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





2021 Conditions at Freeze-up Report Based on Conditions as of November 15, 2021

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 which are more vulnerable to 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 this early in the winter season.

Due to minimal runoff in the spring of 2021 followed by what was generally a hot dry summer, most agricultural areas of the province are currently experiencing drier than normal moisture conditions. Conditions are driest starting in the central area of the province around Saskatoon and extending in a south westerly direction towards Rosetown, and down through Leader and then to the Maple Creek area. In these areas, exceptional drought conditions exist.

While most larger water supply reservoirs across southern and central Saskatchewan have adequate supplies, surface water users who rely on smaller reservoirs or dugouts have been impacted by the dry conditions. This includes diminished supplies and quality. Without an above normal snowpack, these conditions are expected to worsen in 2022.

Below normal rainfall was also received across the north throughout the 2021 growing season. With the wet conditions in 2020, water levels remained high throughout the first half of the year but have since tapered off to near normal going into freeze-up. Winter flows in northern areas are expected to continue to drop to somewhat below normal over the course of the winter. In the grainbelt region of the province where conditions at freeze-up were much drier, the infiltration capacity of the soils and storage capacity within wetland areas will be higher, reducing the risk of above normal runoff this spring. Across most of the grainbelt, above normal snowfall is needed to result in sufficient runoff to replenish surface water supplies in spring 2022.

At this time, there are no areas where WSA believes that there is a heightened risk of above normal spring runoff in 2022.

Current long-range forecasts and climate indices suggest near normal precipitation and below normal temperatures over the winter months over much of the province. However, La Niña and 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 2022 will be issued in early February.

Precipitation and Conditions Leading into Freeze-Up

2021 Spring Runoff Summary

Most of south and central Saskatchewan experienced a well below normal snowmelt runoff in 2021. The exception is the Cypress Hills area and the Swift Current Creek Basin where, due to a quick melt, a near normal runoff response was observed. Northern portions of the province saw a near to above normal runoff response. Areas in both the Churchill River Basin and the Lake Athabasca Basin recorded peak flows that were above normal as the high precipitation accumulations observed in 2020 was continuing to impact water levels and flows.

2021 Summer Precipitation Summary

As shown in Figure 1 and Figure 2, precipitation over most of central and southwestern Saskatchewan was lower than normal throughout the 2021 summer. This area of the province generally received 40 to 60 per cent of normal precipitation. Conditions were particularly dry in the Saskatoon area where precipitation accumulation percentiles were classified as extremely low. In the southeast, precipitation ranged from 80 to 100 per cent of normal as a couple of late summer rainfall events improved the tally. In the north, some rainfall events occurred in the spring, but the summer was generally drier then normal with most of the area receiving around 80 per cent of normal precipitation.



Figure 1: 90-day Per cent of Normal Rainfall Accumulations June 3 to August 31, 2021



Figure 2: April 1 to August 31, 2021 Precipitation Compared to Historic (Map Courtesy of Agriculture and Agri-Food Canada)

2021 Fall Precipitation Summary

Figure 3 shows how the precipitation for the entire growing season (April 1 to October 31, 2021) compared to normal. Conditions were generally drier than normal across the entire province over this period. The north and the southeast generally received 80 per cent of normal while central and southwestern portions of the province received 40 to 60 per cent of normal precipitation over this period.

Figure 4 shows the per cent of normal rainfall received from mid-September to mid-November, and Figure 5 shows total precipitation percentiles over the same period. As shown in these two figures, central and southwestern portions of the province generally received 40 to 60 per cent of normal accumulations. In the area between Saskatoon and Leader, less than 40 per cent of normal fall precipitation was received. In the southeast, rainfall accumulations were closer to normal. Over the north, fall precipitation ranged from near to below normal.



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Figure 3: Per cent of Normal Precipitation April 1 to November 15, 2021



Figure 4: Per cent of Normal Precipitation, September 16 to November 15, 2021 (Map Courtesy of Agriculture and Agri-Food Canada)



Figure 5: Precipitation Percentiles, September 16 to November 15, 2021 (Map Courtesy of Agriculture and Agri-Food Canada)

Soil Moisture Conditions

Figure 6 and Figure 7 indicate that topsoil moisture conditions across the agricultural region of the province generally ranged from adequate to short across the southeastern portion of the grain belt during the final crop report on October 4, 2021. In the southwest and across most of central Saskatchewan, conditions are generally drier with short to very short conditions being reported.



Figure 6: October 4, 2021 Cropland Topsoil Moisture Conditions (Map Courtesy of the Saskatchewan Ministry of Agriculture)



Figure 7: October 4, 2021 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 conditions are generally much drier than normal across most of Saskatchewan. The driest area is in east central portions of the province and up into the Churchill River Basin where soil moisture is more than 10 per cent drier than normal. Across the north, there are still some small pockets where soil moisture is above normal, particularly the southern parts of the Reindeer Lake area. The Canadian Drought Monitor assessment for October 31 is shown in Figure 9. Across southern and central portions of the province drought conditions still exist, ranging from severe to exceptional drought. The exception is the Regina area where moderate drought conditions persist. Conditions are driest starting in the central area of the province around Saskatoon extending in a south westerly direction towards Rosetown, down through Leader and then to the Maple Creek area. In these areas, exceptional drought conditions exist — conditions that are expected to occur, on average, only once in a 50-year period. Conditions across northern Saskatchewan generally range from abnormally dry in the far north to severe in southern portions of the Churchill River Basin.



Figure 8: November 8 – November 14, 2021 Per cent of Normal Soil Moisture (Map Courtesy of Agriculture and Agri-Food Canada)



Figure 9: Canadian Drought Monitor – September 30, 2021 (Map courtesy of Agriculture and Agri-Food Canada)

Current Water Supply Conditions

Figure 10 shows the hydrological drought risk map developed for 2022. This map is developed based on current conditions and illustrates the risk to surface water and shallow ground water supplies in 2022 based on current moisture conditions. It is also 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 south and central portions of the province are expected to cause impacts to water supply in 2022. In areas where the risk is high or extreme, even a normal snowpack would likely result in further water supply shortages in 2022.

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



Figure 10: 2022 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, 2021. October 31 is used for this table as many of these streamflow gauges are only operated seasonally. Table 1 shows that October 31 flows were generally near to below normal across southern and central Saskatchewan, with flows on many rivers being near lower quartile levels at freeze up. In the north, due to the dry conditions during 2021, flows are expected to continue to drop to below median levels over the winter and into the early spring. The exception is Reindeer River, where, due to increased outflows from White Sand Dam, flows remain near upper quartile levels. As conditions in the fall of 2021 are drier than normal across most of southern and central Saskatchewan, there is a decreased runoff potential for next spring.

Pre-Spring Runoff Lake Level Projections

Table 2 shows the current lake levels on the Qu'Appelle River, and their projected March 1, 2022 levels. Buffalo Pound, Mission-Katepwa, and Crooked lakes are expected to be near their normal levels on March 1, 2022. With dry conditions within the watershed above Echo Lake, some stoplogs will be kept in the Echo Lake control structure over the winter. As a result, levels on Echo Lake will be higher than normal in spring 2022 unless WSA elects to remove logs ahead of snowmelt runoff. Due to the dry conditions over the past couple of years, Last Mountain Lake is expected to be below normal levels in spring 2022.

Fishing Lake and the Quill Lakes are expected to see small gains over the winter period 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 steady going into 2022 spring runoff.

In the Souris River Basin, Grant Devine Lake and Rafferty Reservoir are both below their prescribed February 1 maximum levels. As such, winter releases prior to Feb 1 will not be required. Beginning on February 1, 2022, spring runoff forecasts for the Souris River Basin will be prepared in consultation with our United States partners for both reservoirs on a semimonthly 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 somewhat below normal through the winter, and Lake Diefenbaker is expected to remain below normal. Winter releases from Lake Diefenbaker will also remain well below normal resulting in Lake Diefenbaker water levels being near median coming into the spring runoff period. The low flows on the South Saskatchewan River this winter will result below normal flows on the Saskatchewan River.

Table 1: Fall Stream Flow Conditions

	2021	2021 Rank	Years of Record	Lower Quartile Flow (m ³ /s)	Median Flow (m³/s)	Upper	Historical Rankings				
Station	Flow (m³/s)					Quartile Flow (m³/s)	1	2	3	4	5
ASSINIBOINE RIVER AT KAMSACK	0.20	62	78	0.3	0.7	1.7	2010	2016	2014	1954	1995
BALLANTYNE RIVER ABOVE BALLANTYNE BAY	3.5	35	46	3.5	6.4	8.6	2016	1970	1979	2012	1993
BATTLE CREEK AT ALBERTA BOUNDARY	0.22	20	47	0.2	0.2	0.3	2010	2016	2011	2012	1993
BATTLE RIVER NEAR THE SASKATCHEWAN BOUNDARY	0.8	39	43	1.1	1.9	3.0	1980	1982	1981	2020	1986
BEAVER RIVER BELOW WATERHEN RIVER	22	39	47	28	41	69	2005	1973	1997	2017	1974
BIRCH CREEK NEAR ELFROS	0.0	36	59	0.0	0.0	0.0	2016	2010	2006	1995	2005
CANOE RIVER NEAR BEAUVAL	7.9	35	49	7.6	11	18	1973	2005	1997	1995	2012
CARROT RIVER NEAR TURNBERRY	0	56	56	4.9	9.4	15	2016	2006	2005	2010	1978
CHURCHILL RIVER ABOVE OTTER RAPIDS	325	26	59	201	308	411	2020	1974	2005	1997	2017
CHURCHILL RIVER NEAR PATUANAK	155	15	39	90.7	140	182	1974	2020	2017	1975	2019
CUTARM CREEK NEAR SPY HILL	0.15	29	80	0.0	0.1	0.2	2016	2010	2014	1953	1954
DORE RIVER NEAR THE MOUTH	3.1	21	51	1.0	2.0	5.4	2017	1974	2007	1975	2018
FRENCHMAN RIVER AT INTERNATIONAL BOUNDARY	0.00	85	96	0.1	0.2	0.5	2016	2014	2010	2019	1983
HAULTAIN RIVER ABOVE NORBERT RIVER	23	16	53	12.9	16.9	24.3	2016	2012	1978	2020	1997
IRONSPRING CREEK NEAR WATSON	0.0	43	60	0.0	0.0	0.0	2016	2006	2010	2005	2014
LANIGAN CREEK ABOVE BOULDER LAKE	0.0	22	64	0.0	0.0	0.0	2010	2006	2015	2016	2005
LIGHTNING CREEK NEAR CARNDUFF	0.0	28	49	0.0	0.0	0.0	1975	2014	2016	1985	2013
LONG CREEK NEAR NOONAN	0.0	76	93	0.0	0.0	0.0	2013	1911	2011	2014	2010
MOOSE JAW RIVER NEAR BURDICK	0.0	53	69	0.0	0.1	0.2	2016	1959	1993	2002	1954
MOOSE MOUNTAIN CREEK ABOVE GRANT DEVINE LAKE	0.0	56	85	0.0	0.0	0.2	2014	2010	2011	1954	1955
NOTUKEU CREEK NEAR VANGUARD	0.0	64	74	0.0	0.1	0.1	2016	2011	1963	1916	1965
PIPESTONE CREEK ABOVE MOOSOMIN LAKE	0.0	30	49	0.0	0.0	0.2	2014	2011	2010	2016	2001
QU'APPELLE RIVER NEAR WELBY	5.5	30	60	3.8	5.7	10.0	2014	2010	2011	2016	1954
RED DEER RIVER NEAR ERWOOD	0.6	65	68	2.0	4.2	7.2	2016	2010	1954	1970	2006
REINDEER RIVER ABOVE DEVIL RAPIDS	450	10	36	249	344	432	1997	2009	1987	1992	1991
STURGEON RIVER NEAR PRINCE ALBERT	0.3	26	45	0.2	0.4	2.1	2010	2016	2015	2012	2018
STURGEON-WEIR RIVER AT LEAF RAPIDS	40	27	44	32.3	44.8	54.9	2005	2020	1974	1983	2016
SWAN RIVER NEAR NORQUAY	0.52	44	47	1.1	2.2	3.4	2016	1970	2010	1993	2009
SWIFT CURRENT CREEK BELOW ROCK CREEK	0.37	31	67	0.2	0.3	0.5	2016	2015	2014	2013	2011
TORCH RIVER NEAR LOVE	7.5	16	65	3.0	5.1	7.3	2016	2005	1954	2015	2004

	2021 Flow (m³/s)	2021 Rank	Years of Record	Lower Quartile Flow (m ³ /s)	Median Flow (m³/s)	Upper Quartile Flow (m ³ /s)	Historical Rankings				
Station							1	2	3	4	5
WATHAMAN RIVER BELOW WATHAMAN LAKE	42	39	51	42.1	59.7	83.8	1997	2005	1978	2020	1976
WHEELER RIVER BELOW RUSSELL LAKE	17	24	49	14.4	17.2	20.4	1976	2020	1997	1978	1979
WHITESAND RIVER NEAR CANORA	0.0	59	75	0.0	0.2	0.5	2016	2010	2014	1995	1954
WOOD RIVER NEAR LAFLECHE	0.0	27	65	0.0	0.0	0.0	2016	2014	2013	2019	2015
YELLOW GRASS DITCH NEAR YELLOW GRASS	0.0	11	65	0.0	0.0	0.0	2011	2010	2000	2014	2009
YORKTON CREEK NEAR EBENEZER	0.1	42	77	0.0	0.1	0.2	2016	2014	1954	2010	1995

Table 2: November 15, 2021 Observed Levels and Projections for March 1, 2021

Lake		November 1, 20	020	March 1, 2021				
	Observed 2021 (masl)	Median (masl)	Departure from Median (m)	Projected 2022 (masl)	Median (masl)	Departure from Median (m)		
Last Mountain	489.61	489.88	-0.27	489.5	489.9	-0.40		
Echo-Pasqua	478.90	478.56	0.34	478.85	478.5	0.35		
Mission-Katepwa	478.23	478.35	-0.12	478.23	478.27	-0.04		
Crooked	450.63	451.07	-0.44	450.6	450.8	-0.20		
Round	441.78	441.83	-0.05	441.57	441.55	0.02		
Quill Lakes	519.52	515	4.52	519.53	515	4.53		
Fishing	529.45	529	0.45	529.48	529	0.48		

Climatic Conditions and Long-Range Weather Forecasts

Large Scale Climate Influences

The hydroclimate of Saskatchewan is heavily influenced by teleconnections with recurring large-scale climate patterns such as the Pacific Decadal Oscillation (PDO), Pacific North American mode (PNA), and the El Nino-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 (PDO) 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 on inter-decadal time scales, typically 20-35 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 over the past year. This has continued through the fall and has been strengthening. The PDO is expected to remain in its negative phase through the winter.

PNA

The Pacific North American Pattern (PNA) 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 and is expected remain positive for the next month.

ENSO

The El Niño-Southern Oscillation (ENSO) 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 converse generally occurs during La Niña (Cool Phase) years.

Weak La Niña conditions are currently present. Based on model outputs, these conditions are likely to continue, but weaken, through the winter and there is about a 90% chance that these conditions will continue into spring 2021. Most models also expect for the La Niña signal to become closer to neutral during the spring of 2022.

Seasonal Outlooks

The US National Weather Service host 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 December 1 and February 28. One exception is through central areas 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 cooler than normal temperatures over northern regions and near normal over southern regions during this three-month period. Threemonth spatial anomalies maps for precipitation (Figure 10) and temperature (Figure 11) covering the December 1 and February 28 forecast period are provided here.

Summary of Winter Precipitation Outlook

Most indices and models suggest that over the winter months Saskatchewan will receive near normal snowfall and experience cooler than normal temperatures. It is important to keep in mind that seasonal weather forecasts are statistically unreliable.



Figure 11: North American Multi-Model Ensemble Precipitation Anomaly Outlook for December 1, 2021 to February 28, 2022 (Map courtesy of the US National Weather Service)



Figure 12: North American Multi-Model Ensemble Temperature Anomaly Outlook for December 1, 2021 to February 28, 2022 (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 winter of 2021/2022. Beginning in early February, Spring Runoff Outlooks will be released on www.wsask.ca