit: J. Stephen Conn

Data Collection and Forecasting

Decision-making

The Boards make decisions based on all available facts and the latest forecasts, and in direct communication with government agencies and other knowledge holders. Decisions are informed by, among other sources:

- Regular public engagement activities, including pre-spring webinars
- Meteorological forecasts produced by the:
  - Meteorological Service of Canada
  - U.S. National Weather Service
  - Ontario Ministry of Natural Resources and Forestry
- Hydrological measurements taken by the Water Survey of Canada and the U.S. Geological Survey
- Snow surveys produced by the U.S. Army Corps of Engineers St. Paul District

Latest flood forecasts and guidance

- Ontario Ministry of Natural Resources and Forestry, Flood Forecasting and Warning Program
- U.S. National Weather Service Rainy River Basin

Other sources of information on water levels

- ILWCB updates on water level decisions and data for the Rainy and Namakan lakes.
- Lake of the Woods Control Board:
  - Basin Data page: latest information on water level and flow conditions in the basin.
  - Level forecasts for Lake of the Woods, Lac Seul and the Winnipeg River in Ontario are issued Monday, Wednesday, and Friday on its Notice Board.
- Hydrometric data for the Canadian portion: Water Survey of Canada
- U.S. Geological Survey National Water Dashboard: real-time streamflow information for the U.S. portion.
- U.S. National Weather Service: water level information and forecasts for the United States portion
- Minnesota Department of Natural Resources: monthly hydrologic conditions reports and water level information for its sub-basins.

Appendix F- 2022 Rainy-Lake of the Woods Flooding Frequently Asked Questions

Q: Why did the flooding occur in the spring and summer of 2022 and how severe is it?

A: The Rainy River basin is one area of a much larger region that has seen record or near-record flooding this spring. This area extends to the north (English River basin and beyond) and west (Red River and other regions of Manitoba). The high-water conditions have followed well above-normal precipitation across the region nearly every week from the last two weeks of March through the end of May.

Total April 1-May 31 Precipitation by Sub-Watershed Region										
Rank	Lac Seul		English River		Rainy-Namakan		Lake of the Woods		Winnipeg River, Ontario	
	Year	Precip (mm)	Year	Precip (mm)	Year	Precip (mm)	Year	Precip (mm)	Year	Precip (mm)
1	2022	248	2022	274	2001	261	2022	272	2022	282
2	2001	222	1985	195	2022	257	2001	233	2001	192
3	1985	206	1974	184	1985	204	1985	213	2010	181
4	2012	191	2005	182	1974	200	1999	211	1998	179
5	2004	191	2014	181	1938	197	1937	198	1999	172
MEDIAN	142 mm		128 mm		127 mm		122 mm		121 mm	
Years of Record	109		120		117		120		119	

This precipitation fell largely as snow until late April, adding to the winter's accumulated snowpack. A series of Colorado Lows brought widespread, heavy rainfall, causing a rain-on-snow melt period over frozen ground from late April through much of May. The rapid runoff of the rain and snowmelt led to record flows in many tributary rivers including all major tributaries to Rainy Lake and Namakan Chain of Lakes. The total inflow to the Namakan Chain of Lakes and Rainy Lake set records for the April-May period, far exceeding the outflow capacity of the dams at either lake outlet. This also occurred at natural (undammed) lakes in the watershed, such as Lac La Croix.

These record flows resulted in an extended period of uncontrolled lake level rise for both the Namakan Chain of Lakes and Rainy Lake despite the dams being fully opened by the dam operators well before the lakes rose above the IJC's "All

Gates Open” level. For Namakan Lake, the level has risen to the highest point since 1916, just shy of the record set in that year. For Rainy Lake, a new record was set, 7 cm (2 ¾ in) higher than the previous 1950 record.

The resulting flooding has caused widespread damage to communities, homes, businesses, and natural shorelines. First Nations, municipalities, and counties around Rainy Lake and the Namakan Chain of Lakes declared states of emergency. States of emergency have also been declared for other communities in the Rainy River watershed that border other water bodies due to the flooding (e.g. Seine River, Lac La Croix, Rainy River). Beyond the Rainy River, states of emergency were declared in locations as widespread as Sioux Lookout and in the Whiteshell region of Manitoba. Evacuations took place in the Whiteshell and at Grassy Narrows First Nation on the English River. This event was a wide-ranging natural disaster. Unlike other natural disasters such as earthquakes and tornadoes, this one is caused by multiple weather events, as week after week of above normal precipitation fell through April and May, filling all available storage space and flooding water bodies across the region.

Flood mitigation efforts such as sandbagging have been extensive across the Winnipeg River basin in an effort to protect critical infrastructure, homes and businesses with thousands of hours of volunteer effort.

The Canadian Lake of the Woods Control Board produced a webinar on May 10 that describes in greater detail how basin conditions led to spring flooding across the larger Winnipeg River basin this spring.

Q: Why did the Water Levels Committee decide in March to follow the standard rule curve and not use the High Flood Risk Curve?

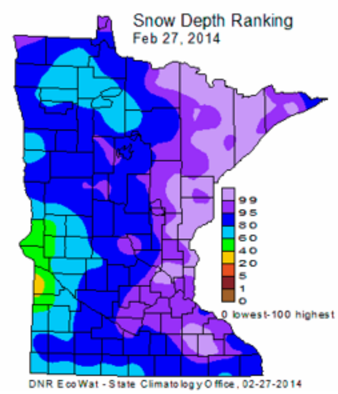
A: Based on the data available at the time, the Water Levels Committee concluded that there was not a *high risk* for flooding in the spring. In making the decision, the Water Levels Committee considered the following information:

Current Conditions at the time of the decision:

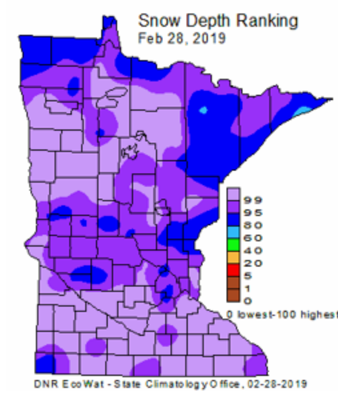
1. The current drought status for the basin ranged from abnormally dry in portions of Canada to moderate to severe drought in the U.S. Drought conditions indicate capacity in the basin to absorb precipitation and reduce runoff.
2. Base flow conditions were in the low to normal range for this time of year, consistent with the drought status. The tributary flows are the best indicator of the basin hydrology and capacity to absorb spring runoff. They did not indicate a lack of capacity in the watershed and therefore did not indicate a high risk for flooding heading into the spring.
3. Overall average winter temperatures were colder than recent years, but warmer than 2014 when spring flooding last occurred in the basin. Colder temperatures accumulated over the winter indicate a delay in ground thawing is possible and therefore an increased risk of rain-on-snow runoff.
4. The accumulated snowpack *depth* at the time of the decision was higher than normal, falling in the 80 to 95 percentile range based on historic records. Snowpack was much less than in 2014 and comparable to 2019 when normal spring flows developed. However, according to the National Weather Service, the water contained in the snowpack, the Snow Water Equivalent, was moderate, generally between 3-5 inches of water. This was less than in 2019 and much less than in 2011, 2013, or 2014 (there was no high water in 2011, or 2019, while in 2013 Rainy Lake rose slightly above the All Gates Open level and 2014 was the highest level since 1950).

Winter To Date

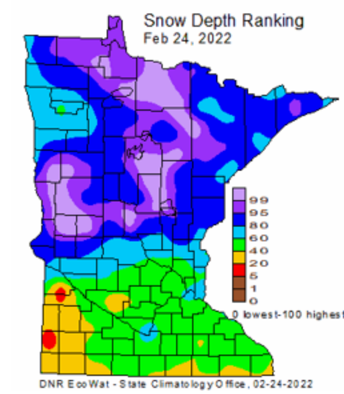
Snowpack Depth Ranking in Minnesota



2014

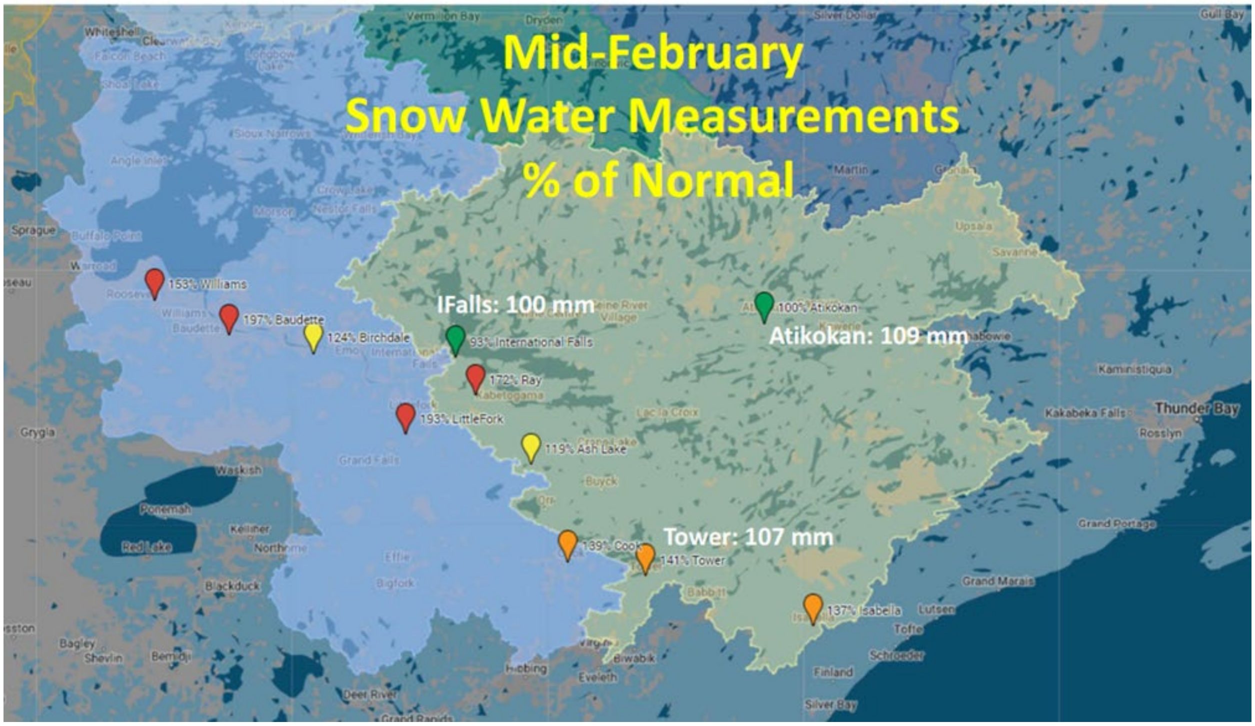


2019



2022

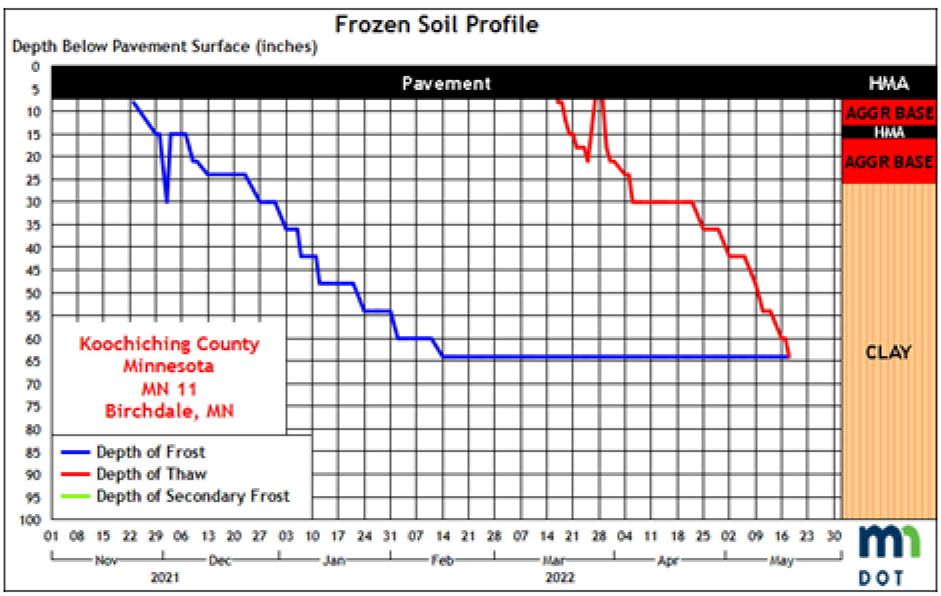
- *On-the-ground measurements of the snowpack water content were conducted at locations across the Rainy River watershed in late February by the US Army Corps. Of Engineers. Measurements indicated higher than normal snow water equivalent in general, with the highest amounts to the west of Rainy Lake in the local Rainy River watershed. The measurement at International Falls was slightly below the median while slightly above at Ash Lake. Compared to the measurements taken in 2014, values were generally less in 2022 (65% of the 2014 value at Tower, 78% at Cook, 72% at Ash Lake and 69% at Birchdale). The measurement at Ray, MN indicated higher snow water content in 2022 compared to 2014.*

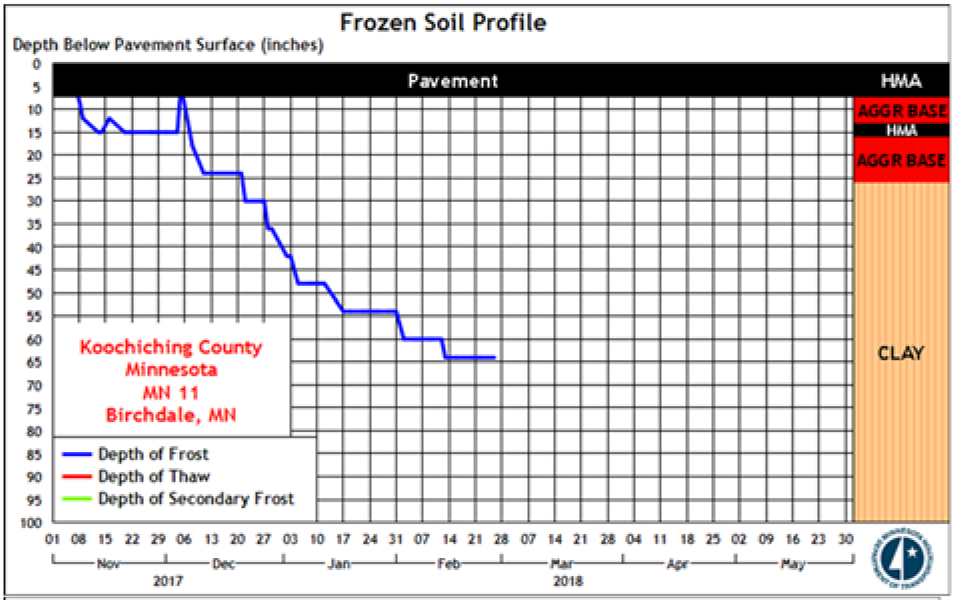


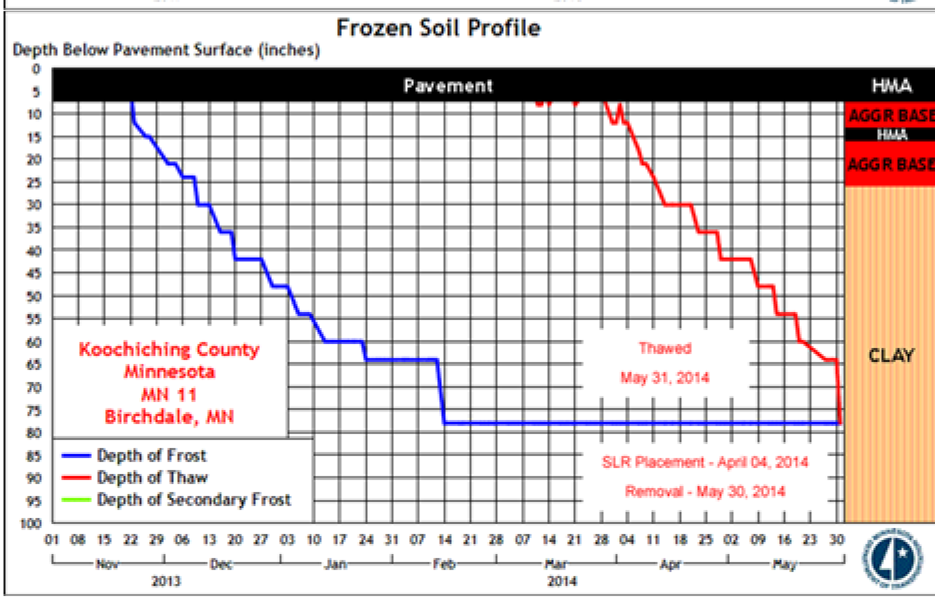
- *A SWE measurement by Ontario Power Generation at Atikokan on February 15 was 100% of normal, while on March 1 it was 146% of normal (falling to 131% by March 15).*

- According to the Accumulated Winter Severity Index provided by the Midwestern Regional Climate Center, the winter began as average then progressed to the severe range by the middle of February when measured by the accumulated snow and severity of cold weather. The severity of the winter was much less than in 2014, and was comparable to recent years that had no high water issues in spring.
- The degree of cold of the winter was evaluated by looking at the accumulated Heating Degree Days for International Falls. This measurement provides an all-season estimate of the temperature as an indicator of likely ground frost penetration. In general, the colder the winter, the greater the frost depth, although early snowpack accumulation can provide some insulating effect. The accumulated Heating Degree Days to the end of February indicated that this winter was colder than normal, but much warmer than in 2014.

Frost depth measured at Birchdale was 64 inches, the same as in 2018 and much less than the 78 inches in 2014.







Q: What forecast information was available at the time:

- A: There was a La Niña pattern in place in the fall and winter. Recent projections of the El Niño–Southern Oscillation (ENSO) in the Pacific Ocean by NOAA showed a 77% chance to continue as La Niña in the Northern Hemisphere this spring (March-May 2022) and then a 56% chance of a transition to ENSO-neutral by May-July 2022.
- Historic data since 1970 show that high water years occur most often when La Niña conditions are present and are less likely during neutral conditions.

- The NOAA long-term forecasts of temperature showed a 33-40% chance of above normal temperatures through March, April, and May.
- The NOAA long-term forecast of precipitation showed equal probabilities of low, normal, or above normal precipitation through March, April, and May.
- Temperatures were expected to fall well below freezing at night during the extended forecast.

Q: What was the feedback from basin interests:

A: Feedback from basin interests is consistent with the information provided by the Water Levels Committee at the pre-spring engagement.

- Ice thickness on the lakes this winter was in the normal range. Early snowpack insulated ice from the colder than normal temperature.
- The snowpack was greater than 2021, but significantly less than in 2014 (extreme event).
- Water level conditions have been low in recent years and refilling the lake (i.e. not holding the lake 20 cm lower) would be beneficial from a fisheries perspective.

Following the pre-spring engagement, the Rainy Lake Property Owners Association wrote to the WLC with the following points:

1. Temperatures are expected to remain well below freezing at night during the extended forecast. This may potentially push the ice-out date into mid-May creating the potential for freshet and spring rains to enter the basin at the same time.

2. It is reported the lakes have as much as 32 inches of ice at this time.

3. Area forestry experts have indicated that higher than normal precipitation rates follow a drought year.

4. Basin wide combination of rain and heavy wet snow (according to the national weather service 6 in of water) in early November has been held up in the bush and will enter the water shed this spring.

The WLC reviewed the feedback provided by RLPOA with the following assessments:

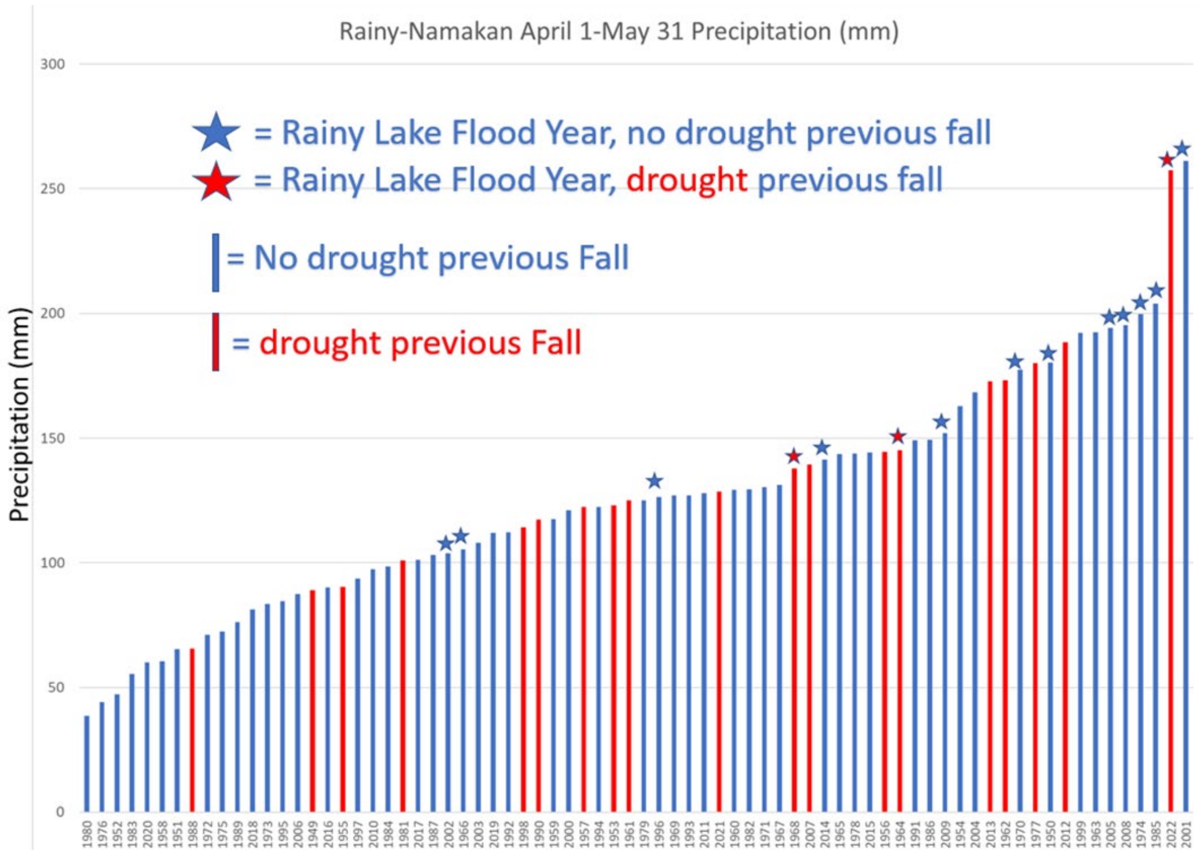
1. The ice out date is not hydrologically relevant to the freshet response. The ice and the snow on top of the lake are already indicated in the lake level measurements. The frost depth, however, is relevant in the event of a rain

on snow condition and late ice-out is an indirect indicator of basin temperature and ground conditions. The long-term forecast from NOAA indicated a slightly higher chance of warmer spring temperatures. While not known at the time of the decision on the High Flood Risk Rule Curve, the average March temperature for the Rainy Lake area in 2022 was 21.1 F, slightly warmer than the median of 20.8 F for 128 years of record, and much warmer than the 13.5 F recorded in 2014. April, however, was much colder than normal, the 13th coldest on record for the area, with an average temperature of 33 F. Data source: https://arcgis.dnr.state.mn.us/ewr/climatetrends/

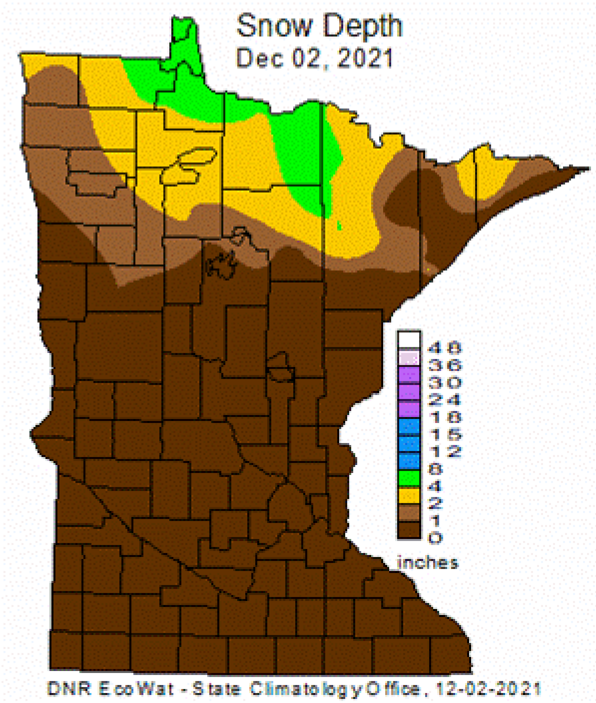
2. Ice thickness is also not hydrologically relevant to freshet response other than as an indirect indicator of basin temperature and frost depth. Accumulated temperature data are more useful for this purpose. The WLC understood that the winter was colder than normal, but not nearly as severe as 2014.

3. The WLC reviewed historical precipitation data following drought years to evaluate whether a trend exists. It confirmed there is a slight skew towards wetter springs following a drought the previous fall (see graph below). However, of the fourteen flood years for Rainy Lake since regulation began in 1949, only two followed droughts the previous fall, whereas seven followed wet conditions the previous fall. This makes sense hydrologically as there is more room in the watershed to absorb runoff after the ground thaws if the underlying watershed is dry, and less if wet.

4. Area-weighted average precipitation across the Rainy-Namakan local watershed in November 2021 was 47 mm (1.9 in) based on the Canadian Precipitation Analysis (CaPA) data. The total for the US-portion of the Rainy Lake watershed was 52.8 mm (2.08 in) according to the National Weather Service (link: https://arcgis.dnr.state.mn.us/ewr/climatetrends/). Total precipitation measured at International Falls airport in November was 45.7 mm (1.8 in).



There was approximately 6 inches of snowpack accumulation by the end of November in the area around Rainy Lake, which is not equivalent to 6 inches of water.



Hydrologically, water is always moving through the system and does not get "held up" in the bush to be released later unless it is accumulated as snowpack. Most of the month's precipitation occurred on November 11 and 12 when temperatures were near the freezing mark. According to the National Weather Service data, between a trace and an inch of accumulated snow water equivalent followed this precipitation, much of it entered the system as runoff. The response to this can be seen in the hydrographs of the area tributaries. This precipitation did not significantly alter the flows in the basin, but it did result in some drought category improvement.

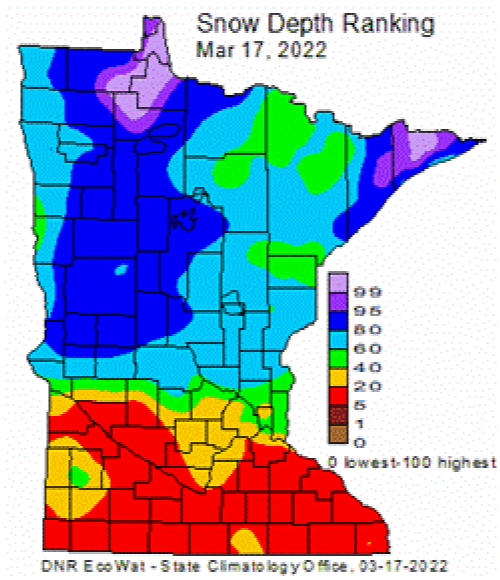
In summary, at the Pre-Spring Engagement web meeting, the Water Levels Committee summarized the factors that contribute to spring flood risk and the situation in 2022 compared to 2014.

1. High base flows across the watershed – the flows across the watershed were on the low end of the normal range following the extended drought period. Base flows did not point to a higher flood risk in 2022.
2. High water content in the snowpack – the snow water content based on National Weather Service modeled data and on-the-ground measurements was above normal but moderate, less than other recent years that did not have flooding, and much less in most locations than in 2014.

3. Frozen Ground – Accumulated temperature by the end of February was colder than normal, but not close to the cold of 2014 and indicated some increased risk of delayed ground thaw.

Taken together, the Water Levels Committee evaluated that the balance of these risk factors indicated some risk of above normal spring flow conditions, but not a *high risk* of flooding or of exceptionally high or record inflows in the spring. The Water Levels Committee emphasized that the last of the risk factors for spring flooding on Rainy Lake is the *timing and amount of spring rainfall*. This cannot be estimated in advance and would prove to be the critical ingredient in the record inflows of the spring.

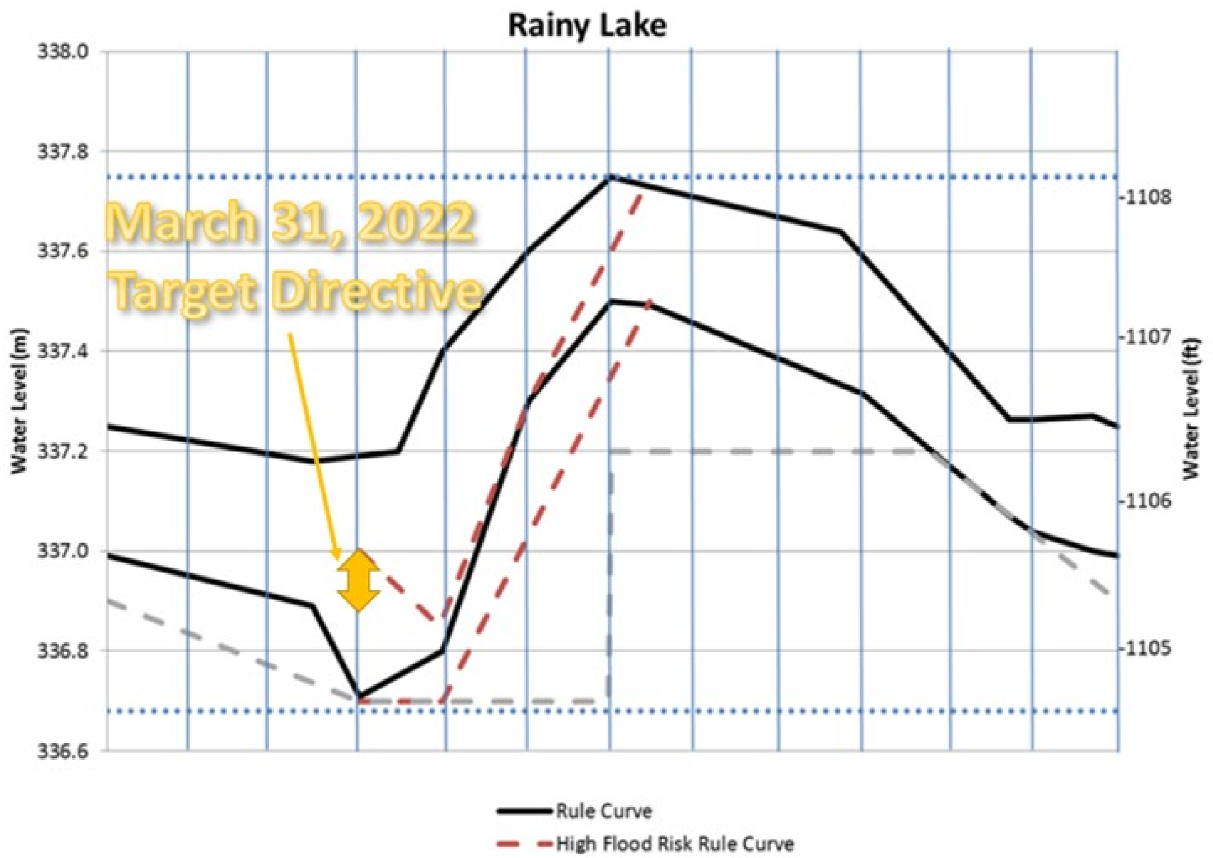
Q: Why didn't the Water Levels Committee lower the lake later in March with the extra snow accumulating?



A: The first two weeks of March saw very little precipitation across the watershed. Statistically, the snowpack depth by mid-March had returned to the normal range for much of the American side of the watershed.

There was little change in the Snow Water Equivalent estimates over this period. On-the-ground Snow Water Equivalent measurements by Ontario Power Generation at Atikokan were in line with the National Weather Service model, indicating some loss of water from March 1 to March 15, followed by some accumulation over the remainder of the month. The April 1 reading at Atikokan was 5 mm (0.2 in) higher than on March 1.

The Water Levels Committee announced on March 10 that it had directed the dam operators to target a Rainy Lake level between 336.90 and 337.0 m on March 31. The lake was lowered 10 cm (4 inches) in March as a result.



While not targeting the High Flood Risk Curve specifically, this level target range was within High Flood Risk Curve range and in the bottom half of the normal Rule Curve band for March 31. In short, the Water Levels Committee hedged against above normal spring flows in line with the basin conditions but did not identify a *high risk* of flooding as March progressed.

Q: How much lower would the level of Rainy Lake be if the Water Levels Committee had followed the High Flood Risk Rule Curve?

A: This has not yet been modeled, as the event is still happening. The Water Levels Committee will conduct a post-event analysis to answer this question. The middle of the High Flood Risk Rule Curve on April 15 was approximately 20 cm below the actual level on April 15, 2022, and 30 cm (12 in) above the very bottom of the High Risk Curve range.

During the review of the Rule Curves from 2015-2017, extensive work was done to analyze and assess the effect of lower spring targets on peak water levels during high inflow springs. This work was reviewed on many occasions with the Citizens Advisory Group. This work included simulations of historical high flow springs since 1950 using the new 2018 Rule Curve and the High Flood Risk Rule Curve and comparing the peaks to the existing 2000 Rule Curves.

For the 1950 event, the regular 2018 Rule Curves were found to reduce the peak level by 2 cm (1 inch) compared to the 2000 Rule Curves. The High Flood Risk Rule Curve was found to reduce the peak level by an additional 2 cm (1 in) over the regular 2018 Rule Curves. With the level in 2022 exceeding the 1950 peak on Rainy Lake, the difference between the normal 2018 Rule Curve target and the use of the High Flood Risk curve is likely less than 2-4 cm (1-2 in), but further analysis will be needed to verify this. However, it is certain that the High Flood Risk Rule Curve would not have prevented or significantly reduced the 2022 flooding of Rainy Lake.

It may be difficult to understand how having the level up to 30 cm (12 inches) lower on a lake as large as Rainy Lake could not substantially reduce the peak. There are two key points to consider. The first is the extreme inflows to the lake over the April-May period, a new record and nearly four times the flow normally seen in this period. Between April 15 and Jun 13, enough water flowed into Rainy Lake to fill the equivalent of the storage at the very bottom of the High Risk Flood Curve (30 cm or 12 in) on average *every two days*, or 30 times over these 60 days. This is simply an enormous volume of water, unprecedented since records began.

The second, and more important, factor is the constrained outflow from Rainy Lake. When the Rainy Lake dam is not backing up water to the lake, the outlet near Rainier / The Point limits the rate of flow out of the lake into the upper river (see fact sheets and videos for more details). On April 15, the maximum outflow from the middle of the High Risk Rule Curve band is 25% less than if the lake is in the middle of the regular Rule Curve. The higher lake level drives higher outflow. If following the lower target, each day the level rises a little faster than if following the higher target, and this happens day after day until the two are very close together. This is generally true of outlet-limited lakes, including Lac La Croix, Namakan Lake and Lake of the Woods, and is why in the 1950 flood simulations, the High Flood Risk Rule Curve only reduced the peak 2 cm (1in) compared to the normal 2018 Rule Curve.

Q: What actions did the Water Levels Committee or the IJC take to address the high water?

A: Given the extreme, record inflow, no action at the dams could be taken to prevent the flooding on the Namakan Chain of Lakes or Rainy Lake. As inflows quickly picked up in mid-April and the likelihood of flooding increased quickly, the focus of the Water Levels Committee was on ensuring that the dam operators increased flow according to the IJC Order, and in sharing key hydrologic and forecast information with the agencies responsible for flood forecasting in Ontario and Minnesota.

At Namakan Lake, all logs were pulled from the two dams by April 26, when the level was well below the All Gates Open level for that lake. At Rainy Lake, gates were opened as the lake level rose, adding flow to match the natural outflow capacity of the outlet of the lake (for more information on the limitations of outflow from Rainy Lake see this factsheet and a series of three educational videos). All gates at Rainy Lake dam were opened by May 5, again, well before reaching the All Gates Open level. With all gates and sluices fully opened at the three dams, there were no additional actions that the dam operators or the Water Levels Committee could take to pass additional water. The rate of water released from both lakes steadily rose as the water levels of the lakes increased but remained well below the inflow rates as week after week of above-average precipitation continued to fall. The average inflow rate to both lakes for the April 1-May 31 period was the highest on record.

The Water Levels Committee Engineering Advisors worked closely with Ontario and the US National Weather Service to provide advice on forecasts for the levels of both lakes three days a week. At the end of May, the U.S. Co-Chair of the WLC and local US member visited with officials and community members around International Falls. The WLC and IJC representatives, including a U.S. Commissioner, also traveled through the larger basin to meet with affected residents and community officials during the week of June 6, 2022. Local WLC members have been in regular contact with affected residents, providing information and answering questions.

Q: Where can I find the latest news on weather forecasts and flood information?

A: The US National Weather Service and the Province of Ontario are maintaining information through their websites. The Canadian Lake of the Woods Control Board also has been posting updates on its website Notice Board, and provides updates to recent outflows and water levels throughout the basin on their water flow data page.

September 19, 2022,

IRLWWB Co-Chairs Michael Goffin and Col Karl Jansen

Re: Community Advisory Group Recommendations following the 2022 basin Flood Event

Dear Mike and Karl,

On behalf of the CAG we thank the Water Levels committee of IRLWWB for their efforts related to this past summers flood event, and for the opportunity to provide comments for consideration in its post flood report.

Our group met on August 14th to review our observations on the event and discuss recommendations/advice we might have for the board in this regard.

The CAG observed that generally there seemed to be a greater understanding among basin residents of the extraordinary events that lead to this flood. (Especially compared to the 2014 flood). The unprecedented/widespread damage as well as the associated cumulative stress on residents was noted, as was the fact that, even as we write, efforts to recover from the impacts are still underway for many. The limited scope of Government flood aid programs has led to additional frustration as we move deeper into the recovery stage.

The tireless work of volunteers, including unincorporated fire departments, as well as the assistance of local businesses, the National Guard on the US side, and the Ontario Fire Rangers in Canada were thankfully recognized by residents. It was also noted that, unlike the 2014 flood, sandbags were much more readily available to residents who needed them. Perhaps with recognition of the potential of increased flood frequency due to climate change, the CAG was gratified to hear about residents and businesses discussing plans to adapt and make changes to ensure future asset resilience.

Despite some of these positive observations the CAG notes that challenges, especially in the area of public information/communications were once again evident during this emergency event. Use of the National Weather Service for flood forecasting was seen as a positive for example, but it was not widely publicized to residents, especially on the Canadian side of the border. All too often during the event, our members heard questions from the public regarding areas like dam management, flood forecasting, and roles and responsibilities that the CAG feels could, and should have been proactively communicated through a recognized source. The lack of proactive public communications lead in some cases to misinformation, and left many feeling “on their own” through the event.

Consistent with our role to provide advice to IRLWWB and in response to what we heard during and after the flood event, the CAG respectfully submits the following recommendations for Board consideration:

Recommendation 1: The IRLWWB ask the IJC to urge governments to establish a shared, multi-agency information officer role(s) for future basin flood events such that all agencies with responsibilities, including the IJC may communicate information proactively to the public by means of radio/print and appropriate social media through a recognized single source.

1) a: The board investigate the development of a “watershed app” that provides one click access to watershed related information, including agency contact information by geographic responsibility within the basin

Recommendation 2: The IRLWWB Water Levels Committee investigate establishing an “emergency rule curve” that would result in Rainy and Namakan lakes controlled to a more balanced flood level (perhaps controlling to the same delta level compared to the 2014 peaks) during future flood events. It is widely believed that outflows from Namakan to Rainy Lake continued at maximum despite Namakan falling below flood levels and Rainy Lake continuing to rise.

Recommendation 3: The IRLWWB urge the IJC to conduct a preliminary feasibility study to estimate the cost and environmental impacts of an emergency floodway constructed on the Canadian (Frog Creek) or American side of the watershed.

Recommendation 4: The IRLWWB work with the Duluth National Weather Service to investigate ways in which the service can add value to its existing forecasting for future flood events (additional information, longer range forecasting etc.)

Recommendation 5: The IRLWWB ask the IJC to urge governments to ensure that any future plans to replace the Ranier rail bridge are designed to minimize impacts on flows

Recommendation 6: The Water Levels committee of the IRLWWB consider reviewing its flood curve decision process to allow for a decision to approve the flood rule curve later in the spring period or to provide additional updates to the public as the freshet nears. At a minimum, additional updates would demonstrate that the Water Levels Committee remains engaged throughout the spring and belie the notion that the committee was making a decision in mid-March and making no effort to adjust to changing conditions.

Once again, thanks to the Water levels committee for their efforts during this difficult time.

Please do not hesitate to contact either of us to discuss the matter further,

Sincerely,

Doug Franchot and Matt Myers,

Co-Chairs IRLWWB CAG