Hydrologic Forecast Centre

Manitoba Transportation and Infrastructure

Winnipeg, Manitoba

FEBRUARY FLOOD OUTLOOK

February 18, 2022

Executive Summary

The February Outlook Report prepared by the Hydrologic Forecast Centre (HFC) of Manitoba Transportation and Infrastructure reports high risk of moderate spring flooding in most southern Manitoba basins. Water levels are expected to remain below dikes and community flood protection levels at all locations. The risk of flooding could change depending on weather conditions between now and the spring melt.

Due to above normal to well above normal winter precipitation to mid February, the Red River and tributaries, including the Roseau, Rat and Pembina Rivers, are at a high risk of moderate to major flooding. Due to below normal soil moisture at freeze-up and normal to well above normal winter precipitation, there is high risk of moderate flooding in the Assiniboine River and Souris River basins and along the Whiteshell Lakes areas. The risk of spring flooding is low for Interlake and northern Manitoba regions.

Most of the major lakes are below normal levels for this time of the year and within or very close to their operating ranges heading into the spring runoff. The risk of flooding for most lakes is low. Most lakes are expected to be within their desirable ranges after the spring runoff.

Soil Moisture Conditions at Freeze up:

Soil moisture at freeze-up is one of the major factors that affects spring runoff potential and spring flood risk. Due to normal to below normal summer and fall precipitation, the soil moisture at freeze-up is below normal for most Manitoba basins. The U.S. portion of the Red and Souris River basins have normal to above normal soil moistures, and the soil moisture is below normal in the Assiniboine River and Qu'Appelle River basins in Saskatchewan. Soil moisture is normal to below normal in central and northern Manitoba.

Winter Precipitation:

Winter precipitation has been above normal to well above normal in most Manitoba basins, with the exception of southwestern Manitoba that has received near normal precipitation. Winter precipitation has been above normal to well above normal throughout most of south, central, eastern, and northern Manitoba basins, including the Saskatchewan and Churchill River basins. The United States portion of the Red and Souris River basins also received above normal to well above normal precipitation since November 1st. Some areas in the U.S. portion of the Red River basin received up to 200% of normal precipitation since November 1st.

Snow Water Equivalent (SWE):

Snow Water Equivalent (SWE) is the measure of the amount of water content in the snow. Snow water equivalent (SWE) estimates obtained from January field measurements indicate that the average water content in the snowpack is in the order of 30 to 80 mm (1.2 to 3.1 inches) in most of the southern Manitoba basins with a few measurements just outside of this range, from 20 to 155 mm (0.8 to 6.1 inches). The Shellmouth Reservoir basin has an average SWE value of approximately 60 mm (2.4 inches). Northern Manitoba, including the Saskatchewan River basin, has SWE of approximately 65 to 120 mm (2.6 to 4.7 inches). The highest amounts of snow accumulation were measured in eastern and northern Manitoba.

Base Flows and Levels:

Base flows and levels indicate the amount of water available in the system prior to the spring runoff. Higher base flows indicate higher soil saturation levels and higher spring runoff potentials. Base flows and levels in most rivers have been declining since the fall of 2021. Base flows and levels are generally near normal in most Manitoba basins.

Soil Frost Depth:

Soil frost depth affects the amount of surface water that infiltrates into the soil. Generally, deeper than normal frost depth means the soil absorbs less water and contributes to increased surface runoff; whereas shallower than normal frost depth means the soil can absorb more melting surface water and can potentially decrease the amount of overland flooding. The frost depth is variable across the watersheds, but is generally considered to be normal to deeper than normal throughout most of the province due to below normal winter temperatures.

Future Weather:

Most parts of Manitoba and the U.S. portion of the Red and Souris River basins are forecasted to receive between 5 and 10 mm of precipitation in the next 3 days. In the longer range, climate outlook issued by the International Research Institute (IRI) at the Columbia Climate School indicate higher chance for near normal to above normal precipitation for March, April, May, and June. Future weather predictions are generally not reliable.

Flood Outlook:

The magnitude of the spring runoff on Manitoba's rivers is still very dependent on weather conditions from now until the spring melt and during the spring melt period. The runoff potential is significantly affected by the amount of additional snow and spring rains, frost depth at the time of runoff, and timing and rate of spring thaw; and the timing of peak flows in Manitoba, the United States, Saskatchewan and Ontario. A late thaw and spring rainstorms could result in a rapid snow melt that increases overland flooding and flows on tributary streams and larger rivers.

The province's practice is to plan and prepare for the unfavourable future weather condition ("worst case") scenario, which is a weather scenario that would have a 1-in-10 chance of occurring from now until the spring run-off. The preliminary spring flood outlook based on current basin conditions and future weather condition scenarios shows the risk of major flooding is high for the Red River main stem. The risk of moderate flooding is high for most Manitoba basins, including the Assiniboine River and Souris River basins, and the eastern region, including the Whiteshell Lakes areas. The risk of moderate to major flooding is high for the Roseau and Rat rivers. Northern Manitoba basins, including the Saskatchewan and Carrot River basins are at a low risk of spring flooding. The risk of flooding within the Interlake region is low; however, as in most years, the risk of ice jamming is high for the Icelandic and Fisher Rivers.

Water Control Structures Operations:

The Red River Floodway is expected to be operated under all weather conditions. The Floodway will be operated to reduce water levels within the City of Winnipeg. Also, minimal operation of the Portage Diversion may also be necessary to prevent ice jamming on the Assiniboine River east of Portage la Prairie and to control river levels in the City of Winnipeg and areas along the Assiniboine River downstream of Portage la Prairie. The Shellmouth Reservoir is being operated in consultation with the Shellmouth Liaison Committee members in order to reduce the risk of flooding downstream on the Assiniboine River, while at the same time providing sufficient storage for water supply and recreation.

Preparations:

The Manitoba government, municipalities and First Nations are continuing to prepare for spring flooding. This includes review of existing emergency response plans, information sharing, and preparation of resources used in flood response.

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Soil Moisture Conditions

In Manitoba, the most common method used to determine soil moisture at freeze-up is the MANAPI model, which is expressed by the API (Antecedent Precipitation Index). The API model indicates the amount of summer and fall rain (May to October) that remains in the top soil layer and has yet to contribute to the spring runoff. The API model results indicate that soil moisture is below normal for most Manitoba basins. Northern Manitoba and southern Manitoba, have normal to below normal soil moisture. The U.S. portions of the Red River and Souris River basins have normal to above normal soil. The soil moisture is below normal in the Assiniboine River and Qu'Appelle River basins in Saskatchewan. (Figure 1).

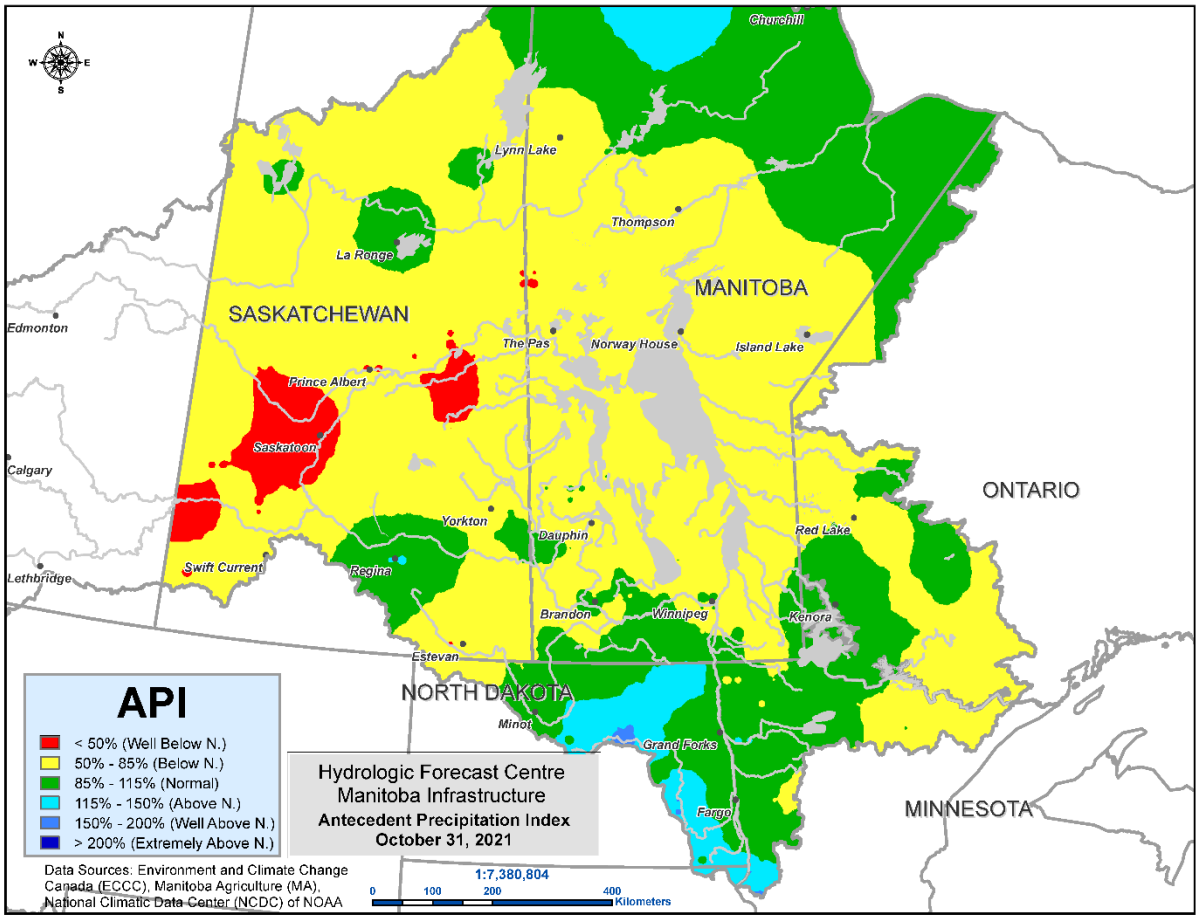

Figure 1 – Soil moisture expressed as Antecedent Precipitation Index (API) for the fall of 2021.

Winter Precipitation

November to mid-February precipitation is generally above normal across much of Manitoba, Saskatchewan and the U.S. Most of southwestern Manitoba and the Interlake have received normal to above normal precipitation. Eastern Saskatchewan has received normal to above normal precipitation while central Saskatchewan and parts of the Saskatchewan River basin have received above normal to well above normal precipitation. The Souris River basin has received near normal to above normal winter precipitation and southeastern Manitoba and the U.S. portion of the Red River basin received above normal to well above normal precipitation over this period (Figure 2).

Generally, the cumulative precipitation amounts across Manitoba, Saskatchewan and the United States portions of the Red and Souris River vary significantly. Southwestern Manitoba and southeastern Saskatchewan including the Souris River basin have received the least amount of precipitation, 60 – 80 mm (2.4 – 3.2 inches). Central Manitoba and the Interlake have received 60 – 100 mm (2.4 – 3.9 inches) of winter precipitation. Northern Manitoba and southeastern Manitoba have both received approximately 80 – 140 mm (3.2 – 5.5 inches) of precipitation. The U.S. portions of the Red and Souris River basins have received 80 – 140 mm (3.2 – 5.5 inches) of precipitation (Figure 3).

Most areas of Manitoba, Saskatchewan and the U.S. portion of the Red and Souris River basins have received winter precipitation that is above the 60th percentile (Figure 4). Put another way, historic precipitation record has been less than the current record for over 60% of the time. Some areas, including northern and southeastern Manitoba, the total snow accumulation is above the historical 95th percentile. Most of the Red River basin in the US has snow accumulation that is within the 80th – 95th percentile. As can be seen in Figure 5, precipitation record as of February 13, 2022 indicates that southwestern Manitoba, eastern Saskatchewan and much of the Interlake have snow accumulation that is approximately 10 – 30 mm (0.4 – 1.2 inches) more than normal. Northern Manitoba, southeastern Manitoba and the U.S. portion of the Red River basin have snow accumulation that deviates from the normal by up to 50 mm (2.0 inches).

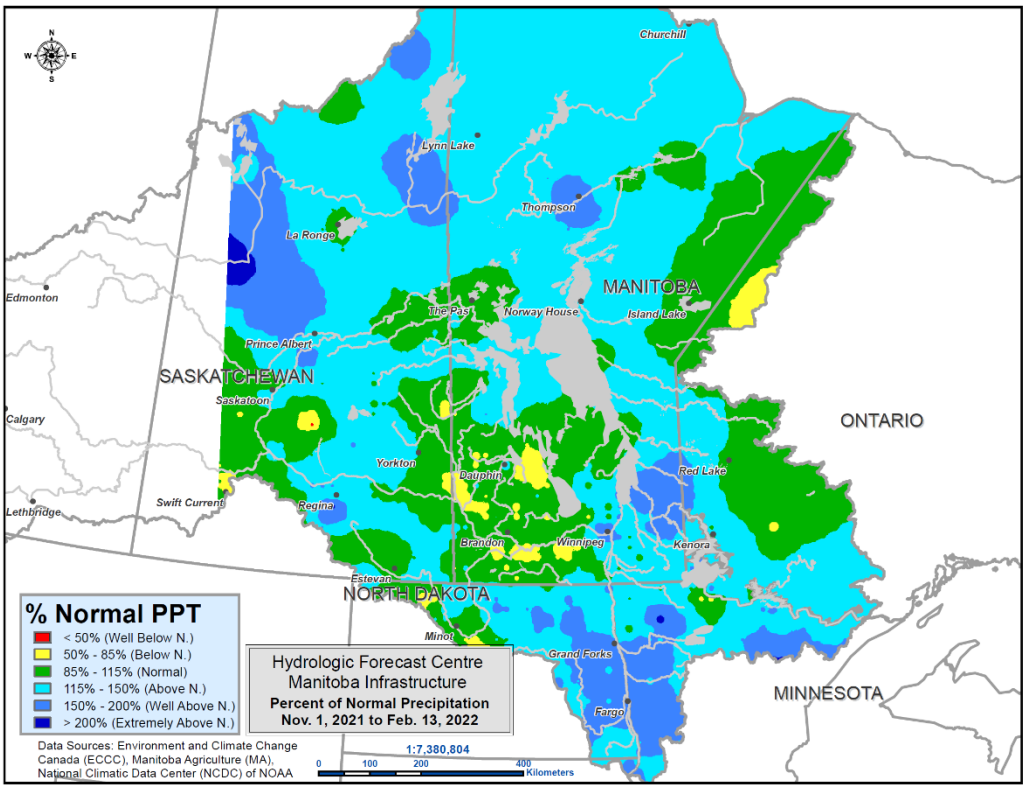

Figure 2 - Percent of Normal Precipitation from November 1, 2021 to February 13, 2022.

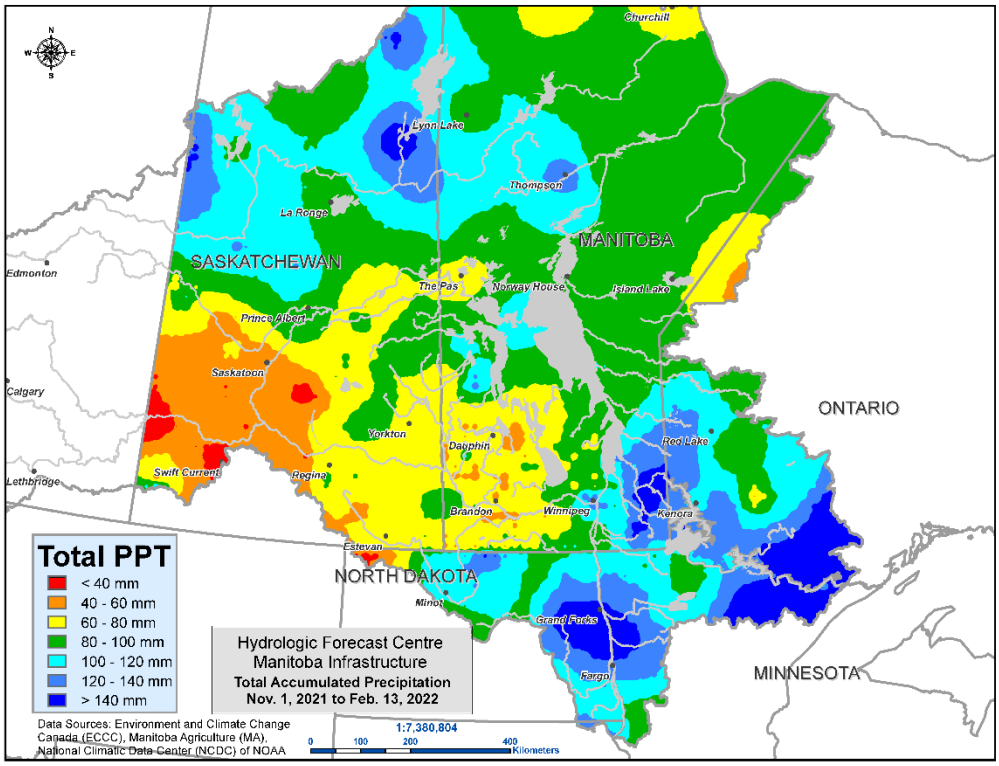

Figure 3 - Cumulative precipitation in mm from November 1, 2021 to February 13, 2022.

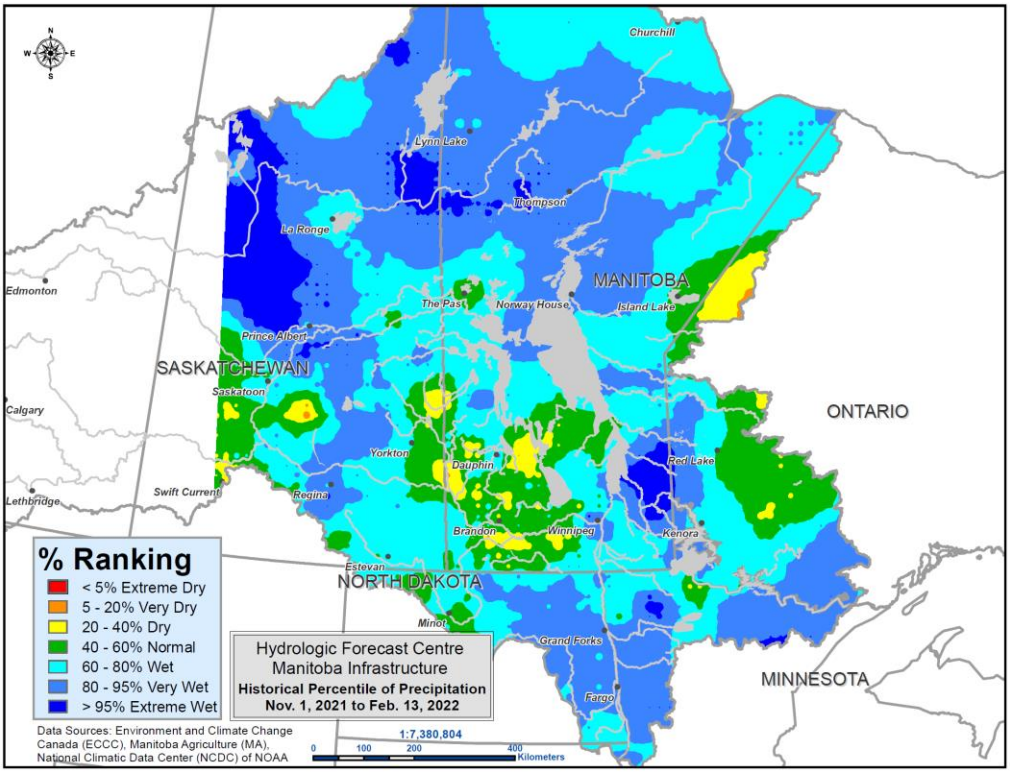

Figure 4 – Percent ranking precipitation from November 1, 2021 to February 13, 2022, compared to historic record.

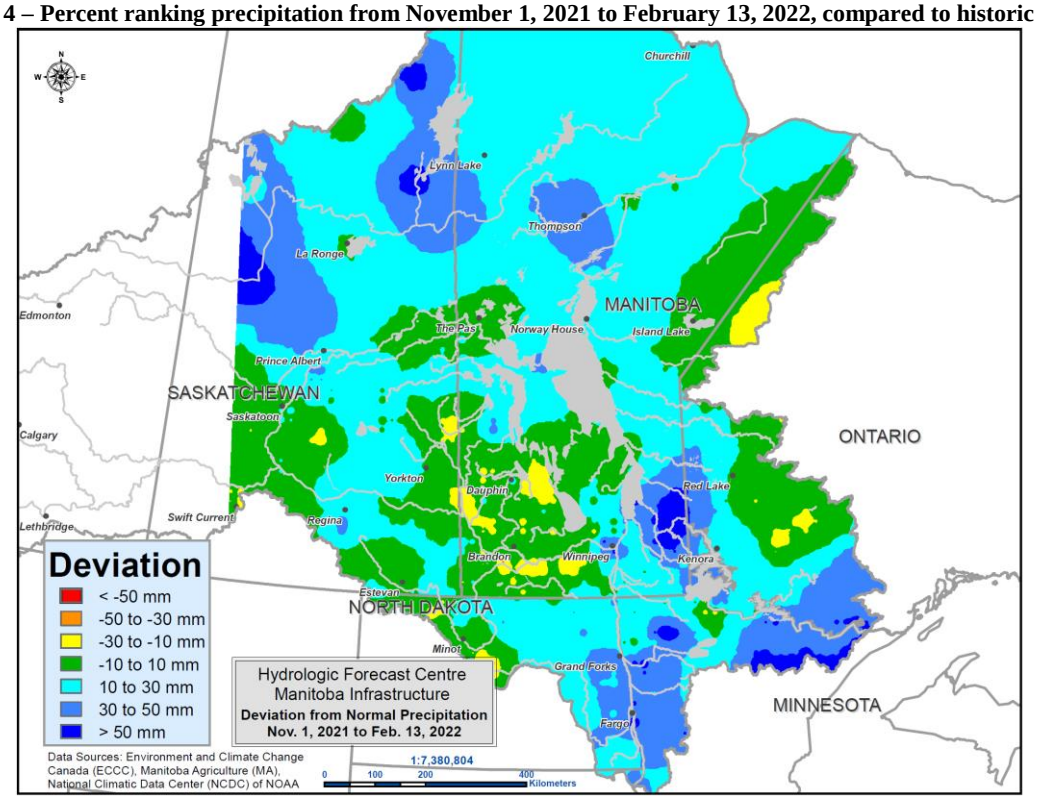

Figure 5 - Precipitation from November 1, 2021 to February 13, 2022, deviation from normal (mm).

Snow Water Content

Snow water equivalent (SWE) estimates obtained from end of January field measurements indicate that the average water content in the snowpack is in the order of 30 to 80 mm (1.2 to 3.1 inches) in most of the southern Manitoba basins with a few measurements just outside of this range (Figure 6). The Interlake region has SWE values of approximately 40 to 90 mm (1.6 to 3.5 inches). The Shellmouth Reservoir basin has an average SWE value of approximately 60 mm (2.4 inches). Northern Manitoba, including the Saskatchewan River basin, has snow accumulation with approximately 65 to 120 mm (2.6 to 4.7 inches) SWE. The highest measurements were taken at higher elevations, including Riding Mountain Provincial Park, Duck Mountain Provincial Park and the Porcupine Mountains. SWE in the Duck Mountains measured up to 155 mm (6.1 inches).

Figure 6 – Snow Water Equivalent (SWE) in mm from field measurements.

Base Flows and Level Conditions

Base flows and levels indicate the amount of water available in the system prior to the spring runoff. Higher base flows indicate higher soil saturation levels and higher spring runoff potentials. Base flows and levels in most rivers have been declining since the fall of 2021. Base flows and levels are generally near normal in most Manitoba basins, with a few above normal and below normal base flows and levels (Figure 7).

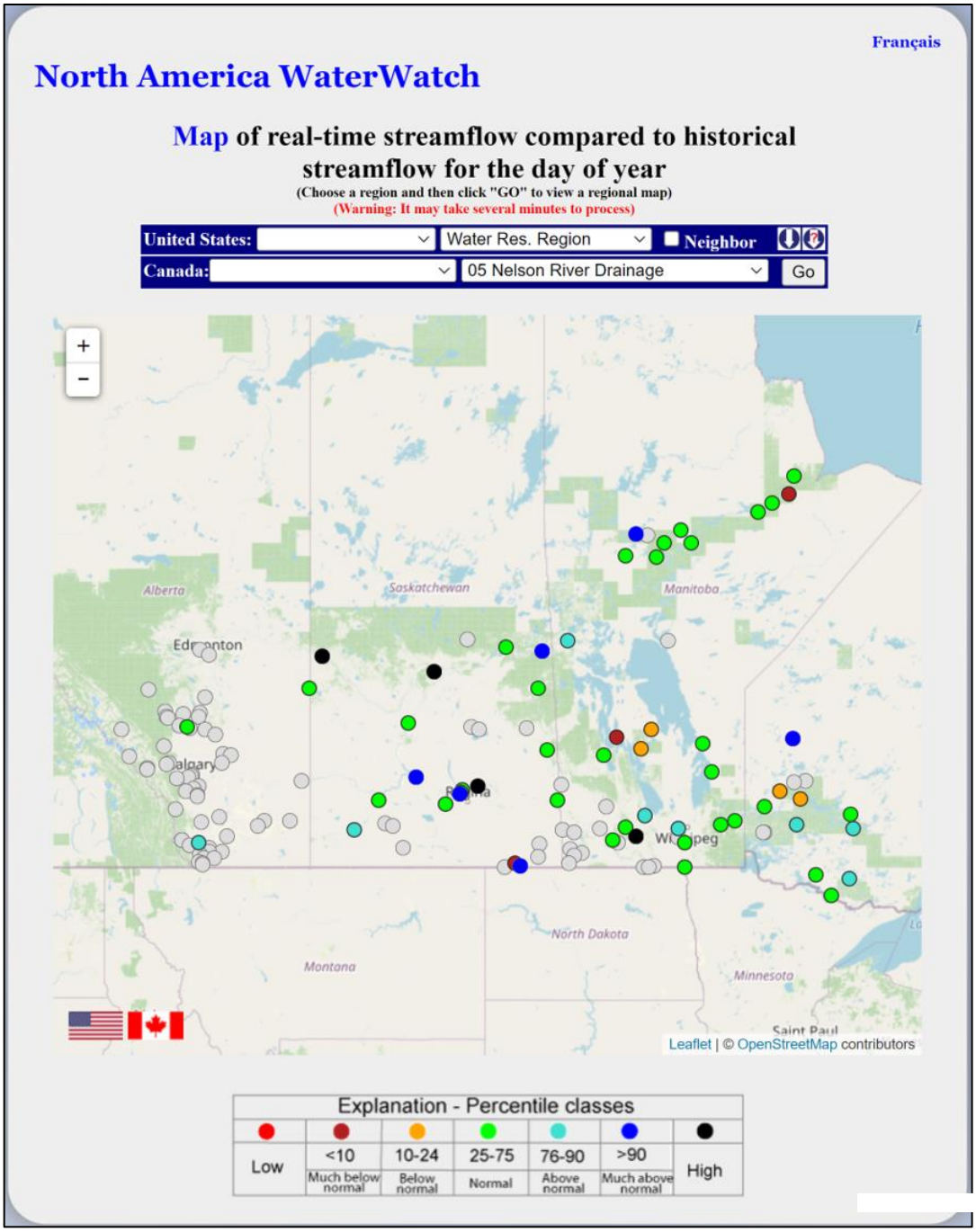

Figure 7 – Base flows and level conditions as of February 15, 2022 (Note: Flows and levels readings at some locations could be ice affected and may not show the actual flows and levels).

Soil Frost Depth

Soil frost depth is dependent on winter temperatures and the amount of snow cover insulation. The frost depth is variable across the watersheds, but is generally considered to be normal to slightly deeper than

normal throughout most of the province. Generally, deeper than normal frost depth means the soil absorbs less water and contributes to increased surface runoff; whereas shallower than normal frost depth means the soil can absorb more melting surface water and can potentially decrease the amount of overland flooding. Figure 8 shows comparative measurements of frost depth at various locations across the province.

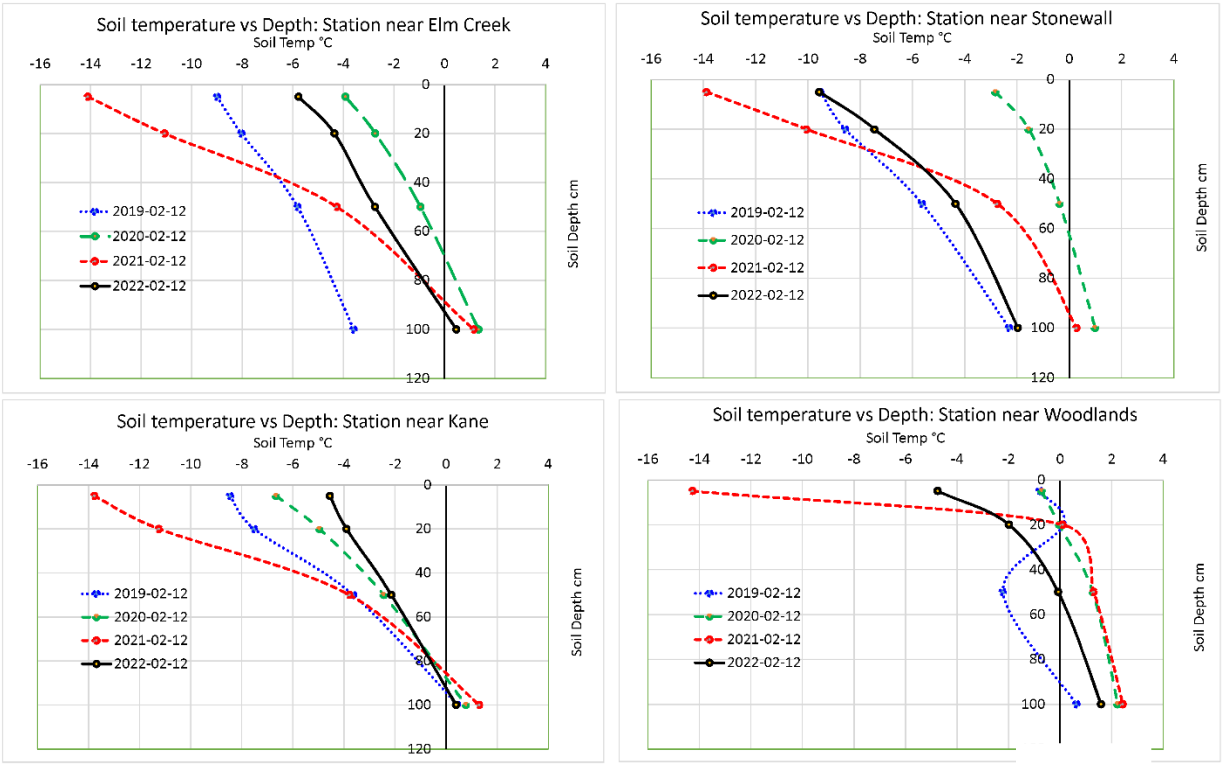

Figure 8 – Frost depth in centimeters at various locations across the province.

Future Weather Outlook

Most parts of Manitoba and the U.S. portion of the Red and Souris River basins are forecasted to receive between 5 and 10 mm of precipitation in the next 3 days (February 18-21) (Figure 9). In the longer range, climate outlook issued by the International Research Institute (IRI) at the Columbia Climate School indicate higher chance for near normal to above normal precipitation for March, April, May and June (Figure 10 and 11).

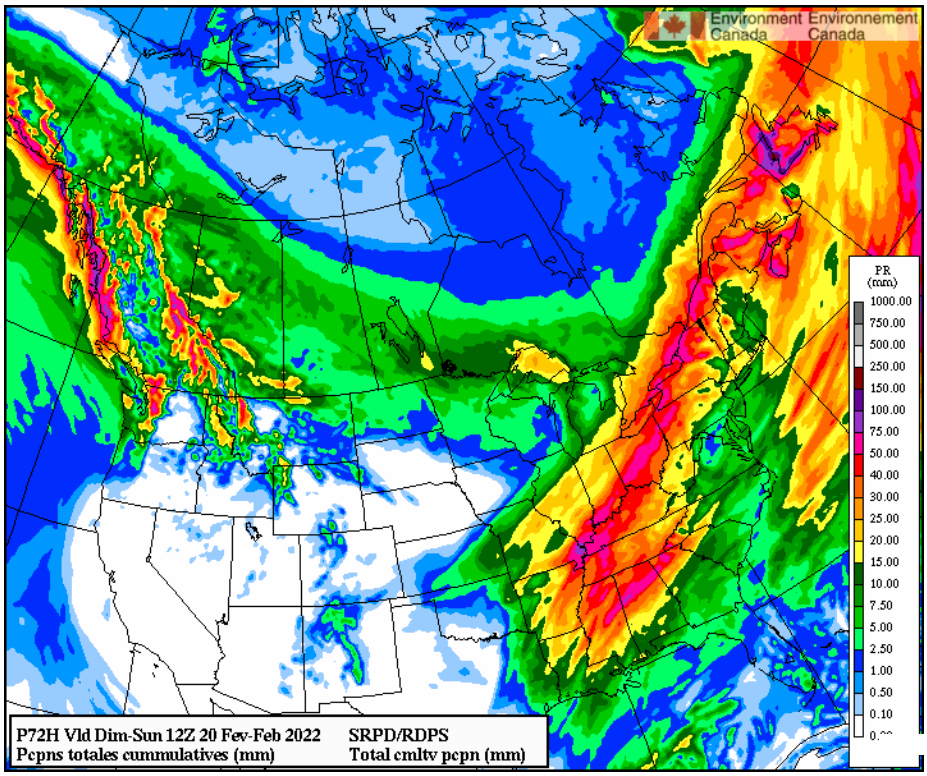

Figure 9 – Short term regional precipitation forecast between February 17th and February 19th.

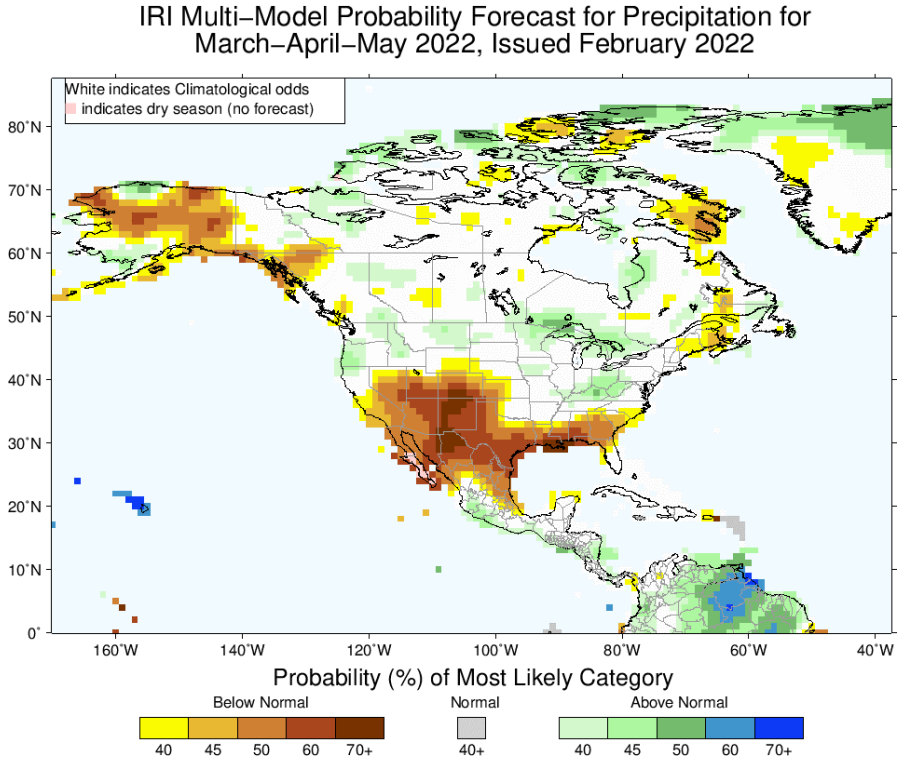

Figure 10 – IRI Multi-Model Probability Forecast for Precipitation for March-April-May 2022, issued February 2022.

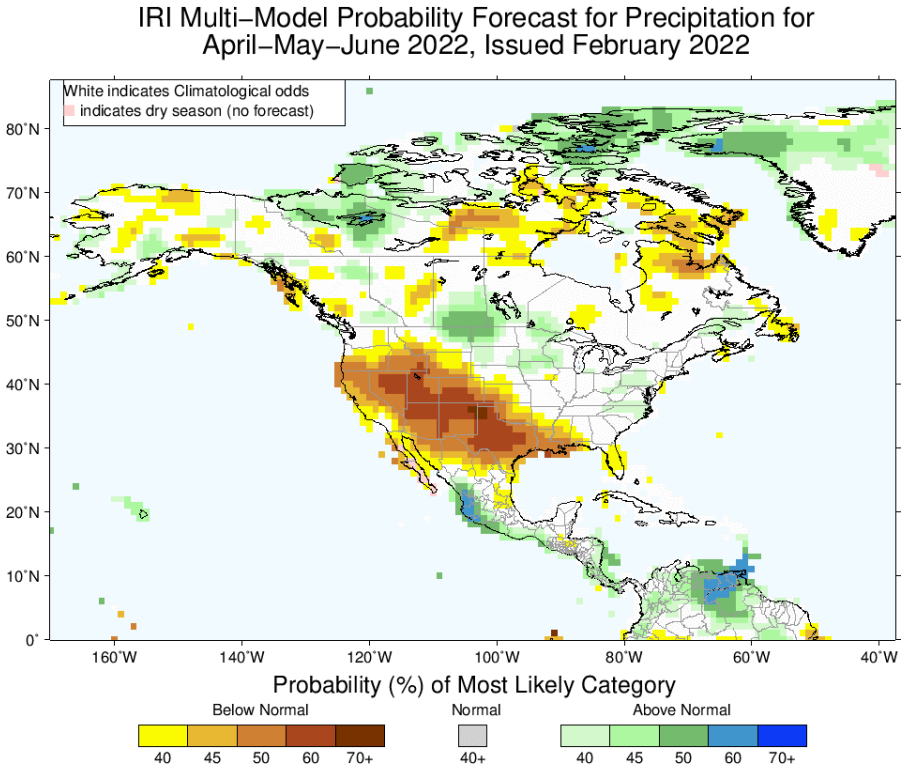

Figure 11 – IRI Multi-Model Probability Forecast for Precipitation for April-May-June 2022, issued February 2022.

Current Lake Level and River Flow Conditions

Water levels and flows at freeze-up:

- Red River: near normal flows
- Saskatchewan and Churchill Rivers: above normal flows
- Carrot, Assiniboine, Souris, Qu'Appelle, Waterhen, Dauphin and Fairford Rivers: below normal flows
- Lake Manitoba, Lake Winnipegosis, Lake St. Martin and Lake Winnipeg: below normal levels
- Dauphin Lake: near normal levels

Current river flow conditions:

- Red Deer, Souris, Qu'Appelle, Roseau and Pembina Rivers: near normal to below normal flows for this time of year

- Due to releases from the Shellmouth Dam, Assiniboine River flows are above normal for this time of year
- Carrot, Saskatchewan and Churchill Rivers: flows are above normal for this time of the year
- Interlake rivers (including the Waterhen, Fisher, and Fairford Rivers): flows are below normal for this time of year

Current lake water levels:

- The water levels for major lakes in Manitoba are below normal heading into the spring. Most lakes are within or very close to their respective operating ranges heading into the spring runoff.

River Ice Conditions and Ice Jamming[1]

The Red River ice thickness measurements will be taken near the end of February. Normal ice thickness for this time of the year varies according to the river flow velocity and the location of the river; it typically ranges between 46 cm (18 inches) and 76 cm (30 inches).

Spring weather affects the timing and rate of the deterioration of the river ice, and will be a significant factor in determining ice strength at break-up. It is difficult to predict the time of occurrence and extent of ice jamming. However, with the ice cutting and breaking activities currently underway on the Red River, the chance of ice jamming and related flooding on the lower Red River should be reduced.

Localized flooding can occur when and where ice jams develop, even with below average river flows.

The chances of localized flooding due to snow and ice blockages in drains, ditches and small streams during the early part of the run-off period will depend on the nature of the spring breakup and rate of melt.

[1] See Appendix A for ‘Ice Jam’ definition

Flood Outlook[2]

Spring flood outlooks provide estimates of peak river flows and lake water levels that are based on current basin conditions, and three possible future weather scenarios. These weather scenarios are: favourable, normal, and unfavourable. These scenarios correspond to three different probabilities of occurrence: lower decile, median, and upper decile. The province's practice is to plan and prepare for the unfavourable (upper decile) future weather conditions. For further information, see Appendix A: Definitions.

The extent of flooding is defined by three categories: major flooding, moderate flooding, and minor (no) flooding. Major flooding is associated with property damages and significant economic impacts. Moderate flooding is associated with flooding of agricultural lands and low-lying areas. In moderate flooding, economic impacts are limited because flood levels are below the tops of most roads and are well below the flood protection levels of community and individual flood protection works. Minor (no) flooding is associated with no or very limited overland flows and peak river water levels generally remain within the river banks.

A number of uncertainties exist with respect to the flood outlook. These include, but are not limited to, the following:

- future weather uncertainties (snowfall and spring rainfall);
- winter snowpack, date of the onset of melt, and melt rate (i.e., timing and speed of snow melt);
- uncertainty in meteorological and hydrometric data collected to date;
- timing of the peak flows;
- frost depth at the time of spring melt; and
- hydrologic model prediction uncertainties.

Red River

- There is a high risk of major spring flooding along the Red River main stem. The current soil moisture is quite high throughout the basin and winter precipitation has been above normal.

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[2] See Appendix A for 'Flood Outlook', 'Weather Scenarios', 'Favourable Weather', 'Normal Weather', and 'Unfavourable Weather' definitions

[7] See Appendix A for 'Minor/Moderate/Major and Severe' Flood risk definitions

- In favourable weather conditions, the risk of flooding is low to moderate
    - Levels would be similar to spring peak levels observed in 2013 from Emerson to the Red River Floodway Inlet.
- Normal weather: high risk of moderate to major flooding
    - Levels would be near the spring peak levels observed in 2019/2020 from Emerson to the Red River Floodway Inlet.
- Unfavourable weather: high risk of major flooding
    - Levels on the Red River main stem would be similar to 2009 from Emerson to Red River Floodway Inlet.
- The flood protection level of the community dikes and the individual flood protection works within the Red River basin are higher than the predicted peak levels, even in the unfavourable weather scenario.

Red River Floodway

- The Red River Floodway has been operated in 34 out of the 53 years since it has been constructed for the purpose of providing flood protection to the City of Winnipeg.
- Due to the forecasted flows on the Red River, the Floodway is expected to be operated under all weather conditions during the 2022 spring melt.
- Open water peak estimated levels at James Avenue are:
    - Favourable weather: 5.2 – 5.5 m (17.0 – 18.0 ft)
    - Normal weather: 5.5 – 5.8 m (18.0 – 19.0 ft)
    - Unfavourable weather: 5.8 – 6.0 m (19.0 – 20.0 ft).

Rat and Roseau Rivers

There is a high risk of moderate to major flooding within the Rat and Roseau River basins.

Assiniboine River and Its Tributaries

- There is a high risk of moderate spring flooding along the Assiniboine River and its tributaries, including the Souris River and Qu'Appelle River.
- The Assiniboine River and its tributaries are expected to remain within their banks for favourable future weather scenarios.

- Overbank flooding of low laying areas may occur on the Assiniboine River and Qu'Appelle River near St. Lazare under normal future weather conditions.
- Significant overbank flooding of agricultural land is expected to occur under unfavourable future weather conditions.
- The flood protection level of the community dikes in the City of Brandon and in towns of Melita, Souris, Wawanesa, and St. Lazare are at elevations which are high enough to protect against expected spring water levels.

Portage Diversion

- The Portage Diversion has been operated 38 out of the 52 years since it has been constructed for the purpose of preventing ice jamming on the Assiniboine River east of Portage la Prairie and to provide flood protection for the City of Winnipeg and areas along the Assiniboine River downstream of Portage la Prairie. Based on the runoff potential in the Assiniboine and Souris basins, the Portage Diversion is expected to be operated under median and unfavourable weather conditions. Under favourable weather conditions, the Portage Diversion may be operated to reduce ice jam related levels downstream of the diversion.

Shellmouth Dam

- The forecasted inflow volumes into the Shellmouth Reservoir for favourable, normal and unfavourable conditions as of February 16th are 250 million meter cube (205,000 acre-feet), 400 million meter cube (325,000 acre-feet) and 610 million meter cube (500,000 acre-feet), respectively.
- The Shellmouth Dam is being operated to provide storage capacity for reservoir inflows in order to reduce flooding downstream as well as to ensure a sufficient reservoir level for recreation and water supply. The current reservoir level as of February 16th, 2022 is 425.37 m (1395.56 ft).
- The Shellmouth Liaison Committee provides regular input into the dam operations to meet the target level of 427.33 m to 427.94 m (1402 ft to 1404 ft) after the spring runoff. The outflow from the reservoir as of February 16th, 2022 is 24.7 cubic metres per second (872 cubic feet per second).

Interlake Region

- The risk of flooding within the Interlake region is low.
- As in most years, the risk of ice jamming is high for the Icelandic and Fisher Rivers.

Fairford River Water Control Structure

- The flow through the Fairford River Water Control Structure is currently 600 cfs due to the low level on Lake Manitoba. In accordance with operating guidelines, the outflow will remain at or below 800 cfs until the water level reaches 247.35 m (811.5 ft).

Eastern Region

- There is a high risk of moderate flooding in the eastern region, including the Whiteshell Lakes and Winnipeg River basin.

Manitoba Lakes

- Currently, most major lakes are just below or within their operating ranges. Most lakes are expected to be within their normal operating range after the spring runoff. The risk of spring flooding in most Manitoba lakes is low.

Lake Manitoba

- Lake Manitoba's current level is 247.02 m (810.43 ft).
- The current level is 0.46 m (1.52 ft) below normal for this time of year, and is just under the operating range of 247.04 m (810.5 ft) to 247.65 m (812.5 ft).
- After spring runoff, the lake level is expected to be within the operating range.

Lake St. Martin

- Lake St. Martin is currently at 242.94 m (797.05 ft).
- The current level is 0.64 m (2.10 ft) below normal for this time of year.
- After spring runoff, the lake level is expected to be below flood protection works.

Lake Winnipeg

- Lake Winnipeg's current level is 217.19 m (712.57 ft).
- The current level is 0.15 m (0.50 ft) below normal for this time of year and within the operating range of 216.71 m (711 ft) to 217.93 m (715 ft).

Lake Winnipegosis

- Lake Winnipegosis is currently at 252.81 m (829.43 ft).
- The current level is 0.31 m (1.0 ft) below normal for this time of year.
- After spring runoff, the lake level is expected to be near normal levels.

Dauphin Lake

- Dauphin Lake's current level is 260.35 m (854.17 ft).
- The current level is normal for this time of year and within the operating range of 260 m to 260.5 m (853 ft to 854.7 ft).
- After spring runoff, the lake level is expected to be within the operating range.

Northern Manitoba and The Pas Regions

- The risk of flooding is low along the Saskatchewan and Carrot Rivers when considering all potential future weather scenarios.
- Levels along the Saskatchewan and Carrot Rivers at The Pas depend greatly on the outflows and the regulation of Saskatchewan's Tobin Lake. Considering the potential future Tobin Lake outflows and future weather conditions, the peak open water levels on the main stems of the Saskatchewan and Carrot Rivers are expected to be below bank full levels.
- The risk of major flooding is also low along Swan River under all future weather conditions.
- As in many other years, there is a risk of ice jam related flooding along the Saskatchewan, Carrot and Swan Rivers.

Flood Preparations

- As a matter of standard practice in the lead-up to the spring flood season, the Manitoba government and municipalities review existing emergency response plans, share information, and prepare flood response resources.
- The ice-jam mitigation program north of Winnipeg will be commencing on February 22 with ice cutters and ice breaking equipment working along the Red River to break the ice.

Future Forecast Information

If the spring melt and runoff has not yet begun, a second flood outlook will be published with updated information in late March when further precipitation and other factors are available.

Appendix A: Definitions

[1] Ice Jam:

- A blockage of ice on a river/stream which restricts flow, resulting in increased water levels upstream.

- Jams may occur due to changing river channel geometry, bends in the river channel, depth and thickness of ice, rate of water level rise, or a solid section of ice downstream.

[2] Flood Outlook:

- Estimated spring peak water levels and flows provided before spring water flow begins.
- Estimates are based on diverse information, such as soil moisture, winter precipitation, snowpack, topography, current water level, channel capacity, and future weather condition scenarios (precipitation, temperatures, etc.).
- Estimates are provided for three weather scenarios (favourable, normal, and unfavourable) which correspond to three different probabilities of occurrence (lower decile, median and upper decile).

[3] Weather Scenarios:

- Used to account for future weather such as additional snow, melt rates and spring rainfall. These are determined by statistical analysis of the past 30 - 40 years of climate data.
- Three scenarios used:
    - Lower decile (favourable)
        - There is a 10% chance of the weather being ‘favourable’ or better. 90% of the time the weather will be worse than this ‘favourable’ condition.
    - Median (normal)
        - There is a 50% chance of the weather being ‘normal’ or better.
    - Upper decile (unfavourable)
        - There is a 10% chance of the weather being ‘unfavourable’ or worse. 90% of the time the weather will be better than this ‘unfavourable’ condition.
- The Province’s practice is to plan/prepare to the upper decile (i.e., unfavourable) condition.

[3] Favourable Weather:

- Characterized by little additional precipitation and a gradual snow melt.
- The lower decile weather condition

[3] Normal Weather:

- Characterized by normal rainfall and temperature.
- Typically used to describe historic climate conditions.
- The median weather condition

[3] Unfavourable Weather:

- Significant wide-spread precipitation with a rapid snowmelt.
- The upper decile weather condition

[5]Flow/Discharge [expressed in cubic feet per second (cfs) or cubic metres per second (cms)]:

- The volume of water that passes a given location within a given period of time.

[6] FPL – Flood Protection Level:

- Is the water level of the greater of the flood of record or the 1-in-200-yr flood, plus a freeboard allowance for a particular waterway (typically 2 ft) or water body (i.e., the freeboard is site specific).
- It is provided by the Hydrologic Forecasting and Water Management (HFWM) branch of MI on a site-specific and structure-specific basis.
- This is formally set by the Water Resources Administration Act for the Red River Designated Flood Areas.
- In non Designated Flood Areas, the province uses the determined FPLs. For other works or developments, the FPL is recommended by the province, but ultimately regulated by the local planning districts and/or municipalities.

[7]Definition for minor/moderate/major flooding:

- Minor Flooding:
    - Minimal or no property damage is expected, but there is potential for some public impact, such as inundation of roads below the FPL[6].

- Moderate Flooding:
    - Potential for flooding of agricultural and low-lying areas.
    - Flood water levels are expected to be below the FPL.

- Major Flooding:
    - Potential for extensive inundation of buildings, structures and roads below the FPL near drains, streams, rivers and lakes.
    - Flood water levels could exceed the FPL.
    - Evacuations and relocation of personal property to higher elevations or safer locations will likely be required.
    - Major highway closures associated with substantial economic impacts will likely be required.

Additional terminology:

Operational Forecasts:

- Estimated future crest water level, flow and date of occurrence provided once active melt and river flow has begun.

- Estimates are modelled based on observed flow, existing conditions (including channel capacity, topography, and remaining snowpack) and normal future weather.

- Observed conditions are monitored throughout the flood and compared against the historic climate data used to generate the forecast.

- Forecasts are updated when weather conditions are outside the range of historical climate data used to generate the forecast.

- A range of forecasted values is provided further in advance of an upcoming forecasted crest because of unknowns in the basin conditions and river flows, and limitations in the modelling procedures.