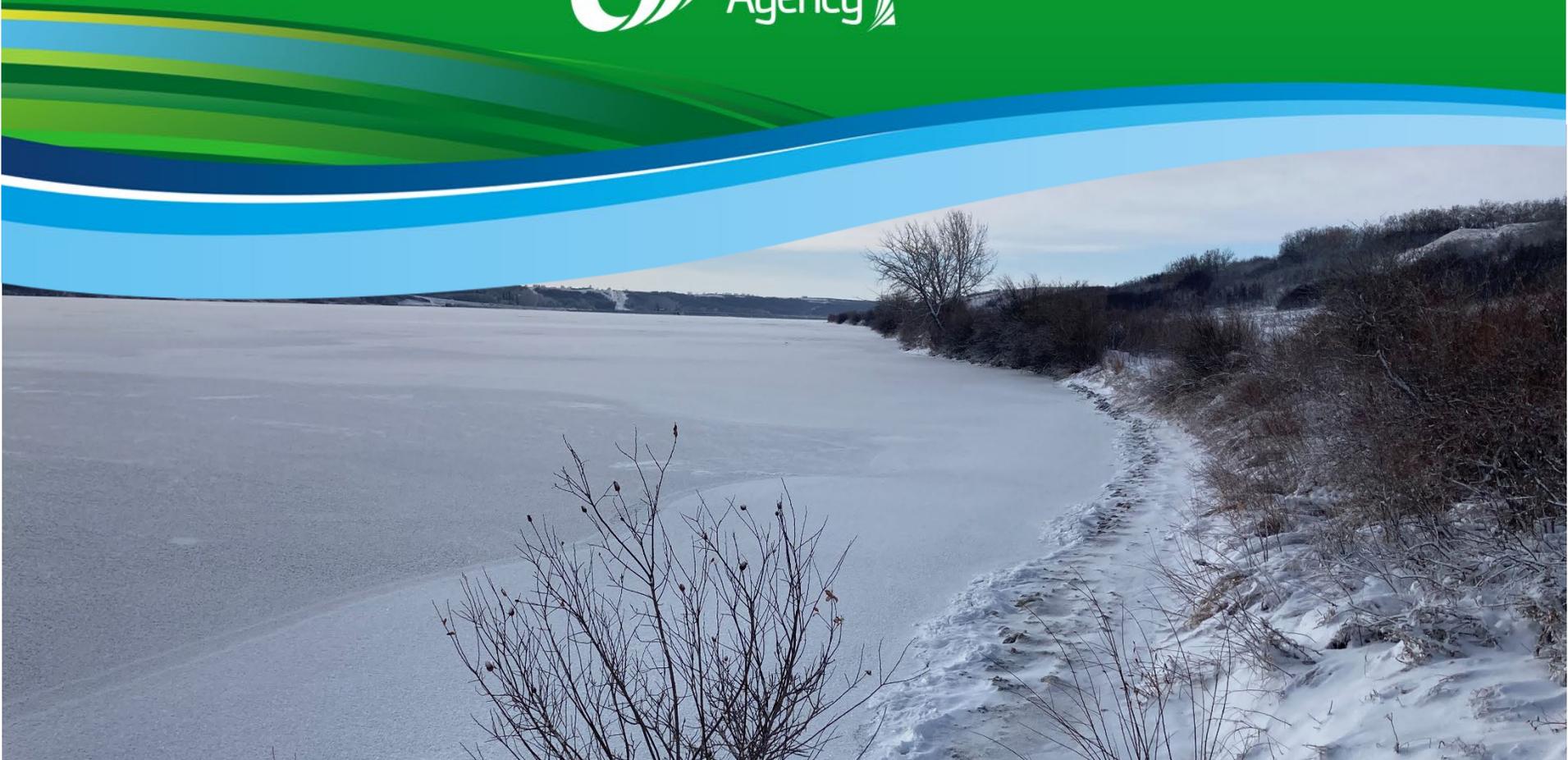


S A S K A T C H E W A N



2022 Conditions at Freeze-up Report

Based on Conditions as of November 7, 2022

Prepared by: Flow Forecasting & Operations Planning - Water Security Agency

Executive Summary

The Water Security Agency (WSA) issues the *Conditions at Freeze-up Report* to summarize conditions during the late fall/early winter period. This, in combination with the winter snowpack, becomes the initial conditions for the spring snowmelt runoff. This report gives an early indication of areas that are more vulnerable to potentially above or below normal runoff during the spring period. It is not a spring runoff forecast, as winter snow accumulation is an integral component in the runoff yield during the melt and is impossible to predict at this juncture.

Across the western portion of the grain belt, precipitation accumulations in 2022 were well below normal. This has resulted in dry conditions at freeze-up. Conditions are driest in the Saskatoon and Swift Current areas where extreme agricultural drought conditions exist.

In the east, precipitation recorded in the spring and early summer was above normal with some areas recording higher than the 90th percentile accumulations. The last half of the summer and the fall were drier than normal, resulting in slightly drier than normal soil moisture conditions at freeze-up.

Similarly in the north, precipitation in the spring was above normal, with the summer and the fall being drier than normal. Water levels were higher than normal throughout the first half of the year but have since tapered off to near normal or even below normal going into freeze-up. Winter flows in northern areas are expected to be below normal throughout the winter.

Most larger water supply reservoirs across southern and central Saskatchewan have adequate supplies. Surface water users in the southwest who rely on smaller reservoirs or dugouts have been impacted by the dry conditions. This includes diminished

supply and quality. Without an above normal snowpack, these conditions are expected to worsen in 2023.

There were two significant, early snowfall events late this fall. The first event impacted areas across the southwest and the east-central portions of the province. This heavy snowfall was followed by warmer temperatures, melting much of the snowpack, and improving near surface soil moistures. The second snowfall event occurred in early November, affecting most of southern and central Saskatchewan.

The early snowfall that melted could result in two outcomes: 1) there is the potential that the increased soil moisture will reduce infiltration capacity come spring because the soil will be frozen, or 2) the early, heavy snow received in early November could insulate the soil and reduce frost penetration, which would result in more infiltration in the spring and therefore reduce the runoff in spring 2023. Snow surveys in February will help ascertain which scenario is likely to develop.

At this time, there are no areas where WSA believes that there is a heightened risk of above normal spring runoff in 2023. There is, however, concern of surface water supply issues in the southwest if winter snowfall is below average.

Current long-range forecasts and climate indices suggest near to above normal precipitation and below normal temperatures through the winter months over much of the province. La Niña conditions and a negative Pacific Decadal Oscillation are present and expected to continue through the winter. Historically, the combination of these two conditions has resulted in some of our largest snowpacks.

The initial Spring Runoff Outlook for 2023 will be issued in early February.

Precipitation and Conditions Leading into Freeze-Up

2022 Spring Runoff Summary

Across the west, snowmelt runoff in spring 2022 generally ranged from near to below normal. The southwest experienced several mid-winter melt events that left much of the area snow free come February. Early spring precipitation received just before the melt in March helped to increase runoff yields in some areas. In the east, spring precipitation generated additional runoff during the later portion of the snow melt period which resulted in runoff responses being near or even above normal. Several areas experienced above average (1:10 year) runoff events due to rainfall occurring concurrently with snowmelt. In the north, observed peaks from the snowmelt runoff ranged from near to above normal. In the Churchill River Basin, runoff responses ranged from 1:2 to a 1:5 year events. In general, moisture conditions across much of the province were near to above normal following snowmelt runoff, except for the southwest where conditions were dry.

2022 Summer Precipitation Summary

As shown in Figure 1 and Figure 2, precipitation received throughout the summer over most of southern and central Saskatchewan was near to slightly below normal. There were some pockets in the east that received above normal precipitation due to some early summer events. There were also some areas in the west that received below normal summer precipitation. Conditions were particularly dry in the Swift Current area where precipitation accumulation percentiles were classified as very low. In the north, the western areas of the Churchill River Basin received above normal precipitation.

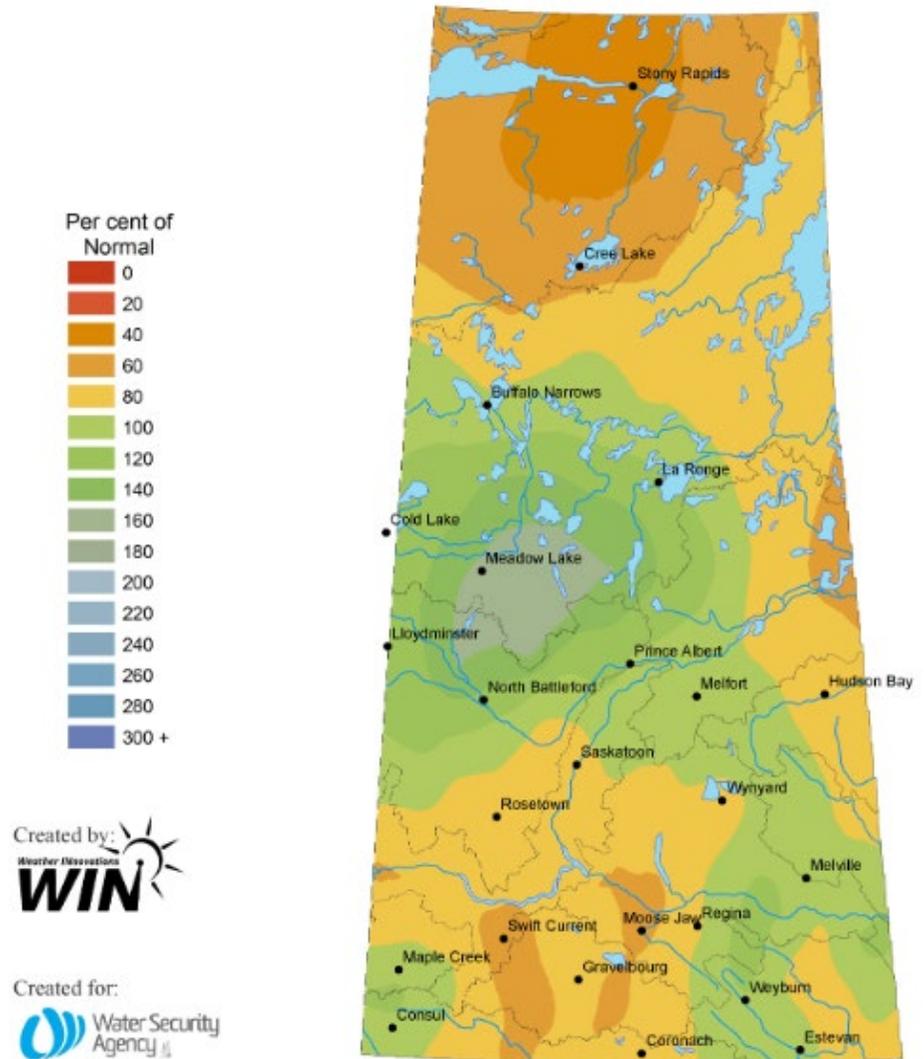


Figure 1: 90-day Per Cent Normal Rainfall Accumulations June 3 to August 31, 2022



Precipitation Percentiles

in past 90 days, as of August 31, 2022

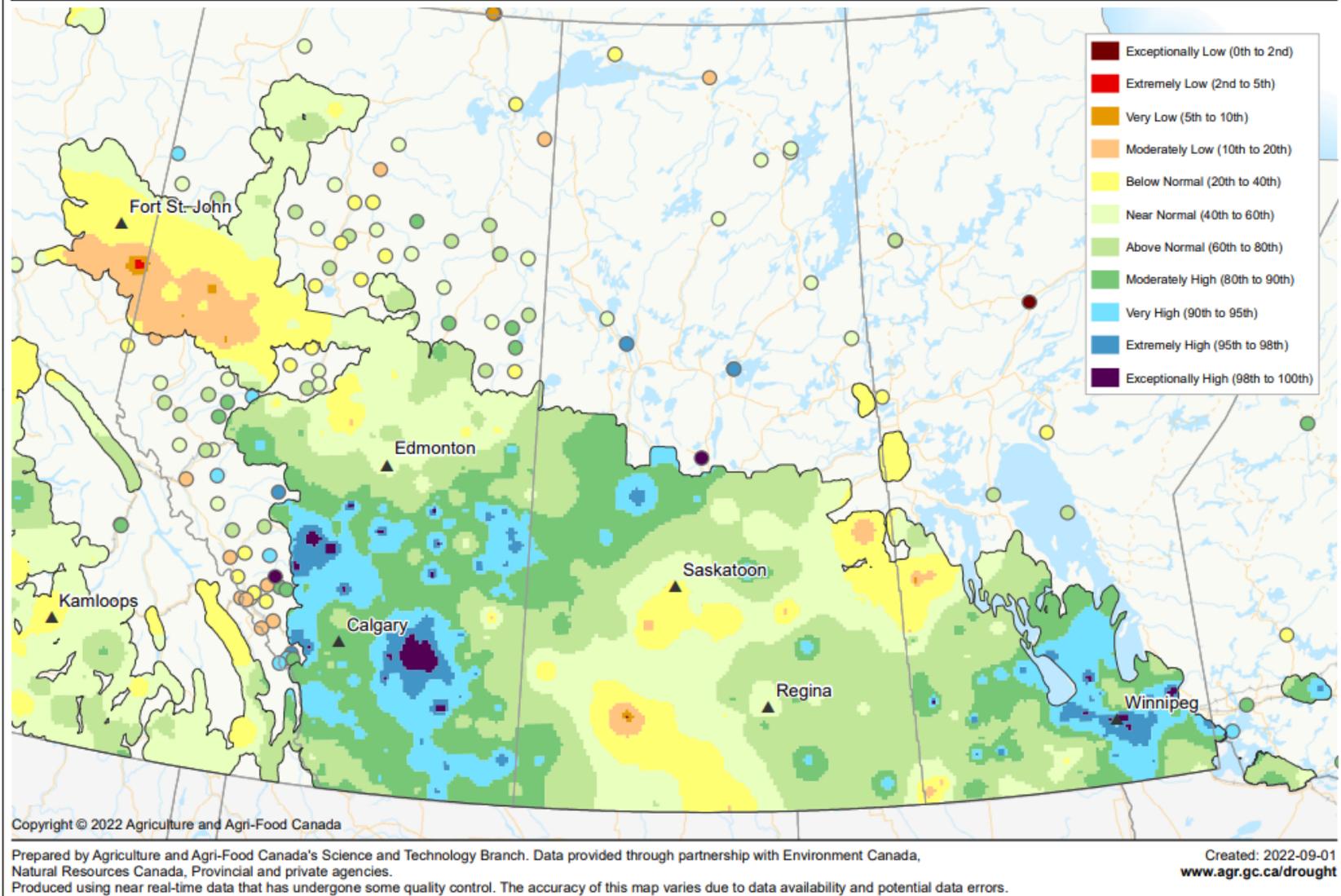


Figure 2: June 3 to August 31, 2022 Precipitation Compared to Historic (Map Courtesy of Agriculture and Agri-Food Canada)

2022 Fall Precipitation Summary

Figure 3 shows how rainfall recorded across the province from September 1 to November 1, 2022 compared to normal (note that this figure does not adequately represent snowfall as the bulk of the gauges used only collect liquid precipitation). Generally, rainfall across the province was below normal in the fall. The Weyburn area and much of the North Saskatchewan River Basin was the driest where only around 20 per cent of normal rainfall was observed.

This fall, a couple early snowfall events occurred. The first occurred between October 22 and 23. Figure 4 shows estimated accumulations from that event. The heaviest snow occurred between Swift Current and Moose Jaw and in the headwaters of the Qu'Appelle River Basin where 30 to 40 mm of precipitation was recorded. Due to warmer temperatures following the snowfall, most of this early snow melted before a second heavier snowfall event occurred in early November. The second event occurred more to the north compared to the first snowfall event. Estimates of total accumulations from the two events are shown in Figure 5. Most of central, southwestern and south-central Saskatchewan received 30 to 50 mm with some areas receiving up to 65 mm from these two events. Across the remainder of the south, accumulations were only between 10 and 15 mm.

The early snowfall that melted resulted in an increase in topsoil moisture conditions; this, in combination with the rain that preceded the November snowfall event, may cause a frozen layer of soil that is less penetrable, which may result in less infiltration come spring. On the other hand, with the heavy snow received in November, there is also the potential that this early snow could insulate the soil and reduce frost penetration which typically allows for more infiltration in the spring and reduces the runoff potential. WSA monitors soil conditions and snowpack in the spring.

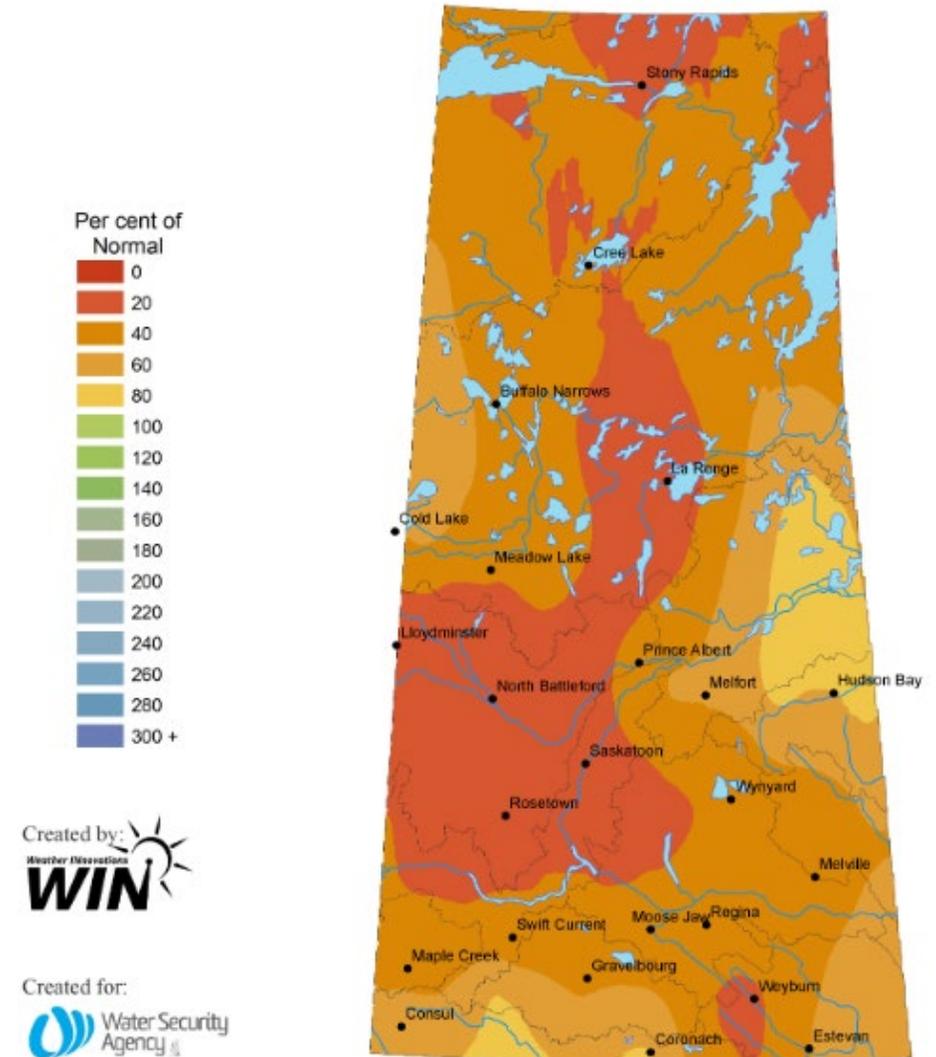
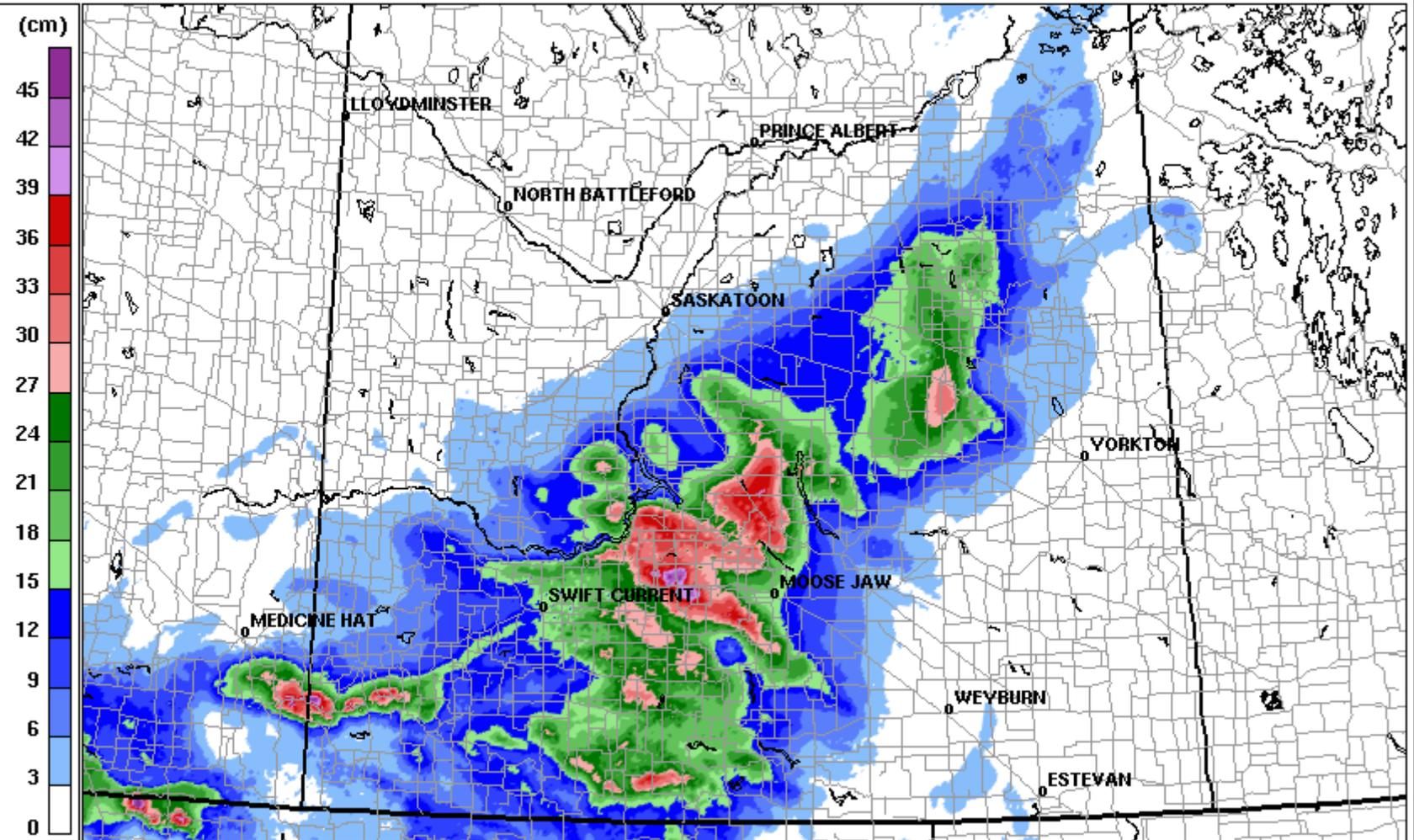


Figure 3: Per Cent Normal Precipitation
September 1 to November 1, 2022

Snowfall: 2 dys, 20221022-20221023
Chutes de neige: 2 jrs, 20221022-20221023



Gouvernement du Canada
Government of Canada



Observations blended with NWP model data / Observations intégrées à des données de modèle de PNT.

2022-10-24 12:46UTC

Figure 4: Snowfall Received from October 22 to 23, 2022
(Map Courtesy of Environment and Climate Change Canada)

Soil Moisture Conditions

Figures 6 and 7 show topsoil moisture conditions across the agricultural region of the province at the time of the final crop report issued on October 17, 2022. These figures show that conditions in the eastern portion of the grain belt generally ranged from below adequate to short (i.e., less than optimal for crop growth). In the west, conditions are generally drier with short to very short conditions being reported.

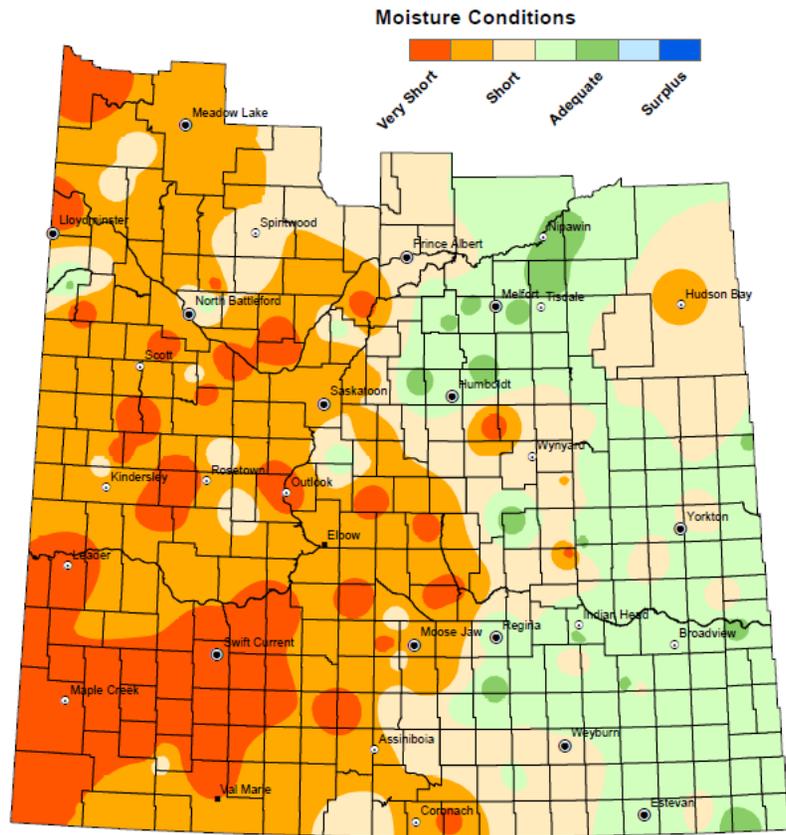


Figure 6: October 17, 2022 Cropland Topsoil Moisture Conditions
(Map Courtesy of the Saskatchewan Ministry of Agriculture)

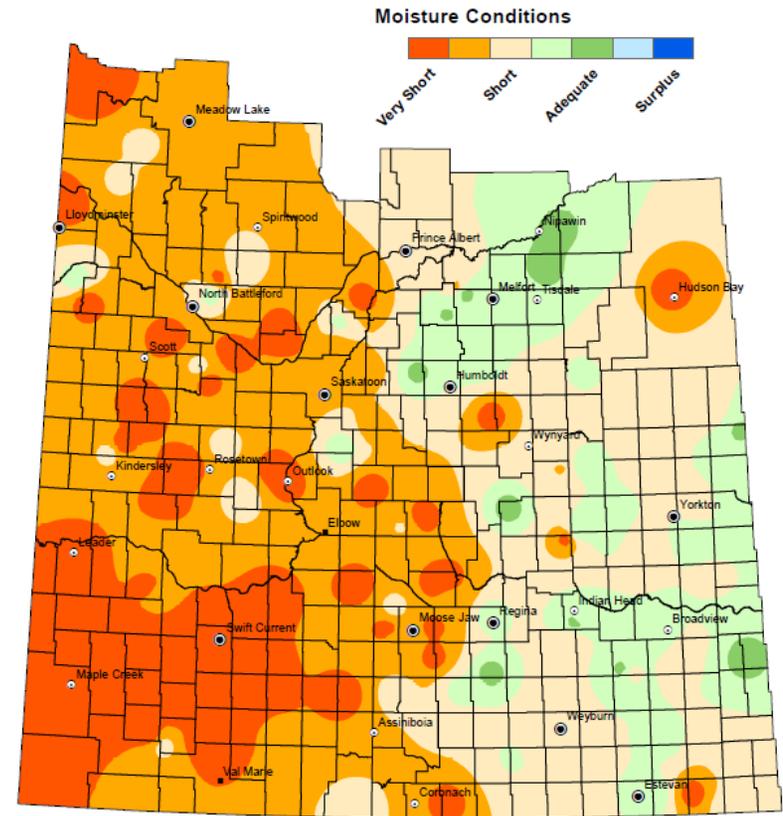


Figure 7: October 17, 2022 Hay and Pasture Topsoil Moisture Conditions
(Map courtesy of Saskatchewan Ministry of Agriculture)

Agriculture and Agri-Food Canada produces soil moisture products using data from the European Space Agency’s Soil Moisture Ocean Salinity (SMOS) satellite mission (Figure 8). This data indicates that the topsoil moisture is generally much drier than normal across most of central Saskatchewan and the Churchill River Basin. The late October snowfall event helped alleviate dry soil conditions in the south, where topsoil conditions now range from near to slightly below normal, with some small pockets where the soil moisture is above normal. In the far north, soil moisture generally ranges from slightly below

normal to slightly above normal. Conditions are wettest in the south portion of the Reindeer Lake area, where soil moisture conditions are more than 10 per cent wetter than normal.

The three-month SPEI (Standardized Precipitation-Evapotranspiration Index) map is shown in Figure 9. SPEI is a normalized drought index that uses climate data to identify areas where drought conditions exist. The SPEI values are a relative measure of surface water surplus (positive values) or deficit (negative values) in an area. The values take the current precipitation minus the potential evapotranspiration and compare it to the mean value at a location. The result is normalized, so the higher the negative number, the drier the conditions are. This map shows that in the three months prior to freeze-up, conditions had been hot and dry, particularly in the west.

The Canadian Drought Monitor assessment for October 31 is shown in Figure 10. This figure shows that with the dry fall, drought conditions ranging from abnormally dry to severe are present across most of the province. Conditions were driest in the southwest and across most of central portions of the province. Here, drought conditions generally range from moderate to severe with some small pockets, namely in the Swift Current and Saskatoon areas, where extreme drought conditions exist. With the dry fall, all of the north and parts of eastern Saskatchewan are starting to experience abnormally dry to moderate drought conditions.

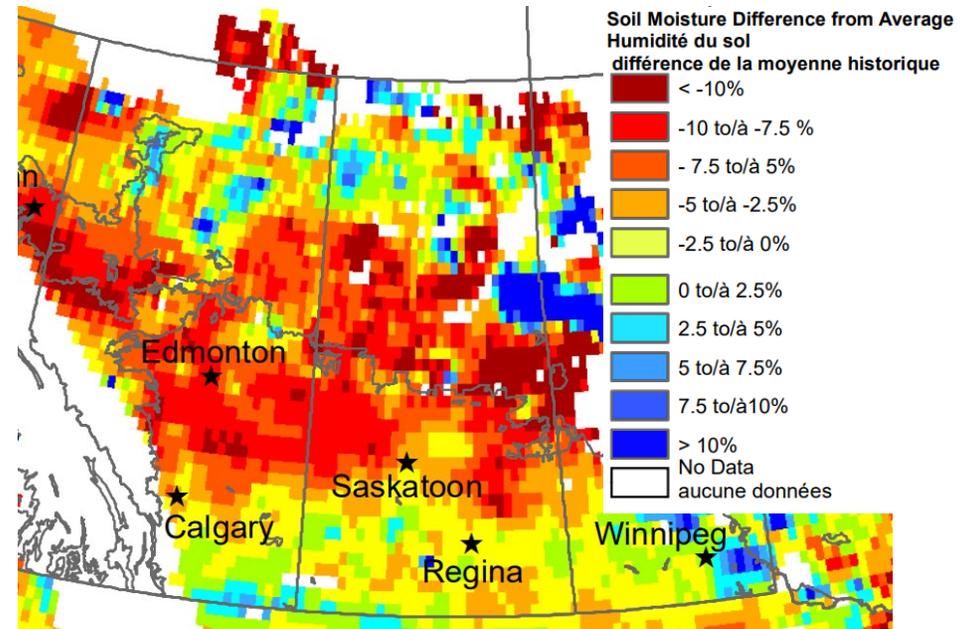


Figure 8: October 31 to November 6, 2022 Per Cent Normal Soil Moisture
(Map Courtesy of Agriculture and Agri-Food Canada)

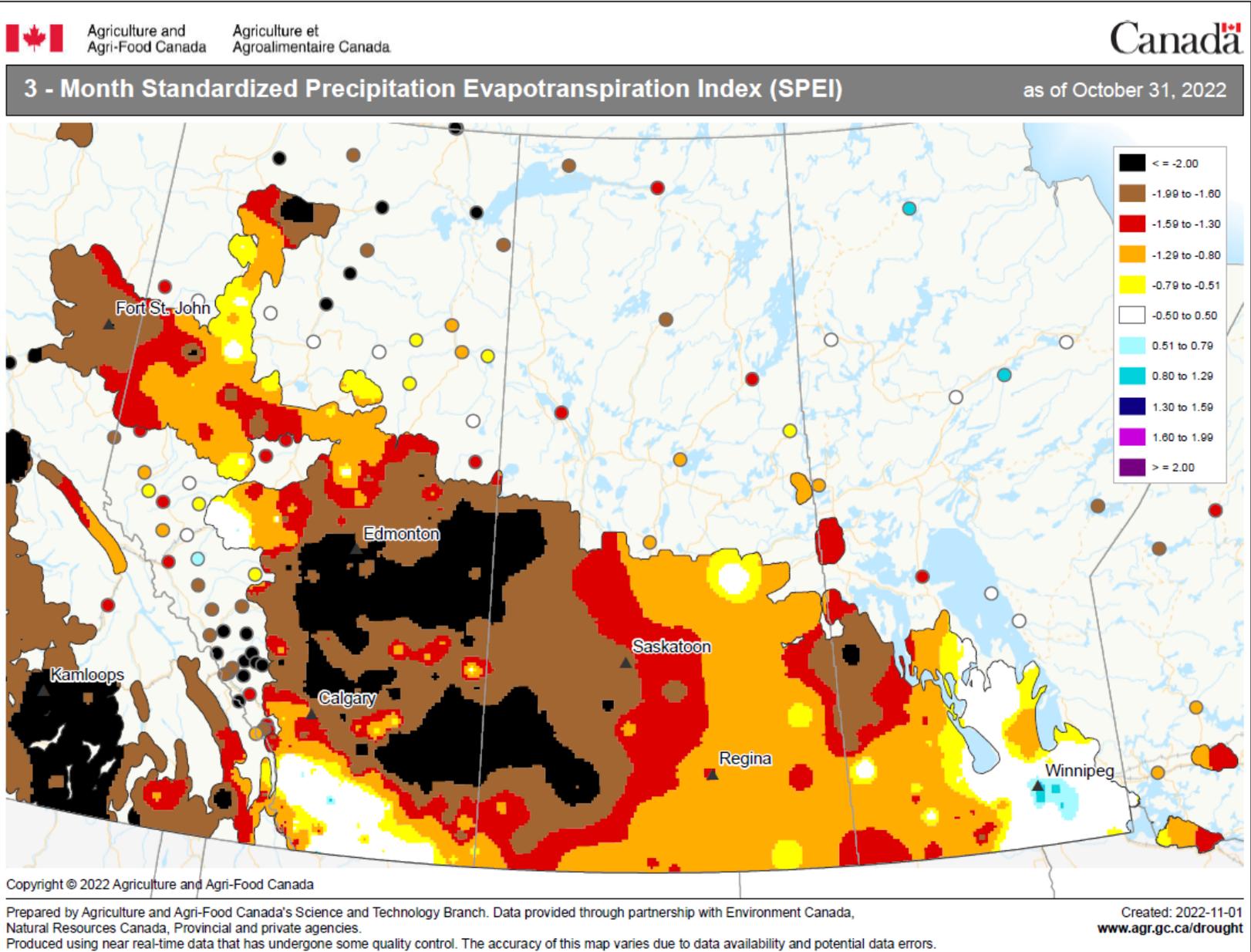
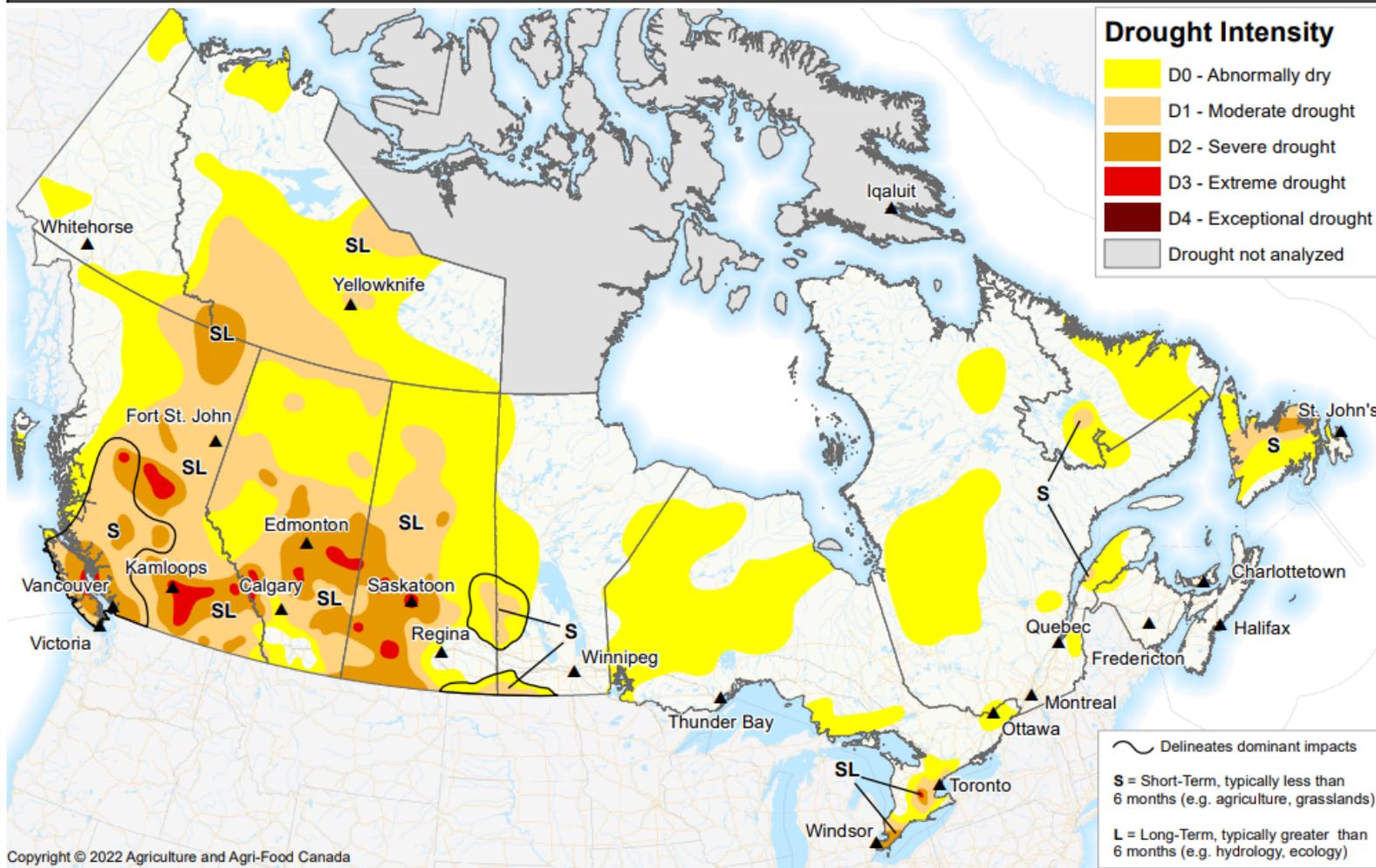


Figure 9: 3-month Standardized Precipitation-Evapotranspiration Index (SPEI) for October 31, 2022
(Map courtesy of Agriculture and Agri-Food Canada)



Canadian Drought Monitor

Conditions as of October 31, 2022



Copyright © 2022 Agriculture and Agri-Food Canada

Prepared by Agriculture and Agri-Food Canada's National Agroclimate Information Service. We also acknowledge various provincial, territorial and non-government organizations whose reports and assessments are consulted. The Drought Monitor focuses on broad-scale conditions. Regions in northern Canada may not be as accurate as other regions due to limited information.

Created: 2022-11-14
www.agr.gc.ca/drought

Figure 10: Canadian Drought Monitor – October 31, 2022
(Map courtesy of Agriculture and Agri-Food Canada)

Current Water Supply Conditions

Figure 11 shows the hydrological drought risk map developed for 2023. This map is developed based on current conditions and illustrates the risk to surface water and shallow ground water supplies in 2023. It is important to note that only local runoff is considered in the creation of this map, not the major river systems such as the Saskatchewan River System.

As this figure shows, the dry conditions across most of the southwest and west-central portions of the province throughout the year has resulted in these areas showing a higher risk to water supply in 2023. In areas where the risk is high or extreme, even a normal snowpack would likely result in further water supply shortages in 2023.

Due to dry conditions throughout the year, major surface water supplies across much of southwestern and central Saskatchewan currently remain at lower than normal levels for this time of year.

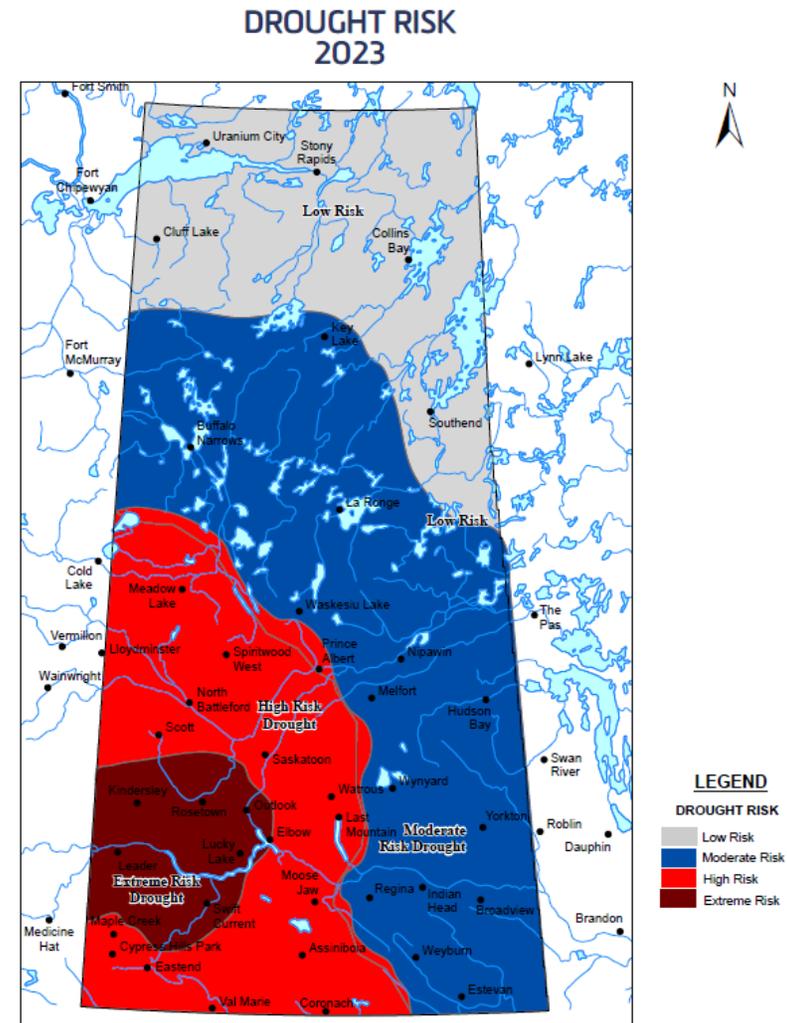


Figure 11: 2023 Drought Risk Map

Fall Streamflow

Fall streamflow is an indication of antecedent conditions within a basin prior to freeze-up. Most creeks in southern Saskatchewan are ephemeral, typically only flowing for a short duration during the spring freshet or during periods of above normal rainfall; however, when conditions are wet, these creeks can flow at elevated rates over extended durations as water stored within the basin is slowly released. This scenario would be an indication of the basin's susceptibility to higher runoff yields during the following year's spring snowmelt.

Table 1 provides a summary of the preliminary flow, rank and historical statistics for select streamflow gauges across the province for October 31, 2022. October 31 is used for this table as many of these streamflow gauges are only operated seasonally. Table 1 shows that October 31 flows generally varied from near to well below normal across southern and central Saskatchewan, with flows on some rivers in the west being near lower quartile levels at freeze-up. In the north, on the Churchill River, flows are near to slightly below normal due to drier conditions over the past few months. Flows in the southeast, including Long, Moose Mountain and Pipestone creeks, had late season flows that were slightly above normal. Drier conditions in fall 2022 across most of western Saskatchewan has resulted in a reduced runoff potential for the spring.

Pre-Spring Runoff Lake Level Projections

Table 2 shows the current lake levels on the Qu'Appelle River, and their projected March 1, 2023 levels. All lakes on the Qu'Appelle River System are expected to be near their normal levels on March 1, 2023.

Fishing Lake and the Quill lakes are expected to see small gains over the winter due to snow loading and potential groundwater inflows.

In other closed or semi closed basin lakes, many of which are not gauged and not included in the table below, water levels have dropped and are expected to remain relatively steady going into the 2023 spring runoff.

In the Souris River Basin, Grant Devine Lake is being drawn down to meet the February 1 target elevation of 561.0 m through a 0.6 m³/s release. This release is expected to continue into late December. Rafferty Reservoir is below its prescribed February 1 maximum level. As such, a winter release prior to February 1 is not required at Rafferty Dam. Beginning on February 1, 2023, spring runoff forecasts for the Souris River Basin will be prepared in consultation with our United States partners for both reservoirs on a semi-monthly basis. The reservoirs may be drawn down further in advance of spring runoff if warranted by these forecasts, in accordance with the 1989 Canada-US Agreement on Water Supply and Flood Control in the Souris River Basin.

Winter streamflows on the North Saskatchewan River are expected to be near normal through the winter. On the South Saskatchewan River, inflows to Lake Diefenbaker are expected to remain slightly below normal through the winter. With the drier conditions in the basin, the plan is to restrict releases from Lake Diefenbaker throughout the winter with a target elevation slightly above normal for the end of March. The below normal releases on the South Saskatchewan River this winter will result in below normal flows on the Saskatchewan River. Cumberland Lake is currently below normal due to dry conditions this past year, which resulted in below normal flows on the Saskatchewan River System. The lake is expected to remain at below normal levels throughout the winter.

Table 1: Fall Stream Flow Conditions

Station	2022 Flow (m ³ /s)	2022 Rank	Years of Record	Lower Quartile Flow (m ³ /s)	Median Flow (m ³ /s)	Upper Quartile Flow (m ³ /s)	Historical Rankings				
							1	2	3	4	5
ASSINIBOINE RIVER AT KAMSACK	0.60	42	79	0.3	0.6	1.7	2010	2016	2014	1954	1995
BALLANTYNE RIVER ABOVE BALLANTYNE BAY	2.9	39	47	3.5	6.4	8.6	2016	1970	1979	2012	1993
BATTLE CREEK AT ALBERTA BOUNDARY	0.25	16	48	0.2	0.2	0.3	2010	2016	2011	2012	1993
BATTLE RIVER NEAR THE SASKATCHEWAN BOUNDARY	2.3	15	44	1.1	1.9	2.8	1980	1982	1981	1986	2005
BEAVER RIVER BELOW WATERHEN RIVER	50	19	48	28	42	68	2005	1973	1997	2017	1974
BIRCH CREEK NEAR ELFROS	0.0	36	60	0.0	0.0	0.0	2016	2010	2006	1995	2005
CANOE RIVER NEAR BEAUVAL	14.6	21	50	7.7	12	18	1973	2005	1997	1995	2012
CARROT RIVER NEAR TURNBERRY	6	41	57	5.0	8.8	15	2016	2006	2005	2010	1978
CHURCHILL RIVER ABOVE OTTER RAPIDS	300	33	60	202	307	410	2020	1974	2005	1997	2017
CHURCHILL RIVER NEAR PATUANAK	171	12	40	91.1	142	180	1974	2020	2017	1975	2019
CUTARM CREEK NEAR SPY HILL	0.00	77	81	0.0	0.1	0.2	2016	2010	2014	1953	1954
DORE RIVER NEAR THE MOUTH	3.3	20	52	1.0	2.1	5.4	2017	1974	2007	1975	2018
FRENCHMAN RIVER AT INTERNATIONAL BOUNDARY	0.04	79	96	0.0	0.2	0.5	2016	2014	2010	2019	1983
HAULTAIN RIVER ABOVE NORBERT RIVER	8	53	54	12.3	16.9	24.1	2016	2012	1978	1997	1979
IRONSRING CREEK NEAR WATSON	0.0	43	61	0.0	0.0	0.0	2016	2006	2010	2005	2014
LANIGAN CREEK ABOVE BOULDER LAKE	0.0	22	65	0.0	0.0	0.0	2010	2006	2015	2016	2005
LIGHTNING CREEK NEAR CARNDUFF	0.0	13	50	0.0	0.0	0.0	1975	2014	2016	1985	2013
LONG CREEK NEAR NOONAN	0.1	14	94	0.0	0.0	0.0	2013	1911	2011	2014	2010
MOOSE JAW RIVER NEAR BURDICK	0.2	29	70	0.0	0.1	0.2	2016	1959	1993	2002	1954
MOOSE MOUNTAIN CREEK ABOVE GRANT DEVINE LAKE	0.1	35	86	0.0	0.0	0.2	2014	2010	2011	1954	1955
NOTUKEU CREEK NEAR VANGUARD	0.0	64	75	0.0	0.1	0.1	2016	2011	1963	1916	1965
PIPESTONE CREEK ABOVE MOOSOMIN LAKE	0.2	14	50	0.0	0.0	0.2	2014	2011	2010	2016	2001
QU'APPELLE RIVER NEAR WELBY	8.7	22	61	3.7	5.5	9.9	2014	2010	2011	2016	1954
RED DEER RIVER NEAR ERWOOD	0.9	65	69	2.0	4.1	7.2	2016	2010	1954	1970	2006
REINDEER RIVER ABOVE DEVIL RAPIDS	338	20	38	253	344	444	1997	2020	2009	1987	1992
STURGEON RIVER NEAR PRINCE ALBERT	0.7	21	46	0.2	0.5	2.0	2010	2016	2015	2012	2018
STURGEON-WEIR RIVER AT LEAF RAPIDS	49	17	45	33.0	45.3	54.1	2005	2020	1974	1983	2016
SWAN RIVER NEAR NORQUAY	0.87	39	48	1.0	2.1	3.4	2016	1970	2010	1993	2009
SWIFT CURRENT CREEK BELOW ROCK CREEK	0.64	11	68	0.2	0.3	0.5	2016	2015	2014	2013	2011
TORCH RIVER NEAR LOVE	3.5	46	66	3.1	4.7	7.3	2016	2005	1954	2015	2004

Station	2022 Flow (m ³ /s)	2022 Rank	Years of Record	Lower Quartile Flow (m ³ /s)	Median Flow (m ³ /s)	Upper Quartile Flow (m ³ /s)	Historical Rankings				
							1	2	3	4	5
WATHAMAN RIVER BELOW WATHAMAN LAKE	34	45	52	41.8	59.6	83.6	1997	2005	1978	2020	1976
WHEELER RIVER BELOW RUSSELL LAKE	11	46	50	14.4	17.1	20.3	1976	1997	2020	1978	1979
WHITESAND RIVER NEAR CANORA	0.3	33	76	0.0	0.2	0.5	2016	2010	2014	1995	1954
WOOD RIVER NEAR LAFLECHE	0.0	21	66	0.0	0.0	0.0	2016	2014	2013	2019	2015
YELLOW GRASS DITCH NEAR YELLOW GRASS	0.0	11	66	0.0	0.0	0.0	2011	2010	2000	2014	2009
YORKTON CREEK NEAR EBENEZER	0.1	39	78	0.0	0.1	0.2	2016	2014	1954	2010	1995

Table 2: November 1, 2022 Observed Levels and Projections for March 1, 2023

Lake	November 1, 2022			March 1, 2023		
	Observed 2022 (masl)	Median (masl)	Departure from Median (m)	Projected 2023 (masl)	Median (masl)	Departure from Median (m)
Last Mountain	489.94	489.88	0.06	489.9	489.9	-0.0
Echo-Pasqua	478.45	478.56	-0.11	478.4	478.5	-0.10
Mission-Katepwa	478.31	478.35	-0.04	478.28	478.27	0.01
Crooked	450.93	451.07	-0.14	450.7	450.8	-0.10
Round	441.93	441.83	0.10	441.68	441.55	0.13
Quill lakes	519.55	515	4.55	519.57	515	4.57
Fishing	529.80	529	0.80	529.82	529	0.82

Climatic Conditions and Long-Range Weather Forecasts

Large Scale Climate Influences

The hydroclimate of Saskatchewan is heavily influenced by varying, recurring large-scale climate patterns such as the Pacific Decadal Oscillation (PDO), Pacific North American mode (PNA), and the El Niño-Southern Oscillation (ENSO). These large-scale climatic influences can provide insight but should be considered within the context of past experiences rather than a forecast of upcoming conditions.

PDO

The Pacific Decadal Oscillation is an index of sea surface temperatures over the northern portion of the Pacific Ocean. This index shifts from warm (positive) to cool (negative) phases lasting about 20 to 35 years. During negative phases, Saskatchewan typically experiences above normal snowfall and consequently experiences larger spring runoff events. Conversely, we tend to see lower than normal snowfall when the PDO is in its positive phase. The PDO signal has been negative since January 2020 and was strong in October 2022 at -1.5. The PDO is expected to remain in its negative phase throughout the winter.

PNA

The Pacific North American Pattern is one of the most prominent modes of low-frequency variability in the Northern Hemisphere extratropics and is associated with fluctuations in the strength and location of the jet stream. During the positive phase, warmer and drier conditions typically persist over western North America. The PNA is difficult to forecast beyond

one month. The PNA is currently in the positive phase. The PNA is expected to go into the negative phase in November.

ENSO

The El Niño-Southern Oscillation is a naturally occurring phenomenon that involves fluctuating Pacific Ocean temperatures near the equator. During El Niño (Warm Phase) years, Saskatchewan typically experiences warmer and drier winters. The opposite generally occurs during La Niña (Cool Phase) years; conditions tend to be cooler and wetter. Strong La Niña conditions are currently present. Based on model outputs, these conditions are likely to continue throughout the winter and there is about a 76 per cent chance that these conditions will continue into spring 2023. Most models also expect for the La Niña signal to become closer to neutral during the spring of 2023.

Seasonal Outlooks

The US National Weather Service hosts a webpage with seasonal forecasts from six models, including two Environment and Climate Change Canada models, and produces multi-model ensemble products. Most of these models are forecasting near normal precipitation over Saskatchewan between November 1 and January 31. One exception is across the far south, along the US border, where the models are trending towards wetter than normal conditions. There is less agreement amongst the models when it comes to temperatures; however, they are tending to suggest near normal temperatures over most of the province during this three-month period. The exception is the far northwest where below normal temperatures are expected. Three-month spatial anomalies maps for precipitation (Figure 12) and temperature (Figure 13) covering the November 1 and January 31 forecast period are provided.

Summary of Winter Precipitation Outlook

Most indices and models suggest that over the winter months, Saskatchewan will generally receive near to above normal snowfall and experience near normal temperatures. However, some of our snowiest winters have occurred when the PDO is in its negative phase during a La Niña event, which is currently the case. It is important to keep in mind that seasonal weather forecasts are statistically unreliable.

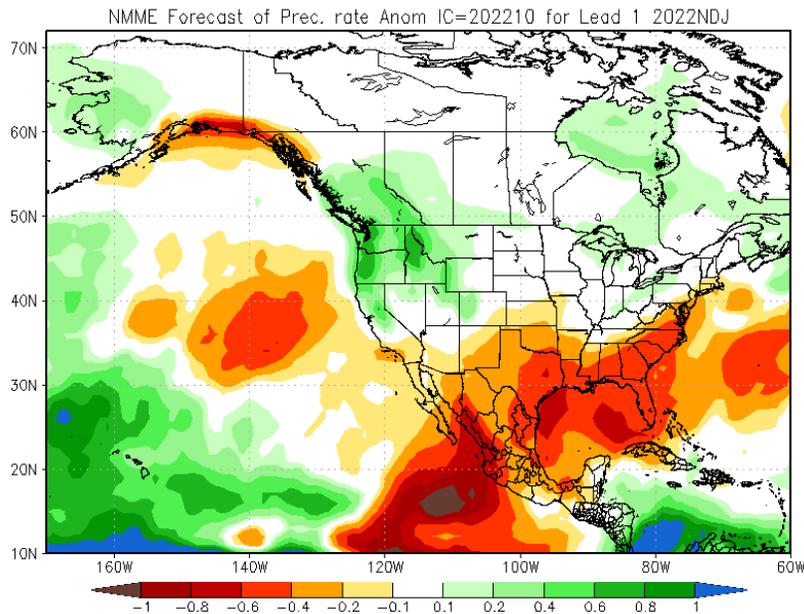


Figure 12: North American Multi-Model Ensemble Precipitation Anomaly Outlook for November 1, January 31, 2023 (Map courtesy of the US National Weather Service)

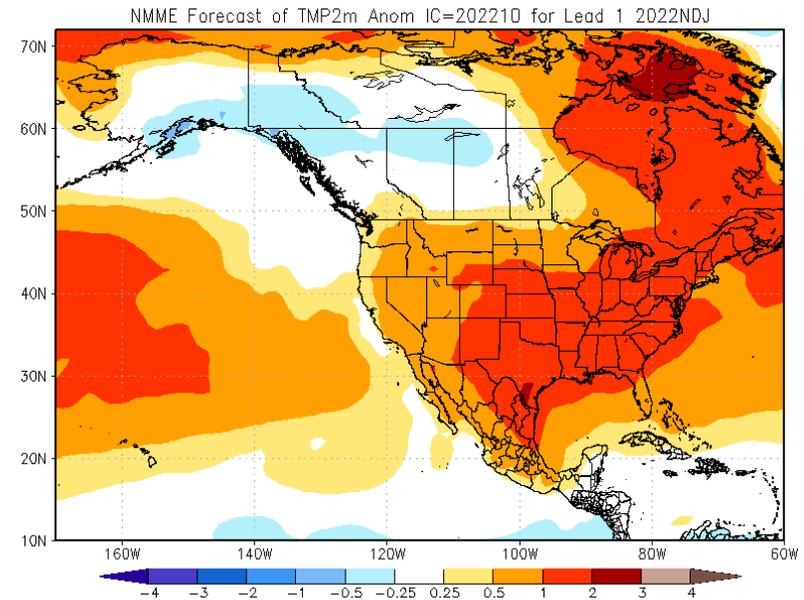


Figure 13: North American Multi-Model Ensemble Temperature Anomaly Outlook for November 1, 2022 to January 31, 2023 (Map courtesy of the US National Weather Service)

Monitoring of Runoff Conditions and Spring Runoff Forecasts

The Water Security Agency will continue to monitor conditions throughout the 2022-23 winter. Beginning in early February, Spring Runoff Outlooks will be released on www.wsask.ca.