Upper Missouri River Basin
January 2021 Calendar Year Runoff Forecast
January 5, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at http://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

The 2020 calendar year runoff summation for the Missouri Basin above Sioux City, IA was **31.1 MAF**, **121% of average**, an upper quartile runoff.

December runoff was 1.2 MAF, 148% of average. Runoff in all reaches, except for the Fort Randall reach, was above average. The above-average December runoff was primarily due to above-normal temperatures over much of the Basin melting accumulated plains snowpack.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **23.1 MAF, 90% of average**. The 2021 calendar year runoff forecast for the Missouri Basin above Gavins Point is **25.3 MAF**, **108% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 12 months, expected inflow could range from the 32.0 MAF upper basic forecast to the 15.3 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier

conditions, respectively. Given that twelve months are being forecast for this January 1 forecast (0 months observed/12 months forecast), the range of possible wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is very large, and is attributed to all six reaches for the entire year. The result is a range or "bracket" for each reach, and thus, for the total runoff forecast.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for December 29, 2020 is shown in **Figure 1**. The drought monitor is available at http://droughtmonitor.unl.edu/. The U.S. Drought Monitor shows only Abnormally Dry (D0) conditions in the most distant headwater areas of the Missouri River and Yellowstone River in the upper Basin. Some D0 conditions also exist within western Kansas. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of March, indicates no drought development within the Missouri River Basin during the outlook period.

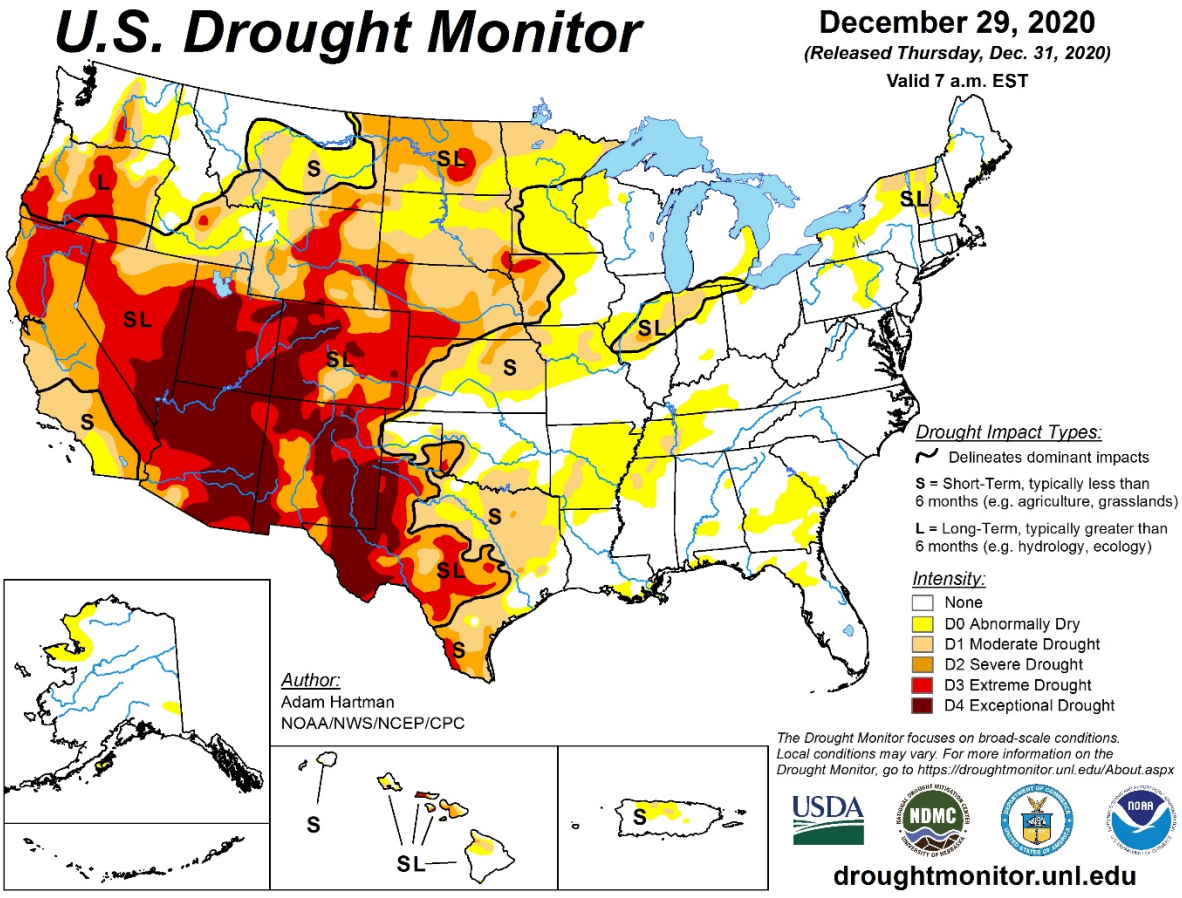

Figure 1. National Drought Mitigation Center U.S. Drought Monitor for December 29, 2020.

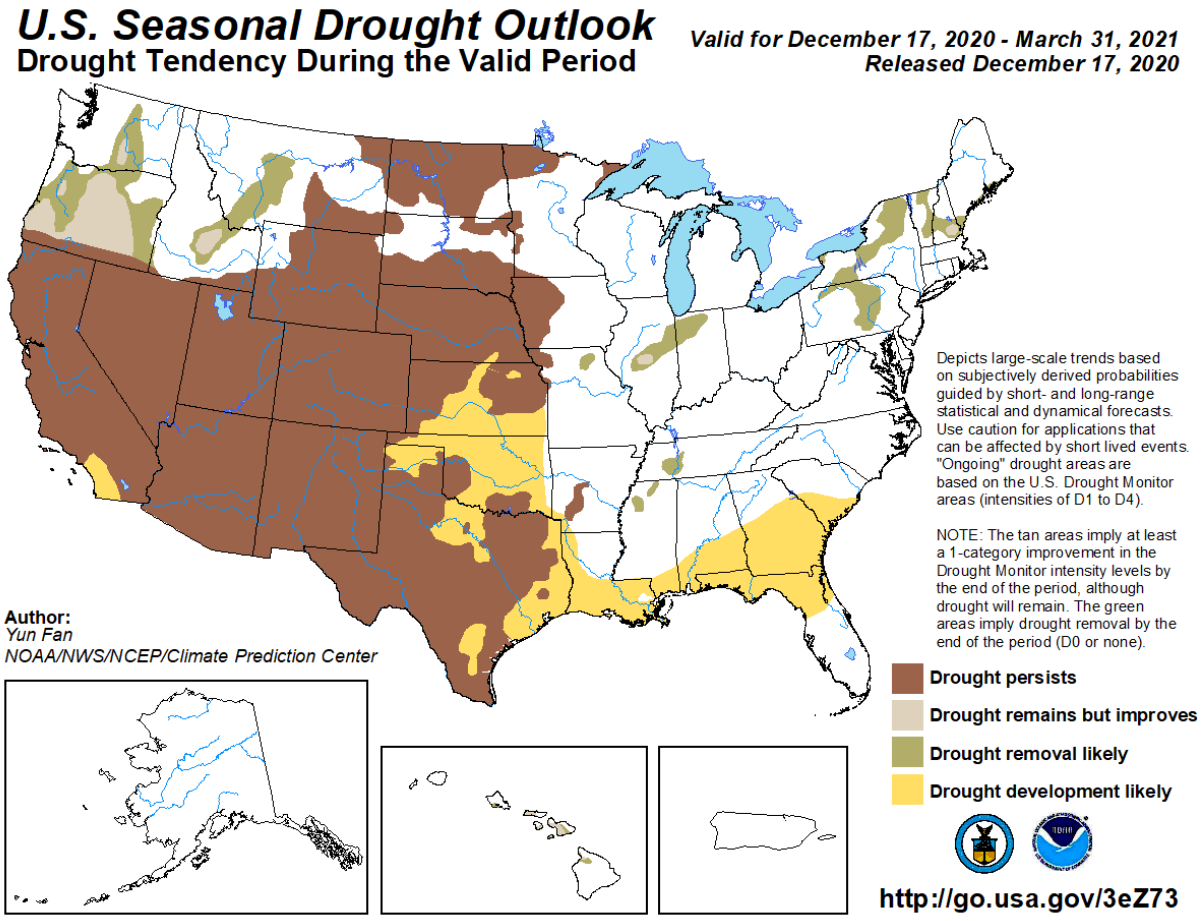

Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at http://www.hprcc.unl.edu/. The December precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. December precipitation was generally below normal across the Basin with large areas of well below normal precipitation in Montana and North Dakota. Heavy precipitation, exceeding 150 percent of normal, did occur in localized areas in each state.

Precipitation as a percent of normal for the October-November-December period was also below normal over most of the basin, especially in North Dakota, Wyoming, and central Nebraska. Wide-spread areas of above normal precipitation were observed in central and western Montana (**Figure 4**).

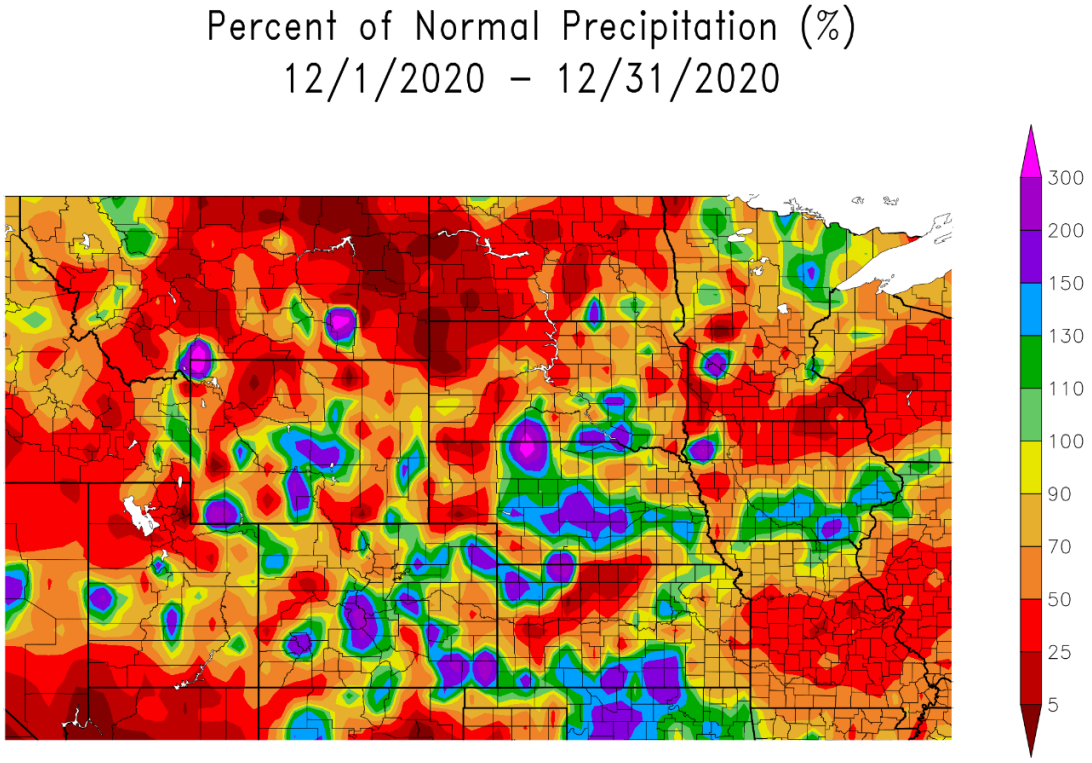

Figure 3. December 2020 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

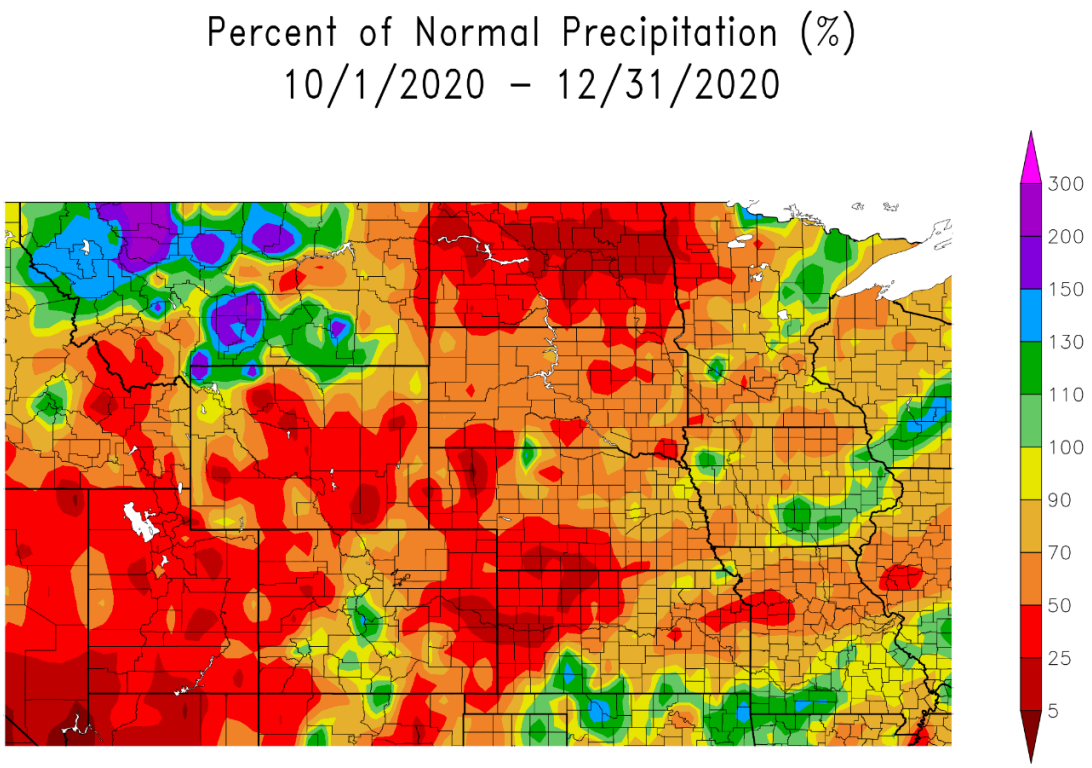

Figure 4. October, November, December 2020 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

December temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures over most of the Basin. December temperatures in Montana and North Dakota ranged from 3 to 12 deg F above normal. Temperatures across the rest of the Basin ranged from 3 to 9 deg F above normal. These warmer-than-normal temperatures limited the formation of river ice and allowed Missouri River tributaries to flow freely in December. The Missouri River at Bismarck, ND is currently ice free. In late December, pan ice formed on the river as water temperatures dipped below 32 deg F, but warmer-than-normal temperatures in early January melted the ice. The warmer temperatures also inhibited the formation of plains snowpack by causing winter precipitation to fall as rain, and by melting shallow snowpack several days after accumulation. October-November-December temperature departures are shown in **Figure 6**. The three-month average departures were similar to the December temperature departure.

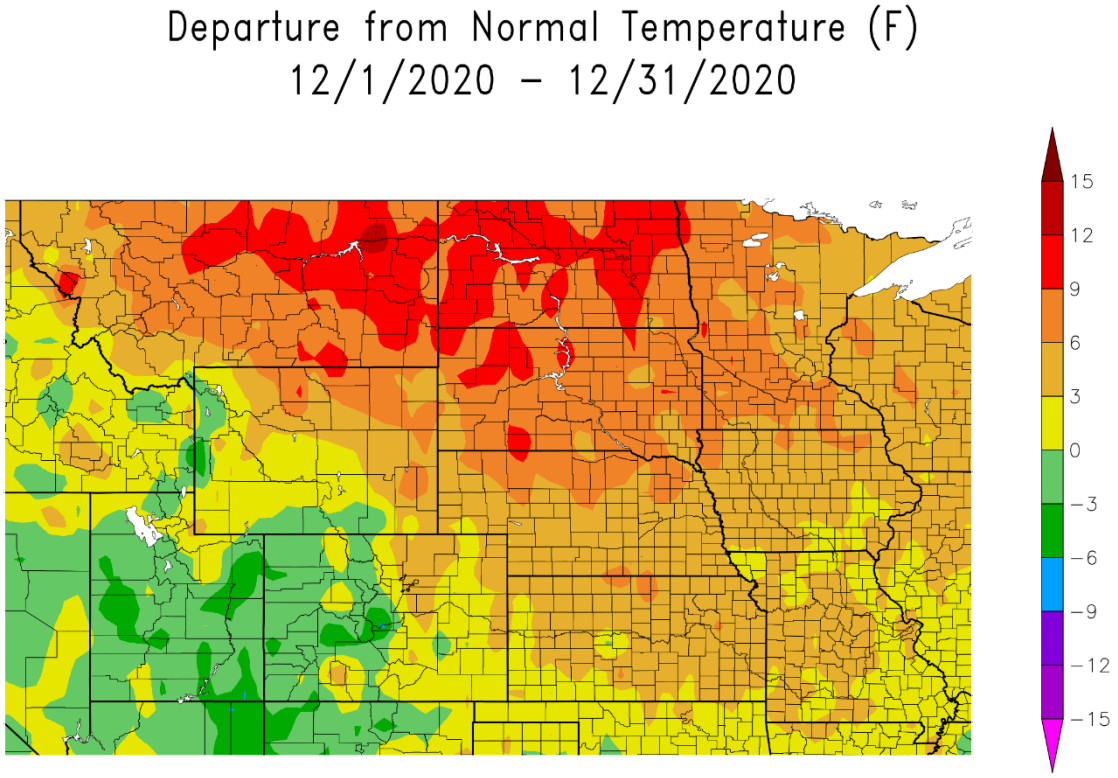

Figure 5. December 2020 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

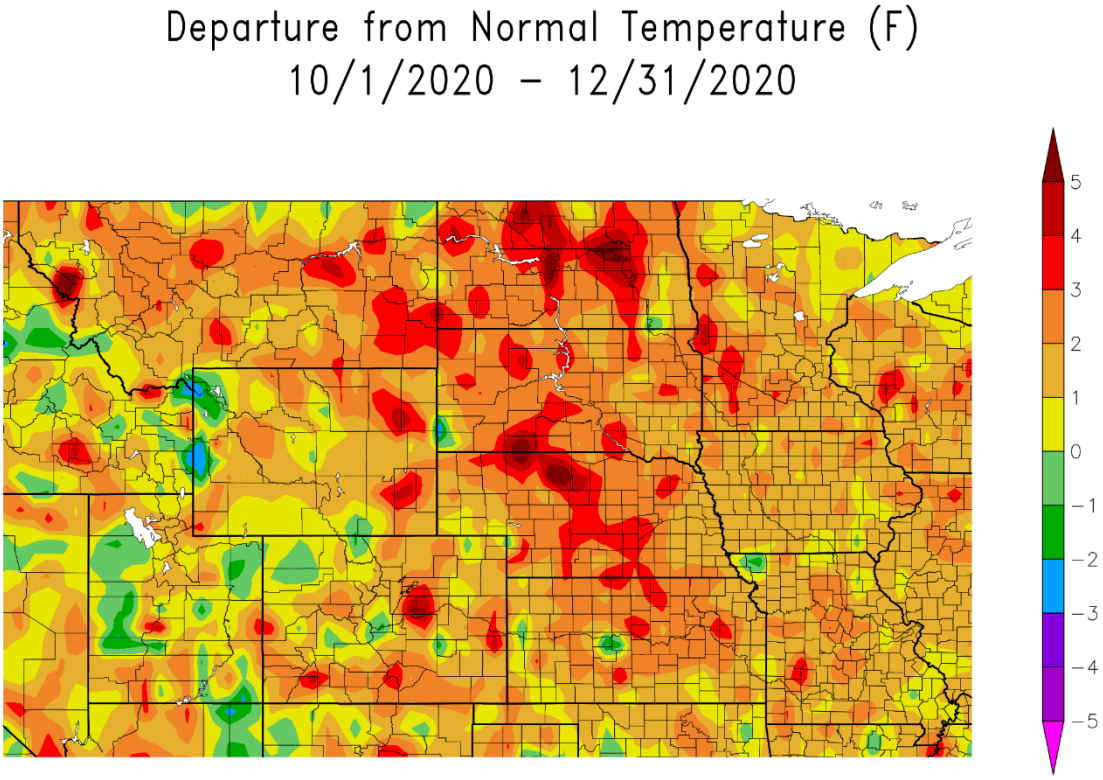

Figure 6. October-November-December 2020 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of January 2021 is drier than normal across much of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**. The figure indicates that early January 2021 soil moisture anomalies in the Missouri River Basin are well-below normal. Furthermore, the soil moisture percentiles rank low; between the 1st and 30th percentiles. The 1st percentile indicates that soil moisture is at its driest for this time of year, compared to long-term soil moisture simulations. Generally, when soil moisture is low during the winter, the potential for high March-April runoff is lower.

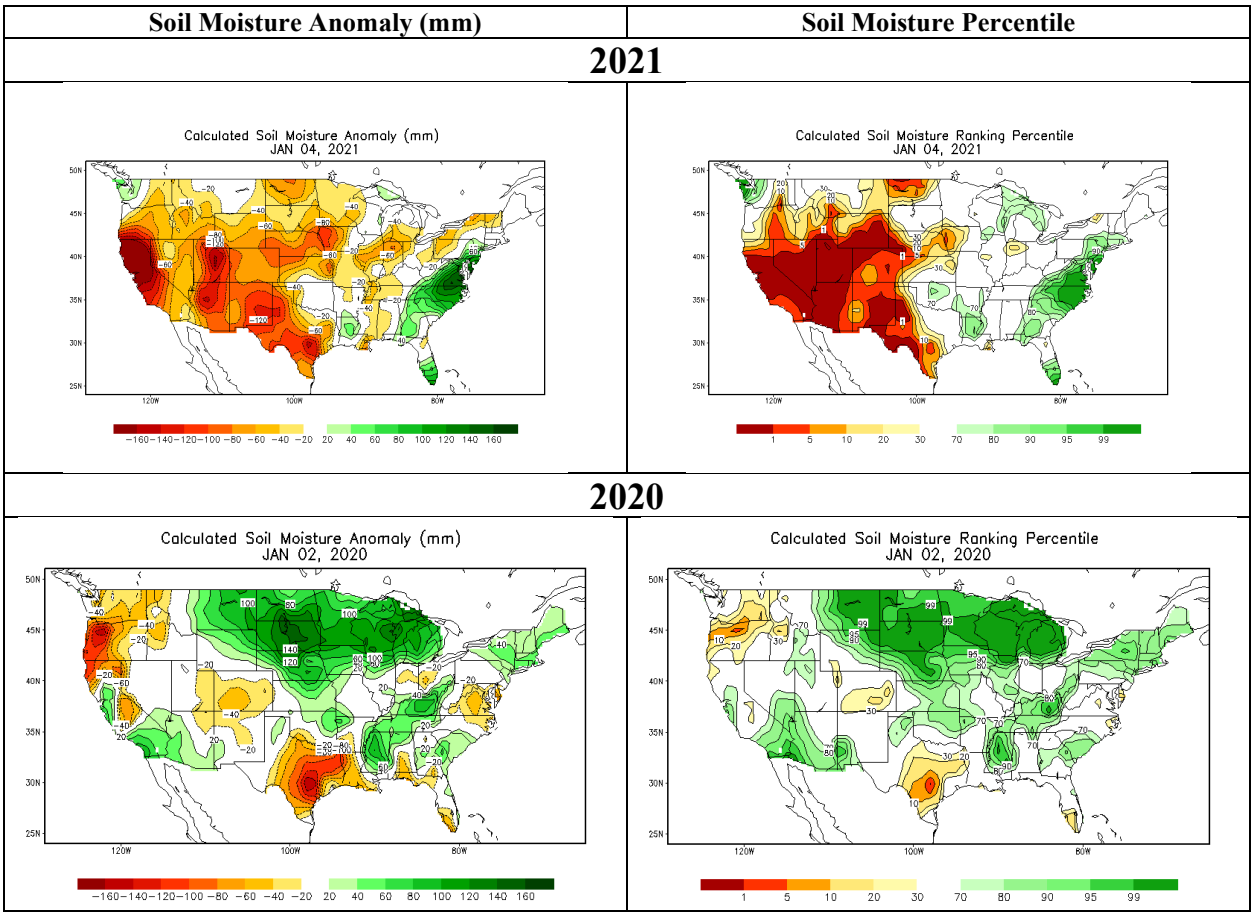

Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks. At this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from January 5, shown in **Figure 8**, indicates trace amounts of liquid content over eastern North Dakota, eastern South Dakota, eastern Nebraska

and parts of Wyoming. The remainder of the Basin does not contain any measurable amount of SWE.

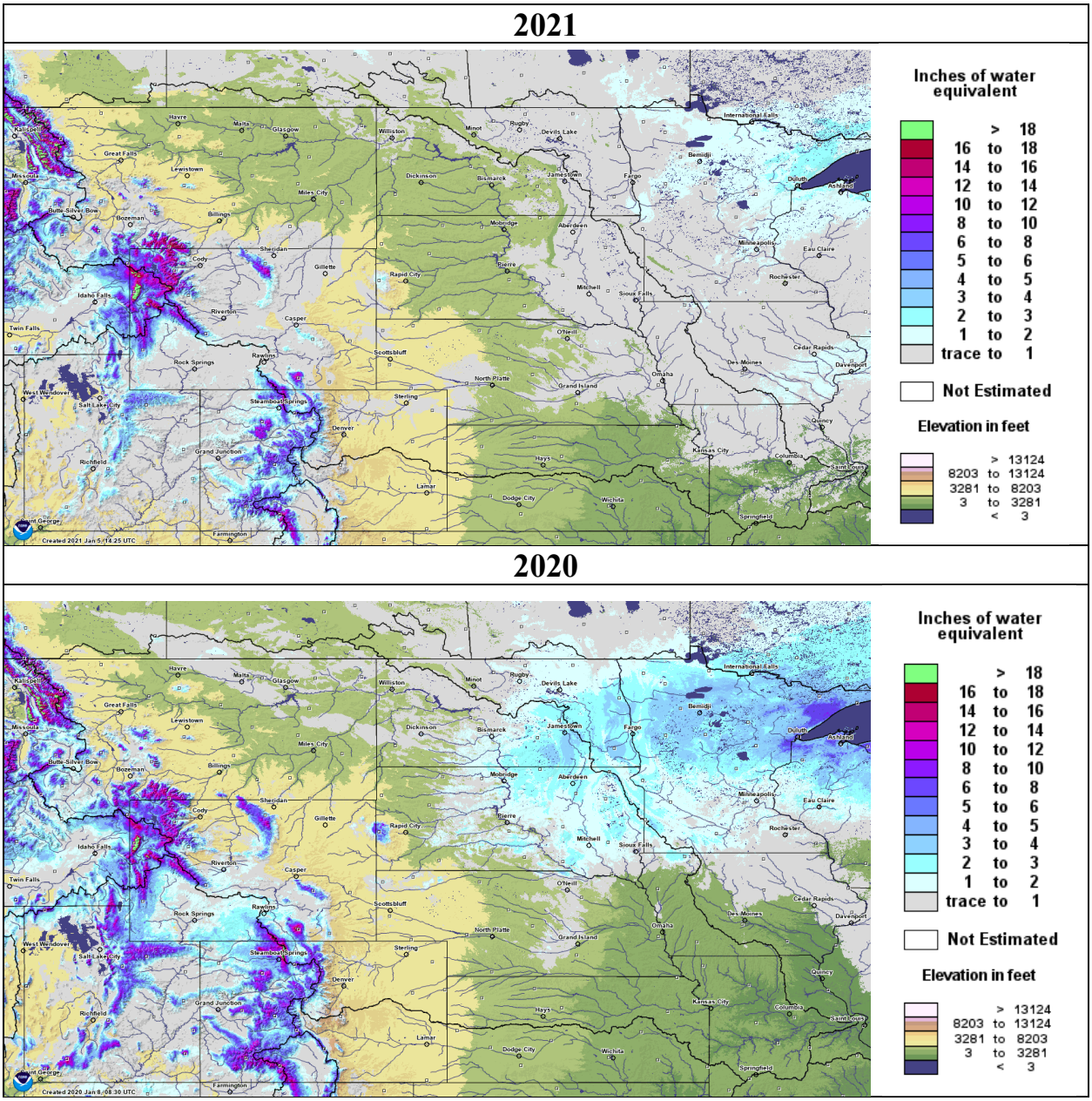

Figure 8. January 5, 2021 NOHRSC modeled plains snow water equivalent (top) and January 5, 2020 snow water equivalent (bottom). Source: NOAA National Operational Hydrologic Remote Sensing Center.
http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has very little correlation to the January 1 snowpack, because less than half of the mountain snowpack has accumulated on January 1. A majority of the mountain snowfall typically occurs from January 1 to mid-April, when snowpack typically peaks, therefore, later measurements of mountain snowpack are better runoff indicators.

Figure 9 includes time series plots of the average mountain SWE beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

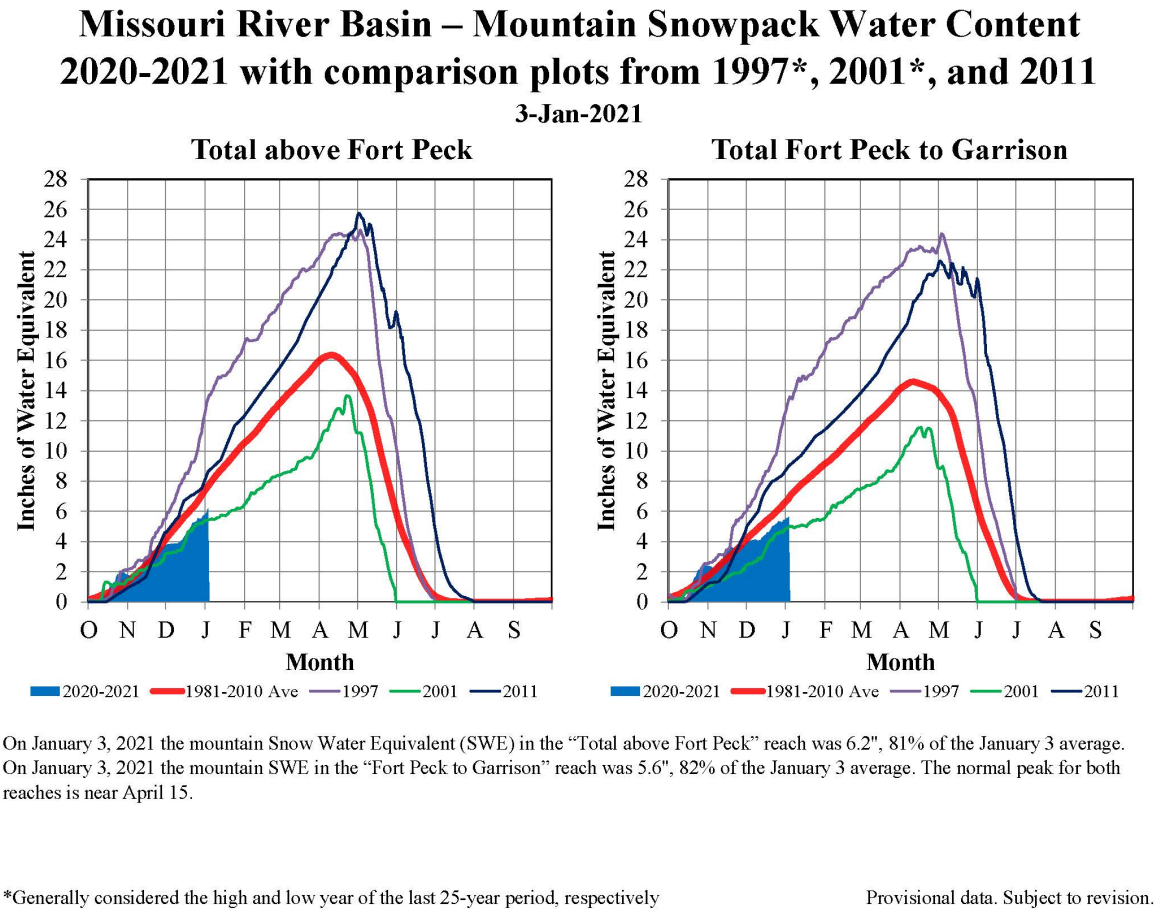

Figure 9. Mountain snowpack water content on January 3, 2021 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

As of January 3, 2021, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 6.2 inches, which is 81% of average based on the 1981-2010 average SWE for the Fort Peck reach. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 5.6 inches, which is 82% of average based on the 1981-2010 average SWE for the Garrison reach. Typically by January 1, 44% of the total accumulation has occurred, and it typically peaks around April 15.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

The latest ENSO Outlook indicates that La Nina conditions are present and will likely remain during the Northern Hemisphere winter, but there is potential for a transition to ENSO neutral during the spring. During La Nina conditions there are increased chances for below-normal temperatures in the upper Basin and increased chances for an above-normal mountain snowpack.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center (CPC) outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at http://www.cpc.ncep.noaa.gov/.

The CPC temperature outlook through January 18 (**Figure 10**) indicates increased chances for above-normal temperatures over the Basin. The precipitation outlook indicates an increase in the chances for above-normal precipitation in the western portions of the Basin.

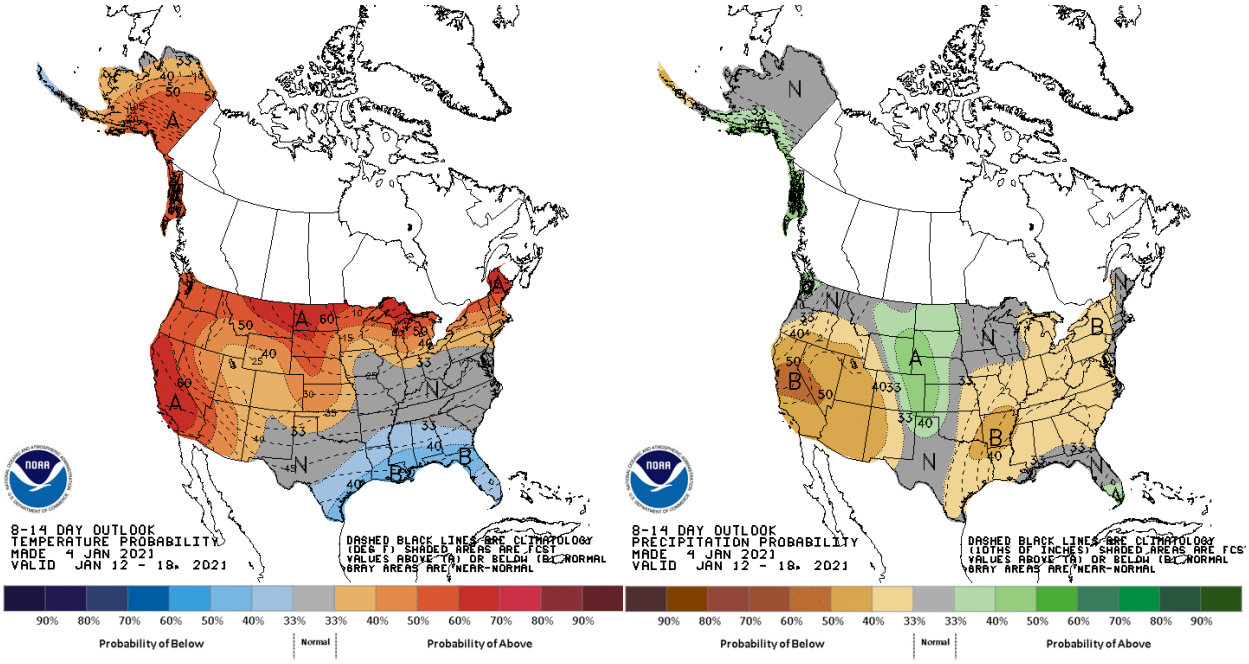

Figure 10. CPC 8-14 Day temperature and precipitation outlooks through January 18, 2021.

The January CPC outlooks in **Figure 11** indicate increased chances for above-normal temperatures over the entire the Missouri Basin. With regard to precipitation, there is a slight increase in chances for above-normal precipitation in eastern portions of the Basin.

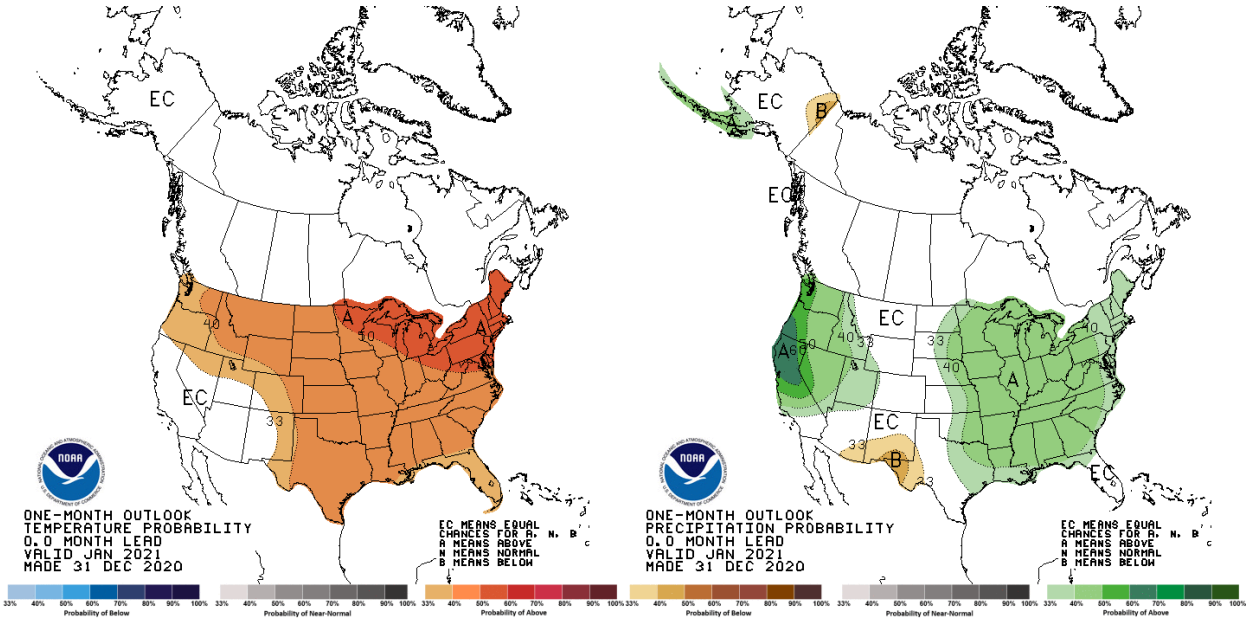

Figure 11. CPC January 2021 temperature and precipitation outlooks.

Three-month temperature and precipitation outlooks for four three-month periods in 2021 are shown below in **Figure 12-Figure 15**. During the January-February-March 2021 period (**Figure 12**), the CPC indicates increased chances for below-normal temperatures in the north central

U.S., including Montana and North Dakota. Increased chances for above-normal temperatures are indicated in Colorado, Kansas, and Missouri. Equal chances for above-normal, normal, and below-normal temperatures are indicated in all other areas of the Missouri Basin. With regard to precipitation, there is an increased probability for above-normal precipitation in the upper Basin, particularly in Montana and North Dakota.

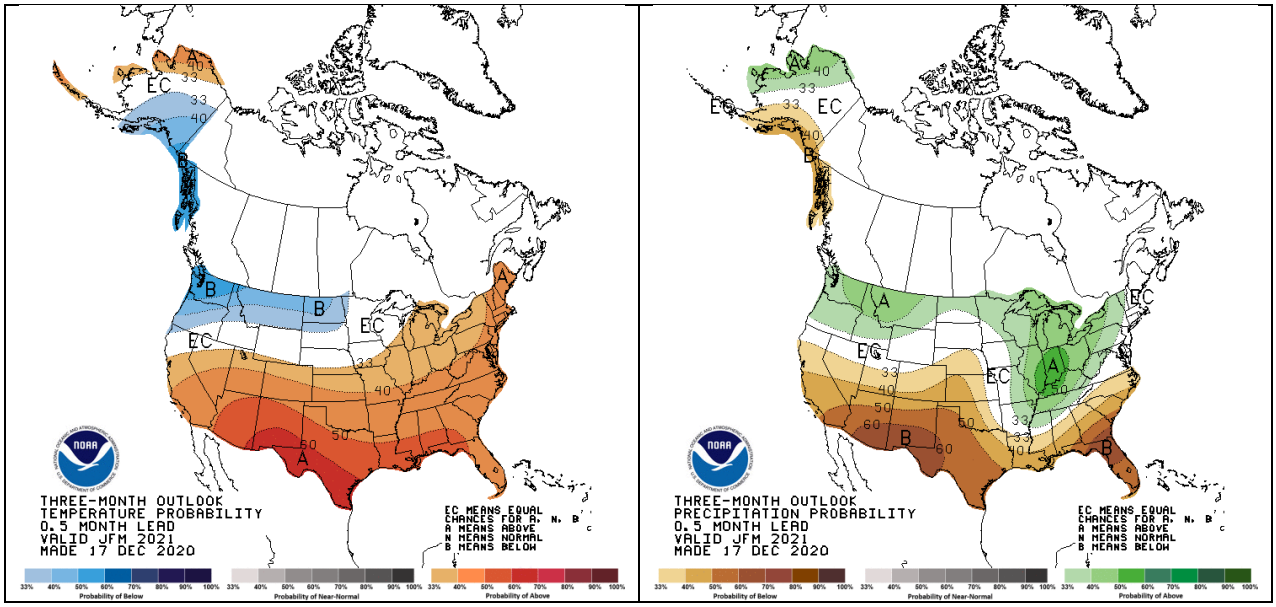

Figure 12. CPC January-February-March 2021 temperature and precipitation outlooks.

During the April-May-June 2021 forecast period (**Figure 13**), there are increased chances for above-normal temperatures in the lower Basin and equal chances for temperatures in the upper Basin. Precipitation chances transition to increased chances for below-normal precipitation in western Montana and slight increases in above-normal precipitation in the southeastern portion of the Basin during July-August-September (**Figure 14**). With regards to temperature, an increased chance of above-normal temperatures remains in the lower Basin while there is equal chances in the upper Basin. During October-November-December, most of the Basin has increased chances for above-normal temperatures and all of the Basin has equal chances for precipitation (**Figure 15**). As previously noted, though, there is limited confidence in climate outlooks beyond the winter and early spring, therefore, the climate outlooks will likely change as the calendar progresses.

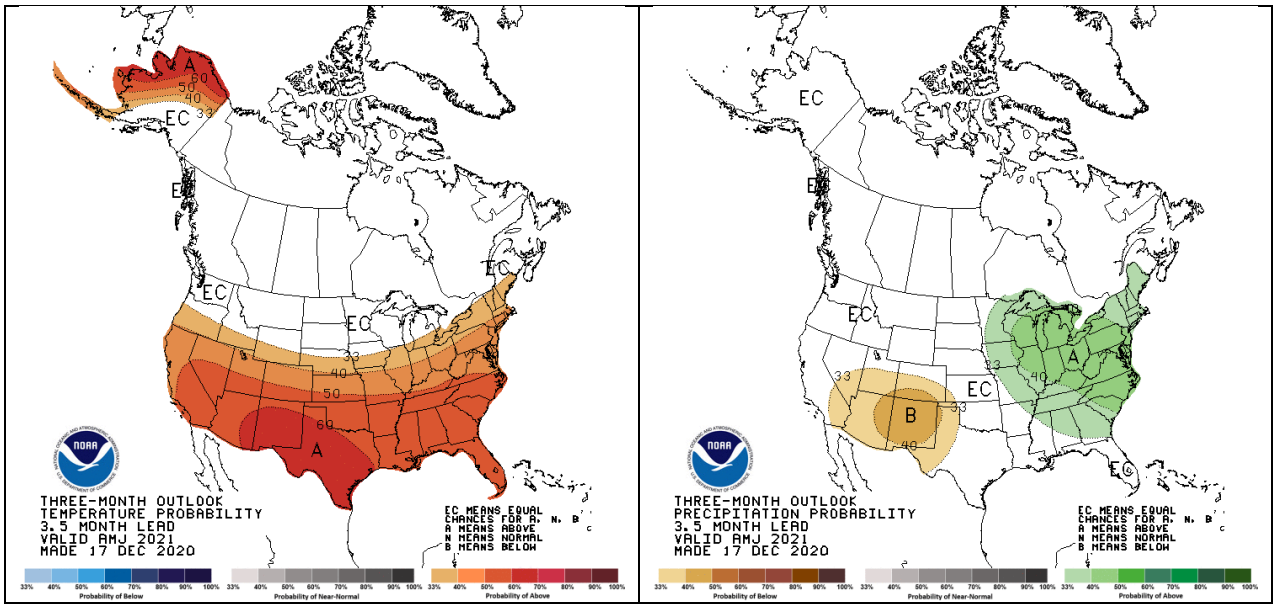

Figure 13. CPC April-May-June 2021 temperature and precipitation outlooks.

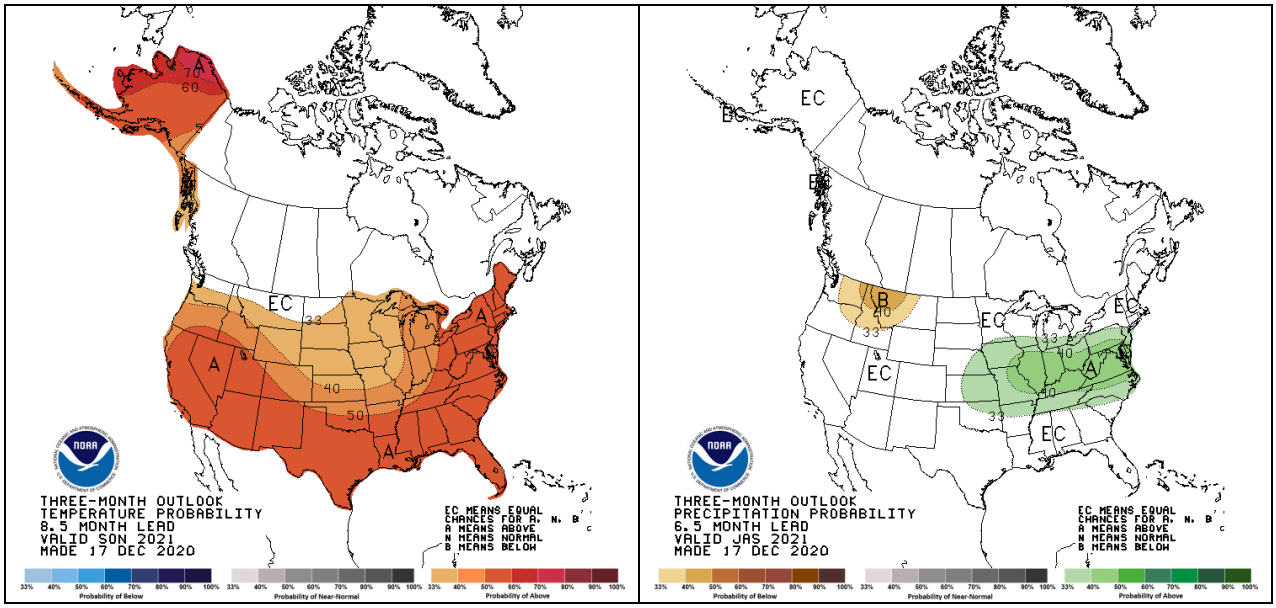

Figure 14. July-August-September 2021 temperature and precipitation outlooks.

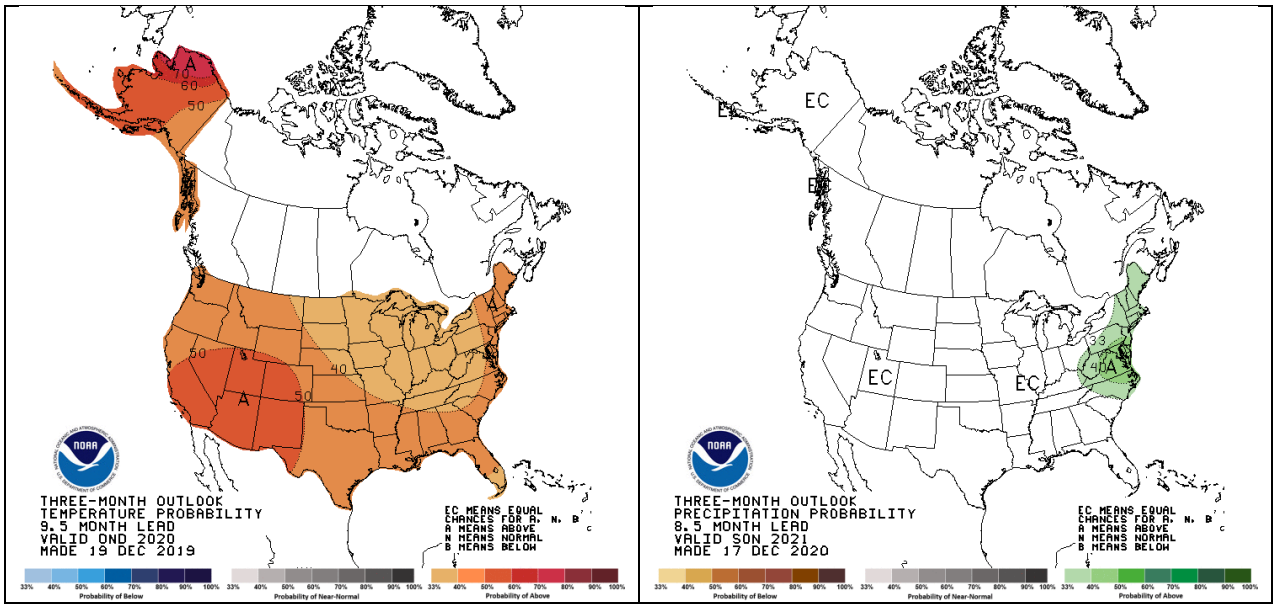

Figure 15. October-November-December 2021 temperature and precipitation outlooks.

Summary

Given the dry soil moisture conditions, moderate streamflow and the observed warmer-than-normal temperatures limiting plains snow accumulation and river ice formation in Montana, Wyoming and the western Dakotas, we expect runoff to be about average in January and below average in February. March-April runoff potential is low due to the dry soil moisture conditions, but it will depend greatly on the accumulation of plains snowpack over the next two to three months. During May, June and July, Fort Peck and Garrison runoff is forecast to be below average due to the below-average January 1 mountain snowpack. In summary, the 2021 calendar year runoff forecast is **23.1 MAF (90% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: January 06, 2021 03:55:36 PM
   - Based on January 01, 2021 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Hebgen Lake Inflow (2)	APR-JUL	300	81	395	340	260	205	370
	APR-SEP	385	82	500	430	335	270	470

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	62	105	72	66	58	52	59
	APR-SEP	80	108	93	85	75	67	74
Wind R ab Bull Lake Ck	APR-JUL	380	84	550	450	315	215	455
	APR-SEP	400	82	585	475	325	220	490
Bull Lake Ck nr Lenore (2)	APR-JUL	99	71	134	113	85	64	139
	APR-SEP	120	71	163	137	103	78	169
Boysen Reservoir Inflow (2)	APR-JUL	350	57	700	490	210	6.1	610
	APR-SEP	370	56	745	520	220	6.6	665
Greybull R at Meeteetse	APR-JUL	95	73	150	118	73	40	131
	APR-SEP	128	72	194	155	102	63	177
Shell Ck nr Shell	APR-JUL	44	80	60	51	37	28	55
	APR-SEP	56	85	74	63	49	38	66
Bighorn R at Kane (2)	APR-JUL	455	54	945	655	255	8.4	840
	APR-SEP	465	51	995	680	250	9.0	905
NF Shoshone R at Wapiti	APR-JUL	490	107	615	540	440	365	460
	APR-SEP	545	106	685	600	490	405	515
SF Shoshone R nr Valley	APR-JUL	210	98	275	235	188	152	215
	APR-SEP	245	100	315	270	215	174	245
Buffalo Bill Reservoir Inflow	APR-JUL	690	102	910	780	600	470	675
	APR-SEP	765	103	1000	860	670	530	745
Bighorn R nr St. Xavier (2)	APR-JUL	980	71	1610	1240	725	355	1380
	APR-SEP	1000	68	1690	1280	720	305	1460
Tongue R nr Dayton (2)	APR-JUL	84	98	116	97	70	51	86
	APR-SEP	96	98	130	110	82	61	98
Tongue River Reservoir Inflow (2)	APR-JUL	187	97	295	230	143	78	193
	APR-SEP	210	98	325	260	165	96	215
NF Powder R nr Hazelton	APR-JUL	7.6	84	11.4	9.2	6.1	3.8	9.1
	APR-SEP	8.2	83	12.1	9.8	6.6	4.3	9.9
Powder R at Moorhead	APR-JUL	132	75	275	189	74	1.77	177
	APR-SEP	146	74	290	205	87	1.96	196

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAR-JUL	5.2	84	9.3	6.9	3.6	1.15	6.2
	APR-JUL	4.1	79	7.7	5.6	2.6	0.46	5.2
Pactola Reservoir Inflow (2)	MAR-JUL	16.8	67	35	24	9.5	0.25	25
	APR-JUL	14.1	64	31	21	7.2	0.22	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate (2)	APR-JUL	118	52	250	172	64	2.2	225
	APR-SEP	129	52	275	188	70	2.5	250
Encampment R nr Encampment (2)	APR-JUL	82	64	152	110	54	11.6	129
	APR-SEP	88	64	161	118	58	15.0	138

Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	44	90	65	52	36	23	49
	APR-SEP	46	88	68	55	37	24	52
Seminoe Reservoir Inflow (2)	APR-JUL	450	63	890	625	275	12.2	715
	APR-SEP	485	63	945	670	300	26	770
Sweetwater R nr Alcova	APR-JUL	17.1	29	51	31	3.3	0.59	59
	APR-SEP	19.4	30	56	34	4.6	0.64	64
La Prele Ck nr Douglas	APR-JUL	9.4	47	27	15.5	4.8	0.84	19.9
	APR-SEP	9.3	47	27	15.4	4.7	0.77	19.9
North Platte R bl Glendo Reservoir (2)	APR-JUL	420	51	1000	655	185	8.2	820
	APR-SEP	430	51	1030	675	187	8.5	850
North Platte R bl Guernsey Reservoir (2)	APR-JUL	405	49	1000	650	164	8.2	820
	APR-SEP	415	49	1030	665	167	8.5	850
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	88	77	144	110	65	32	115
	APR-SEP	96	76	156	120	72	36	126
Little Laramie R nr Filmore	APR-JUL	43	84	69	53	33	17.9	51
	APR-SEP	46	84	73	57	36	19.5	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
February 2021 Calendar Year Runoff Forecast
February 2, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

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Observed Runoff

January runoff was 1.1 MAF, 141% of average. Runoff was slightly below average in the Fort Peck and Garrison reaches, and above average in all other reaches. The above-average January runoff was primarily due to above-normal temperatures over much of the Basin, melting accumulated plains snowpack.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **22.9 MAF, 89% of average**. The 2021 calendar year runoff forecast for the Missouri Basin above Gavins Point is **20.5 MAF**, **88% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 11 months, expected inflow could range from the 31.4 MAF upper basic forecast to the 15.4 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively. Given that eleven months are being forecast for this February 1 forecast (1 month observed/11 months forecast), the range of possible wetter-than-expected (upper basic)

and drier-than-expected (lower basic) conditions is very large, and is attributed to all six reaches for the next 11 months. The result is a range or "bracket" for each reach, and thus, for the total runoff forecast.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for January 26, 2021 is shown in **Figure 1**. The drought monitor is available at http://droughtmonitor.unl.edu/. The U.S. Drought Monitor shows Abnormally Dry (D0) conditions are present in every state in the Basin, with Extreme Drought (D3) conditions present in the mountainous areas of Wyoming and Colorado as well as western Nebraska and Kansas. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of April, indicates drought conditions are likely to persist throughout most of the Basin.

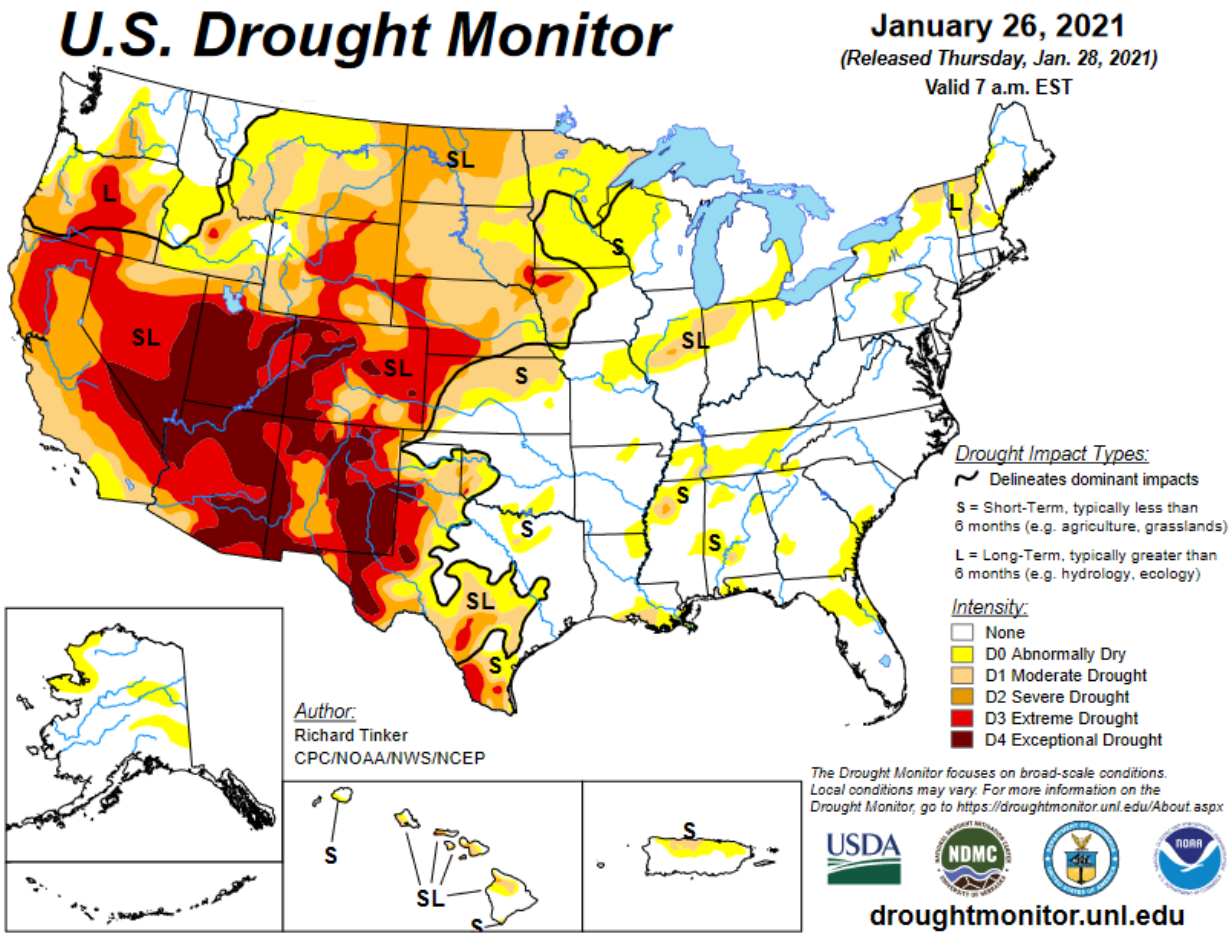


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for January 26, 2021.

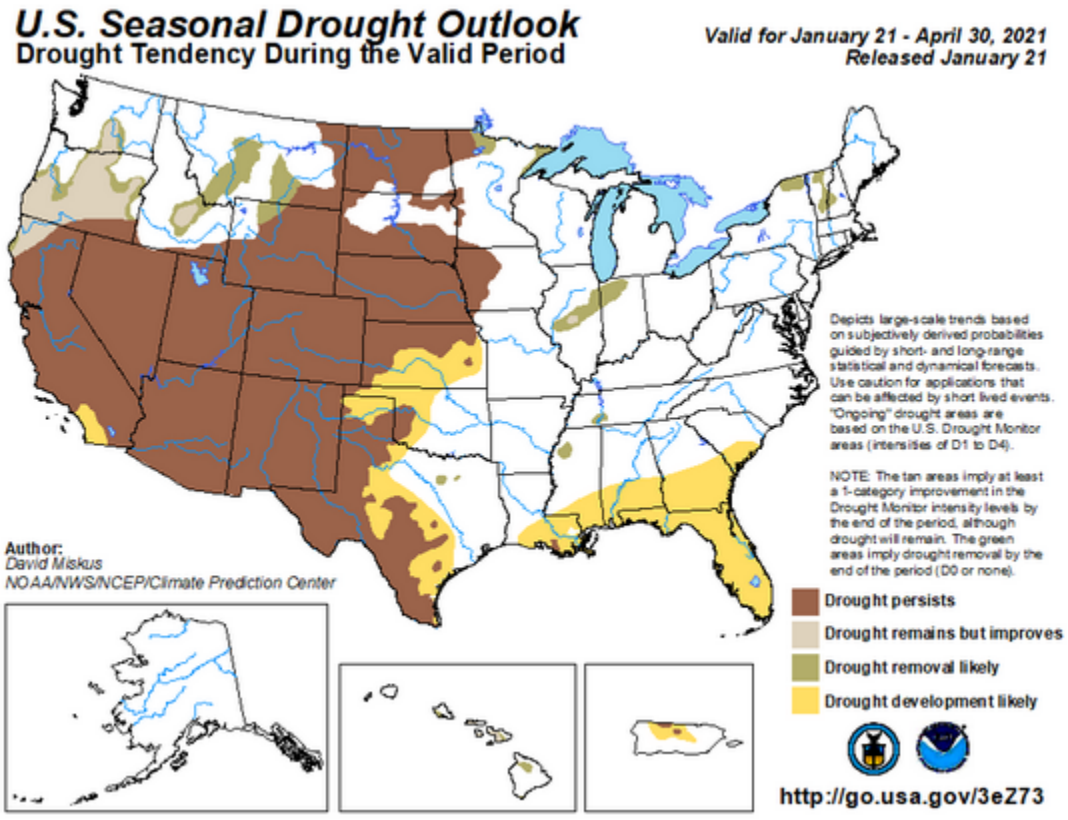


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at http://www.hprcc.unl.edu/. The January precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. January precipitation was generally below normal across the upper Basin with areas of well-below-normal precipitation in Montana, North Dakota, South Dakota, Wyoming, and western Nebraska. Heavy precipitation, exceeding 200 percent of normal, occurred over a large portion of the lower Basin.

Precipitation as a percent of normal for the November-December 2020-January 2021 period was also below normal over most of the basin, especially in North Dakota, South Dakota, Wyoming, and western Nebraska. Wide-spread areas of above normal precipitation were observed in eastern Nebraska, Iowa, Missouri, and Kansas (**Figure 4**).

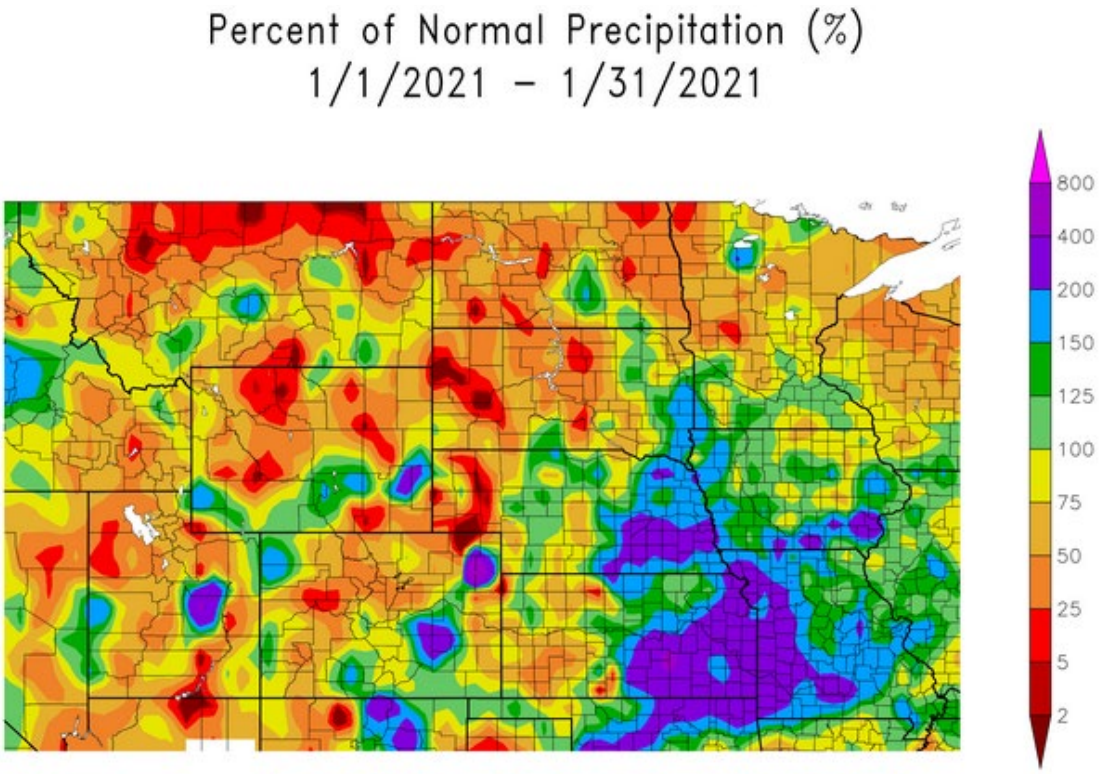


Figure 3. January 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

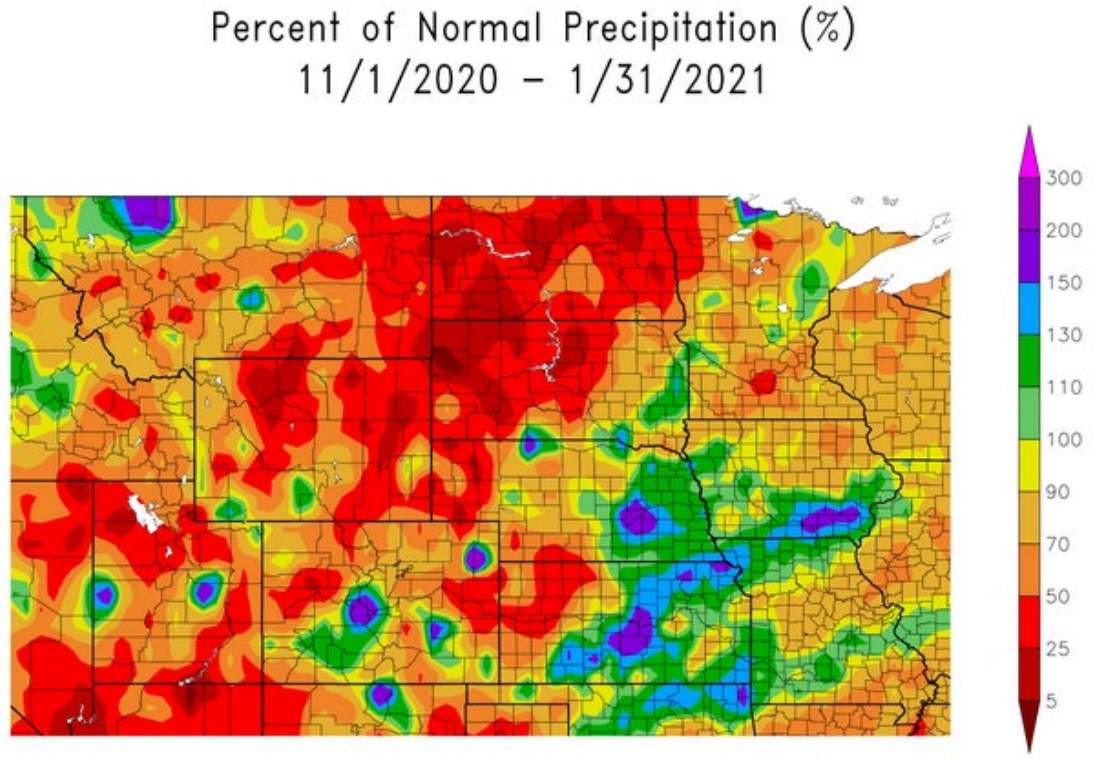


Figure 4. November-December 2020-January 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

January temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures over most of the Basin. January temperatures in Montana and North Dakota ranged from 3 to 15 deg F above normal. These warmer-than-normal temperatures limited the formation of river ice and allowed most Missouri River tributaries to flow freely in January. In late December, pan ice formed on the river as water temperatures dipped below 32 deg F, but warmer-than-normal temperatures in early January melted the ice. The warmer temperatures also inhibited the formation of plains snowpack by causing winter precipitation to fall as rain, and by melting shallow snowpack several days after accumulation. November-December 2020-Janaury 2021 temperature departures are shown in **Figure 6**. The three-month average departures were similar to the January temperature departures.

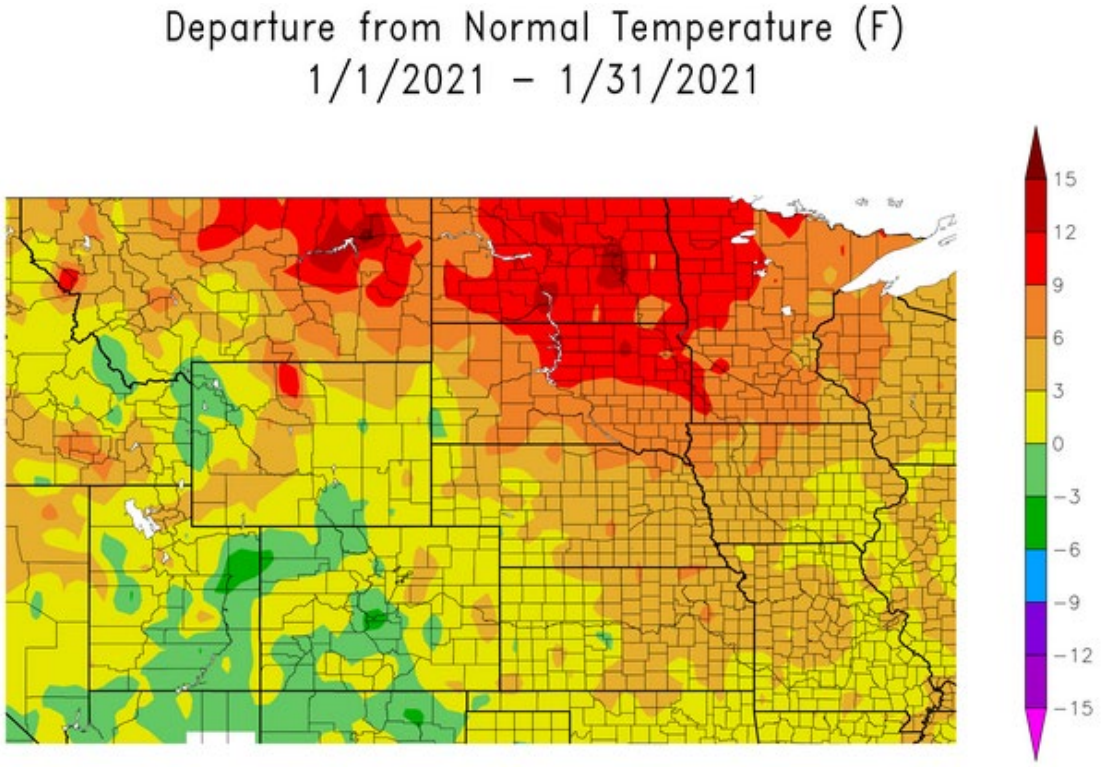


Figure 5. January 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

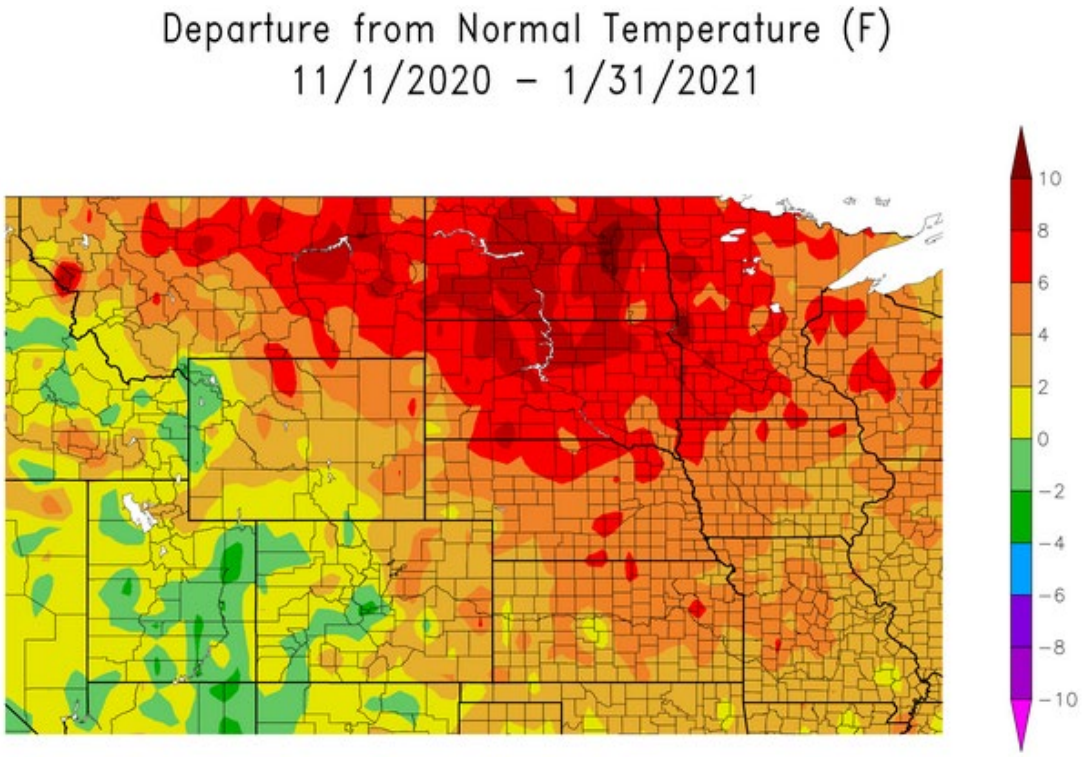


Figure 6. November-December 2020-Janaury 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of February 2021 is drier than normal across much of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**. The figure indicates that end of January 2021 soil moisture anomalies in the Missouri River Basin are well-below normal. Furthermore, the soil moisture percentiles rank low; between the 1st and 30th percentiles. The 1st percentile indicates that soil moisture is at its driest for this time of year, compared to long-term soil moisture simulations. Generally, when soil moisture is low during the winter, the potential for high March-April runoff is lower.

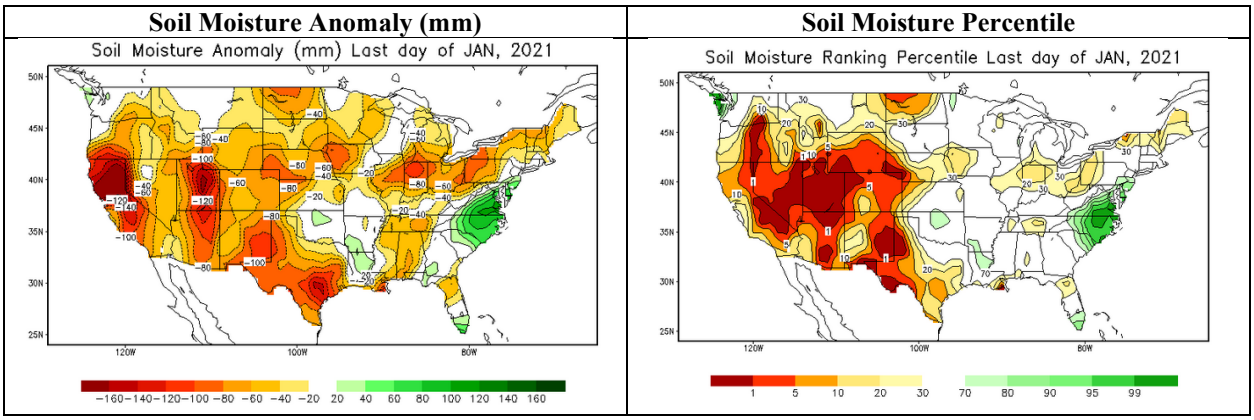


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks. At this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from February 1, shown in **Figure 8**, indicates trace amounts of liquid content over eastern North Dakota, eastern South Dakota, Nebraska, and Iowa. The remainder of the Basin does not contain any measurable amount of SWE.

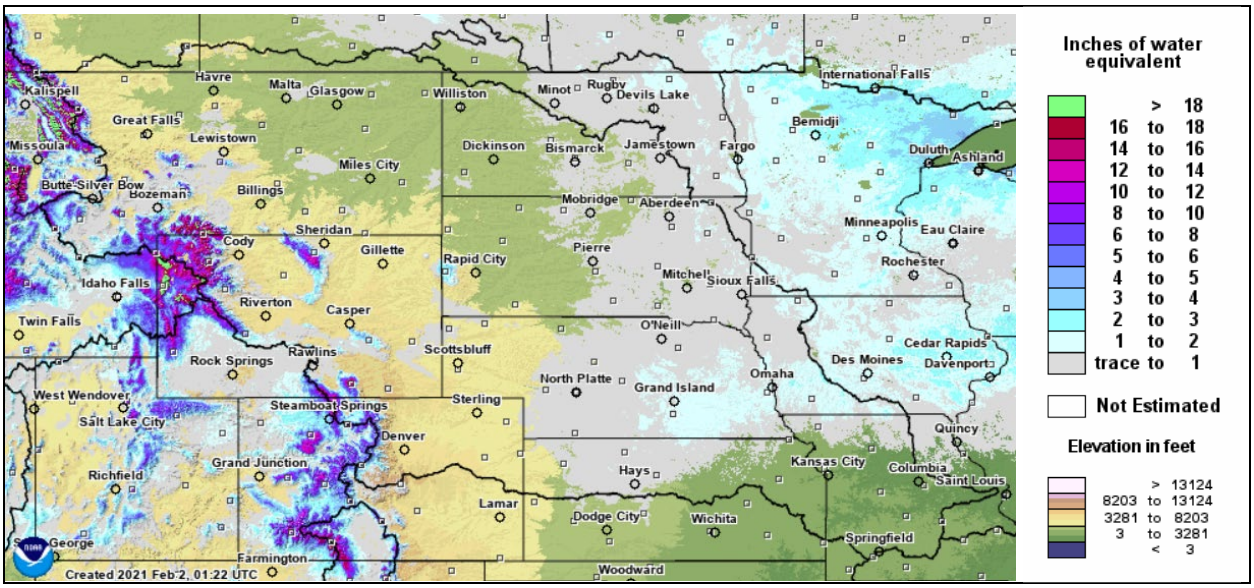


Figure 8. February 1, 2021 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has very little correlation to the January 1 snowpack, because less than half of the mountain snowpack has accumulated on January 1. A majority of the mountain snowfall typically occurs from January 1 to mid-April, when snowpack typically peaks; therefore, later measurements of mountain snowpack are better runoff indicators.

Figure 9 includes time series plots of the average mountain SWE beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

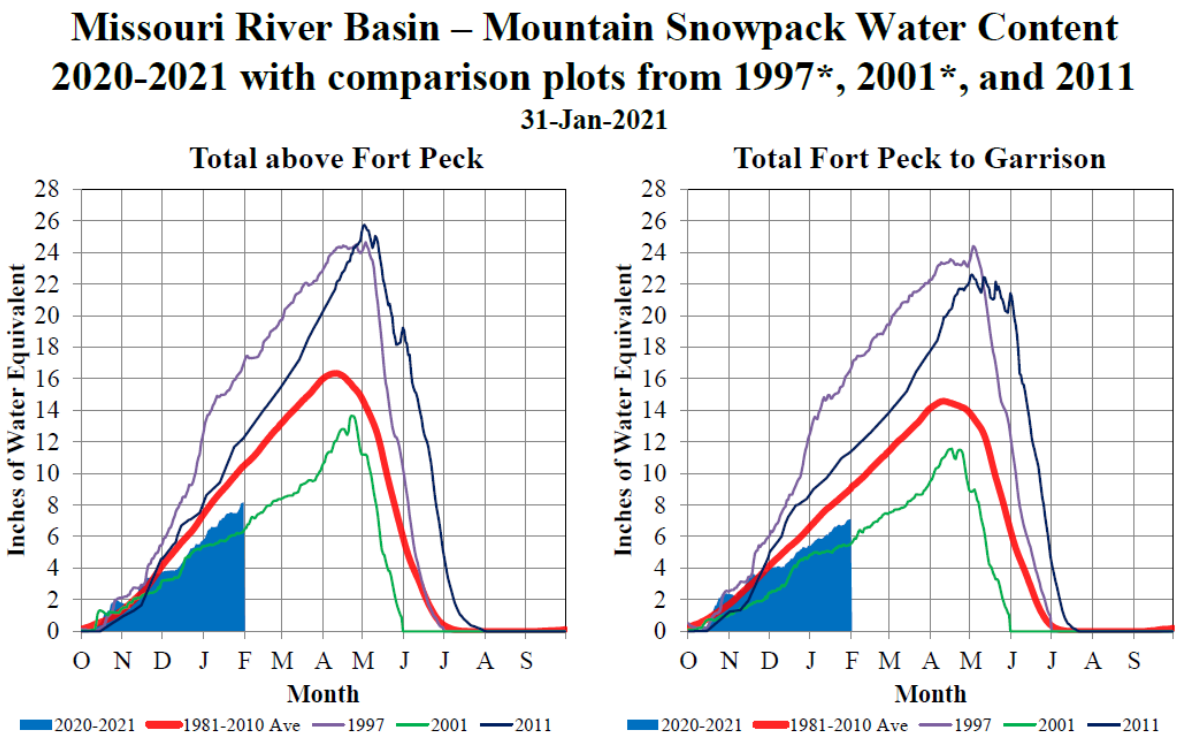


Figure 9. Mountain snowpack water content on January 31, 2021 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

As of January 31, 2021, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 8.2 inches, which is 78% of average based on the 1981-2010 average SWE for the Fort Peck reach. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 7.1 inches, which is 79% of average based on the 1981-2010 average SWE for the Garrison reach. The mountain snowpack typically peaks around April 15.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

The latest ENSO Outlook indicates that La Nina conditions are present and will likely remain during the Northern Hemisphere winter, but there is potential for a transition to ENSO neutral during the spring. During La Nina conditions there are increased chances for below-normal temperatures in the upper Basin and increased chances for an above-normal mountain snowpack.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center (CPC) outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at http://www.cpc.ncep.noaa.gov/.

The CPC temperature outlook through February 15 (**Figure 10**) indicates increased chances for below-normal temperatures, as well as an increase in the chances for above-normal precipitation over the Basin.

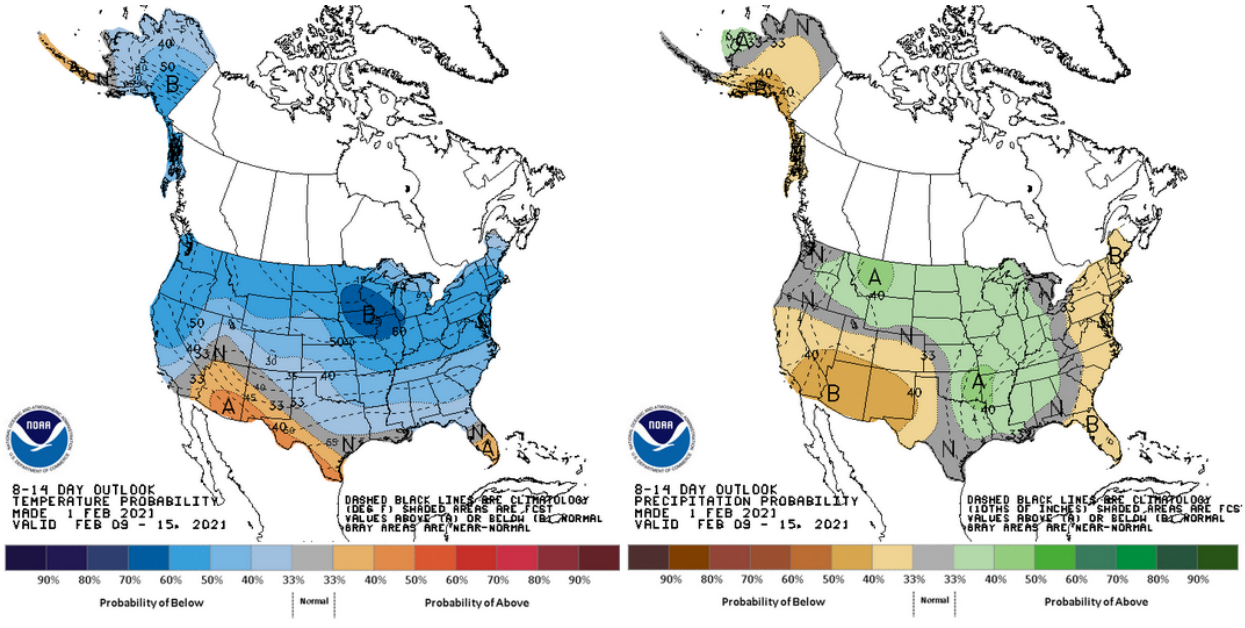


Figure 10. CPC 8-14 Day temperature and precipitation outlooks through February 15, 2021.

The February CPC outlooks in **Figure 11** indicate increased chances for below-normal temperatures and above-normal precipitation over the entire Missouri Basin.

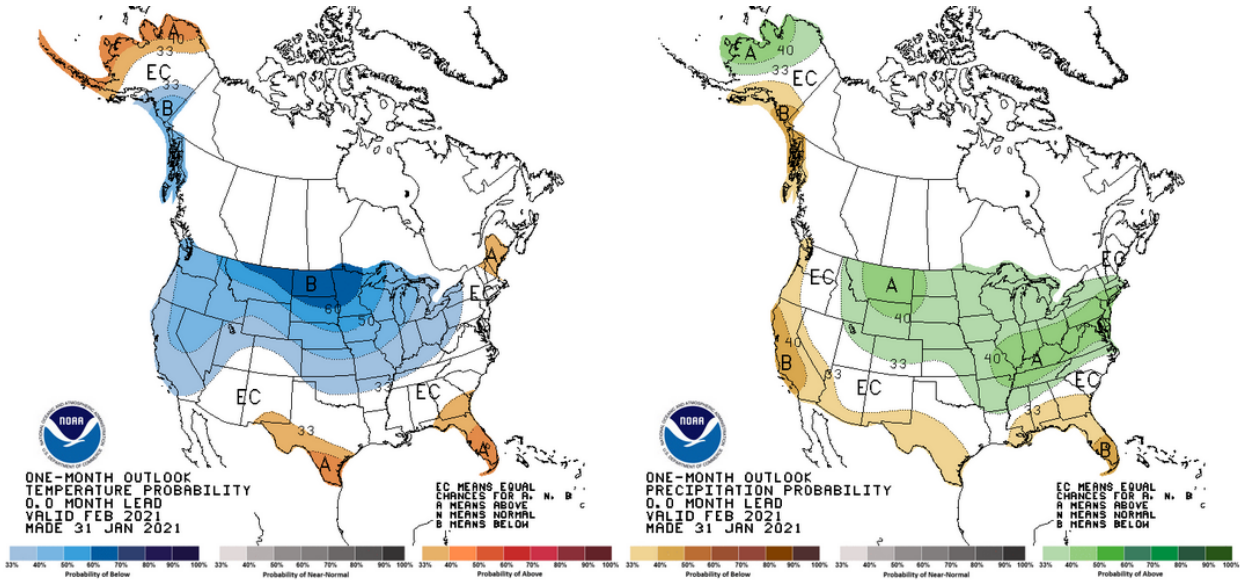


Figure 11. CPC February 2021 temperature and precipitation outlooks.

Three-month temperature and precipitation outlooks for four three-month periods in 2021 are shown below in **Figure 12-Figure 15**. During the March-April-May period (**Figure 12**), the CPC indicates increased chances for below-normal temperatures in northwestern Montana, with equal chances in the remainder of Montana and North Dakota. Increased chances for above-normal temperatures are indicated across the rest of the Basin. With regard to precipitation, there is an increased probability for below-normal precipitation in Nebraska, Kansas, and Colorado, with equal chances for above-normal, normal, and below-normal precipitation elsewhere in the Basin.

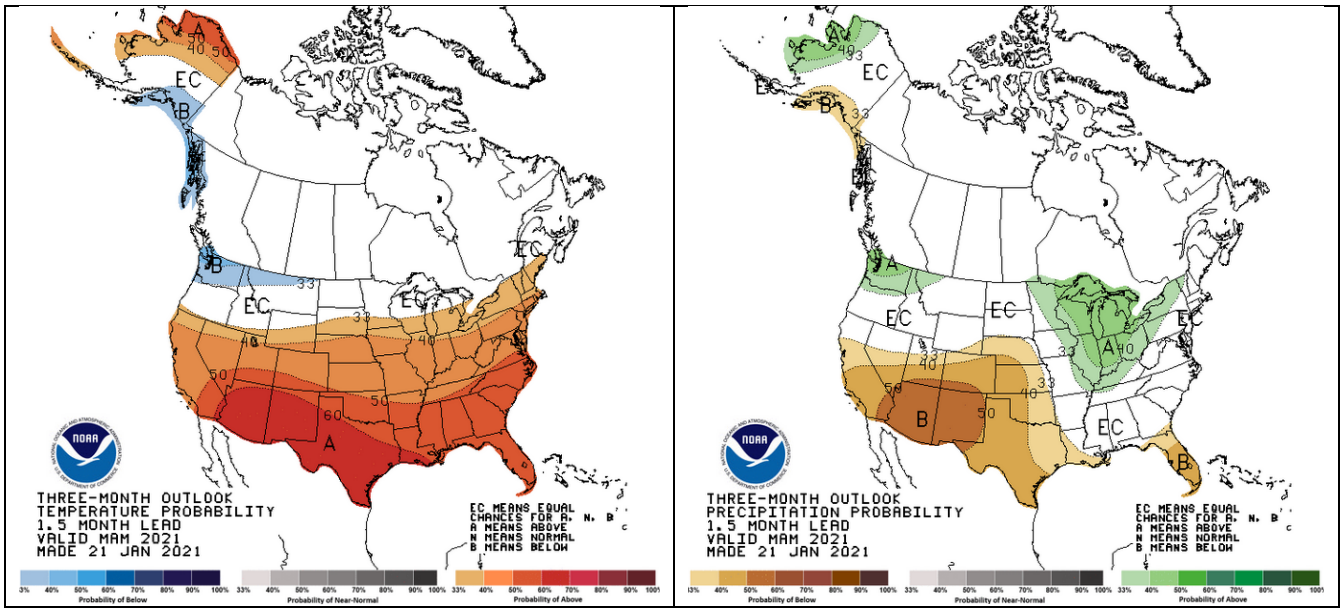


Figure 12. CPC March-April-May temperature and precipitation outlooks.

During the June-July-August forecast period (**Figure 13**), there are increased chances for above-normal temperatures across the entire Basin, with the exception of North Dakota, which has equal chances. Precipitation chances transition to increased chances for below-normal precipitation in Montana and Wyoming, with equal chances elsewhere. During the September-October-November timeframe, the increased chances for below-normal precipitation shift south to Wyoming and Colorado, with equal chances for above-normal, normal, and below-normal precipitation across the rest of the Basin (**Figure 14**). With regards to temperature, an increased chance of above-normal temperatures remains over most of the Basin, with equal chances in North Dakota and Montana. During December 2021-January-February 2022, most of the Basin has increased chances for above-normal precipitation and all of the Basin has equal chances for temperature (**Figure 15**). As previously noted, though, there is limited confidence in climate outlooks beyond the winter and early spring, therefore, the climate outlooks will likely change as the calendar progresses.

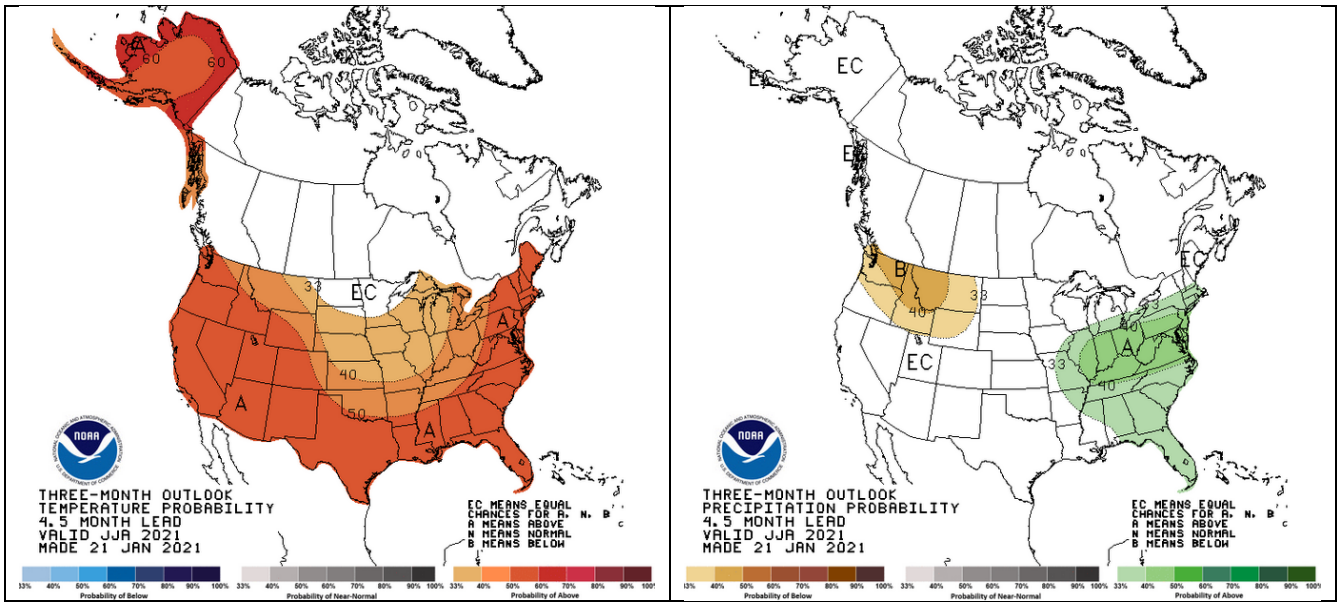


Figure 13. CPC June-July-August temperature and precipitation outlooks.

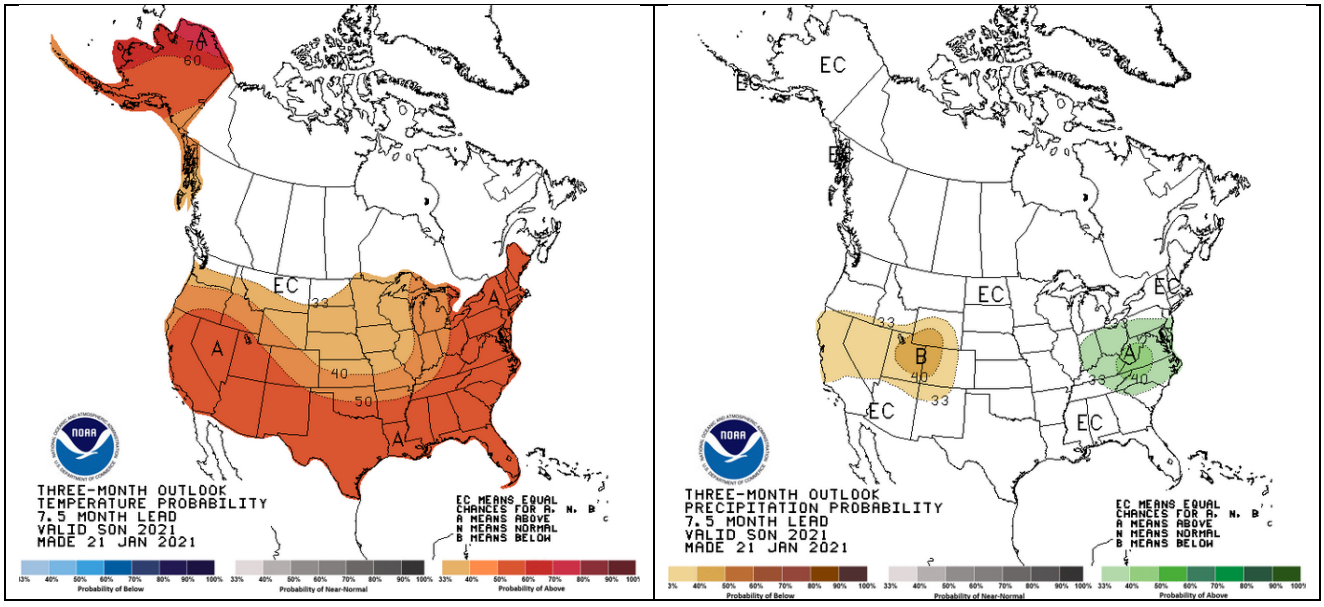


Figure 14. September-October-November temperature and precipitation outlooks.

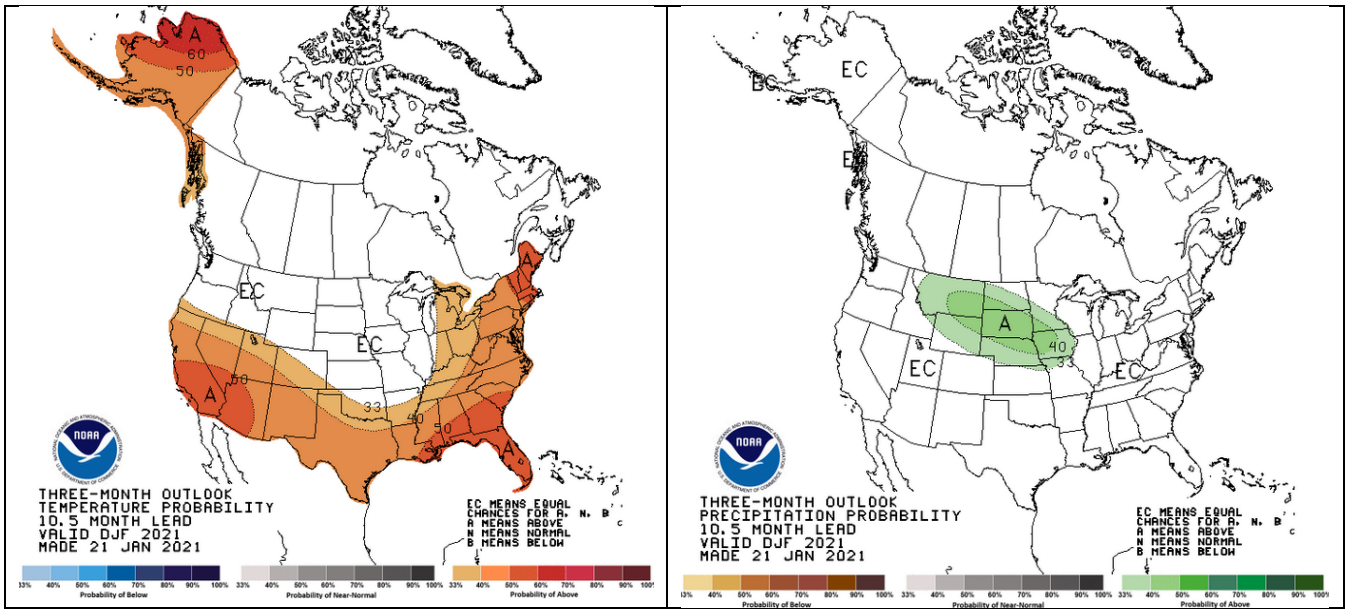


Figure 15. December 2021-January-February 2022 temperature and precipitation outlooks.

Summary

Given the dry soil moisture conditions, moderate streamflow, and limited plains snowpack, we expect runoff to decrease during February. March-April runoff potential is also low due to the dry soil moisture conditions, but it will depend greatly on the accumulation of plains snowpack over the next couple months. During May, June and July, Fort Peck and Garrison runoff is forecast to be below average due to the below normal mountain snowpack. In summary, the 2021 calendar year runoff forecast is **22.9 MAF (89% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: February 03, 2021 03:19:37 PM
   - Based on February 01, 2021 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Hebgen Lake Inflow (2)	APR-JUL	300	81	380	330	265	220	370
	APR-SEP	385	82	485	425	345	285	470

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	60	102	70	64	56	50	59
	APR-SEP	77	104	89	82	72	64	74
Wind R ab Bull Lake Ck	APR-JUL	325	71	485	390	265	171	455
	APR-SEP	335	68	505	405	270	169	490
Bull Lake Ck nr Lenore (2)	APR-JUL	96	69	130	110	83	63	139
	APR-SEP	117	69	156	133	101	77	169
Boysen Reservoir Inflow (2)	APR-JUL	305	50	665	450	158	1.00	610
	APR-SEP	315	47	695	470	160	1.00	665
Greybull R at Meeteetse	APR-JUL	86	66	143	109	64	30	131
	APR-SEP	114	64	180	141	88	49	177
Shell Ck nr Shell	APR-JUL	42	76	57	48	36	27	55
	APR-SEP	52	79	69	59	45	35	66
Bighorn R at Kane (2)	APR-JUL	380	45	885	585	177	1.00	840
	APR-SEP	365	40	910	585	147	1.00	905
NF Shoshone R at Wapiti	APR-JUL	440	96	545	485	395	335	460
	APR-SEP	490	95	605	535	445	375	515
SF Shoshone R nr Valley	APR-JUL	195	91	255	220	171	136	215
	APR-SEP	225	92	290	250	195	155	245
Buffalo Bill Reservoir Inflow	APR-JUL	620	92	815	700	545	430	675
	APR-SEP	690	93	900	775	605	480	745
Bighorn R nr St. Xavier (2)	APR-JUL	835	61	1460	1090	580	210	1380
	APR-SEP	820	56	1500	1100	540	135	1460
Tongue R nr Dayton (2)	APR-JUL	84	98	113	96	72	55	86
	APR-SEP	96	98	127	109	83	65	98
Tongue River Reservoir Inflow (2)	APR-JUL	187	97	290	230	145	83	193
	APR-SEP	210	98	320	255	165	100	215
NF Powder R nr Hazelton	APR-JUL	6.6	73	9.9	8.0	5.3	3.3	9.1
	APR-SEP	7.2	73	10.6	8.6	5.8	3.8	9.9
Powder R at Moorhead	APR-JUL	108	61	240	162	54	1.00	177
	APR-SEP	121	62	255	175	66	1.00	196

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAR-JUL	4.8	77	8.6	6.3	3.3	1.05	6.2
	APR-JUL	3.7	71	7.1	5.1	2.4	0.37	5.2
Pactola Reservoir Inflow (2)	MAR-JUL	14.5	58	30	21	8.0	1.00	25
	APR-JUL	11.9	54	27	18.1	5.8	1.00	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate (2)	APR-JUL	94	42	225	146	41	1.00	225
	APR-SEP	103	41	245	160	46	1.00	250
Encampment R nr Encampment (2)	APR-JUL	79	61	138	103	55	19.1	129
	APR-SEP	84	61	146	109	59	23	138

Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	45	92	63	53	38	27	49
	APR-SEP	48	92	67	55	40	29	52
Seminoe Reservoir Inflow (2)	APR-JUL	430	60	815	585	275	46	715
	APR-SEP	465	60	870	630	305	65	770
Sweetwater R nr Alcova	APR-JUL	15.5	26	51	30	1.11	1.00	59
	APR-SEP	17.5	27	55	33	2.2	1.00	64
La Prele Ck nr Douglas	APR-JUL	11.9	60	31	19.1	7.0	2.0	19.9
	APR-SEP	12.1	61	32	19.4	7.0	2.0	19.9
North Platte R bl Glendo Reservoir (2)	APR-JUL	395	48	930	610	180	1.00	820
	APR-SEP	400	47	950	625	180	1.00	850
North Platte R bl Guernsey Reservoir (2)	APR-JUL	380	46	930	600	158	1.00	820
	APR-SEP	385	45	950	615	156	1.00	850
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	83	72	142	107	59	24	115
	APR-SEP	91	72	154	116	65	27	126
Little Laramie R nr Filmore	APR-JUL	44	86	66	53	35	22	51
	APR-SEP	48	87	71	57	39	25	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
March 2021 Calendar Year Runoff Forecast
March 2, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at http://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

February runoff was 0.8 MAF, 70% of average for the Basin above Sioux City, IA. Runoff was below-average in the Fort Peck, Garrison, and Oahe reaches due to below-normal precipitation in February as well as the much below temperatures which caused many of the tributaries to be locked up in ice.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **21.7 MAF, 84% of average**. The 2021 calendar year runoff forecast for the Missouri Basin above Gavins Point is **19.5 MAF**, **84% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 10 months, expected inflow could range from the 29.8 MAF upper basic forecast to the 14.6 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. Given that ten months are being forecast for this March 1 forecast (2 month observed/10 months forecast), the range of possible wetter-than-expected (upper basic)

and drier-than-expected (lower basic) conditions is very large, and is attributed to all six reaches for the next 10 months. The result is a range or "bracket" for each reach, and thus, for the total runoff forecast.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for February 23, 2021 is shown in **Figure 1**. The drought monitor is available at http://droughtmonitor.unl.edu/. The U.S. Drought Monitor shows Abnormally Dry (D0) conditions are present in every state in the Basin, with Extreme Drought (D3) conditions present in the mountainous areas of Wyoming and Colorado as well as western Nebraska and Kansas. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of May, indicates drought conditions are likely to persist throughout most of the Basin.

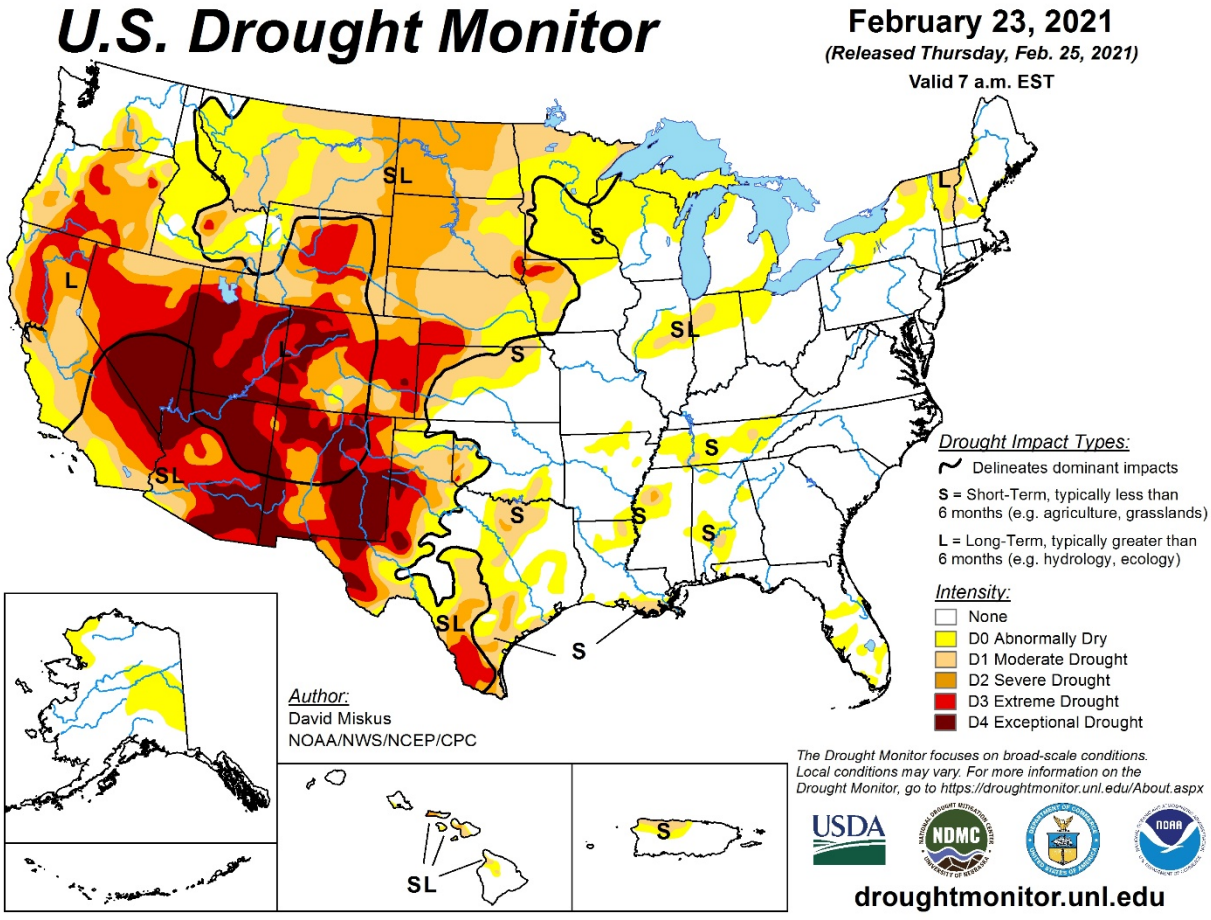


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for February 23, 2021.

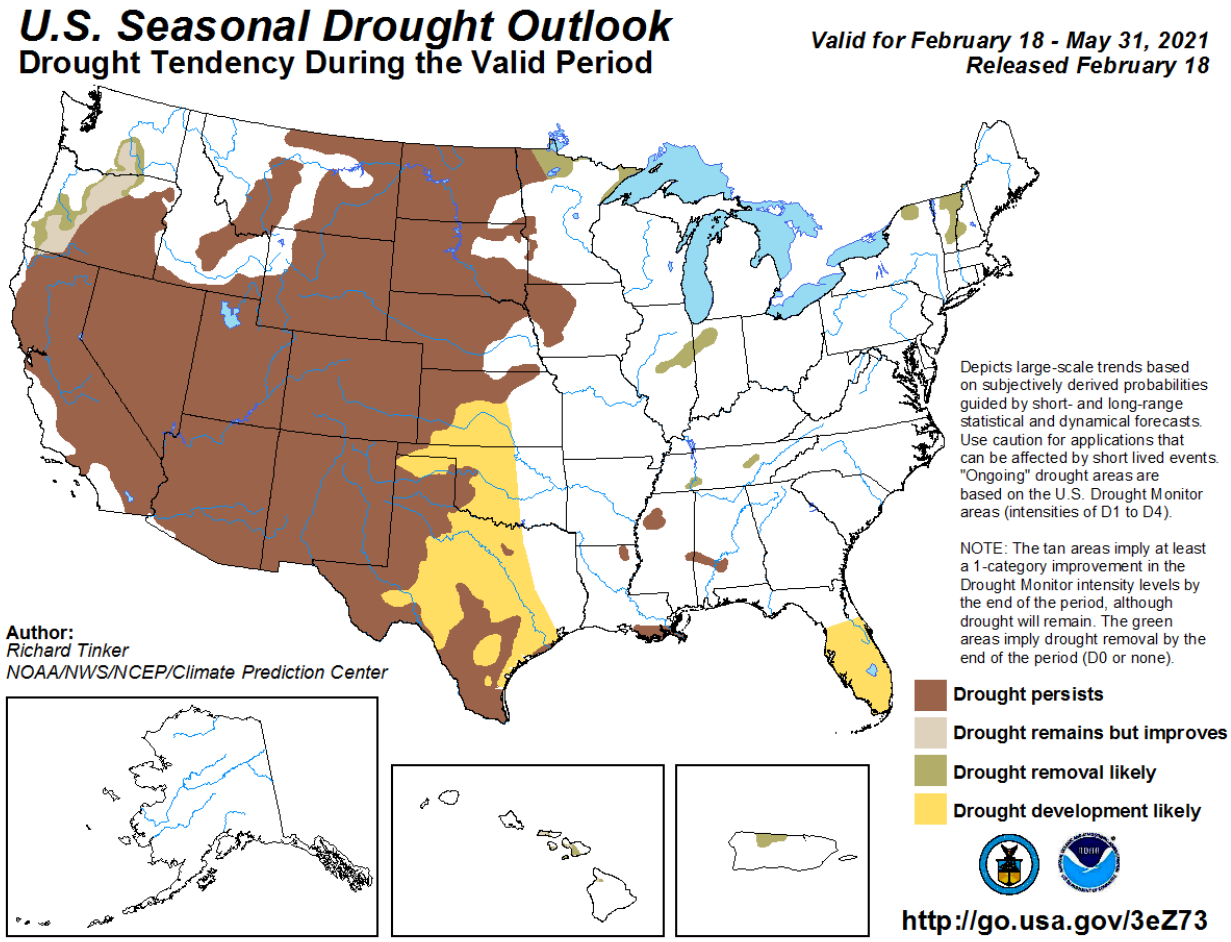


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at http://www.hprcc.unl.edu/. The February precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. February precipitation was generally below normal across the upper Basin with areas of well-below-normal precipitation in southern North Dakota and northern South Dakota. Parts of Montana received 200-400 percent of normal precipitation; however, normal precipitation during February is low so the above-normal precipitation did not result in significant runoff.

Precipitation as a percent of normal for the December 2020-February 2021 period was also below normal over most of the basin, especially in North Dakota, South Dakota, and Montana. Localized areas of above normal precipitation were observed in Nebraska, Iowa, Missouri, and Kansas (**Figure 4**).

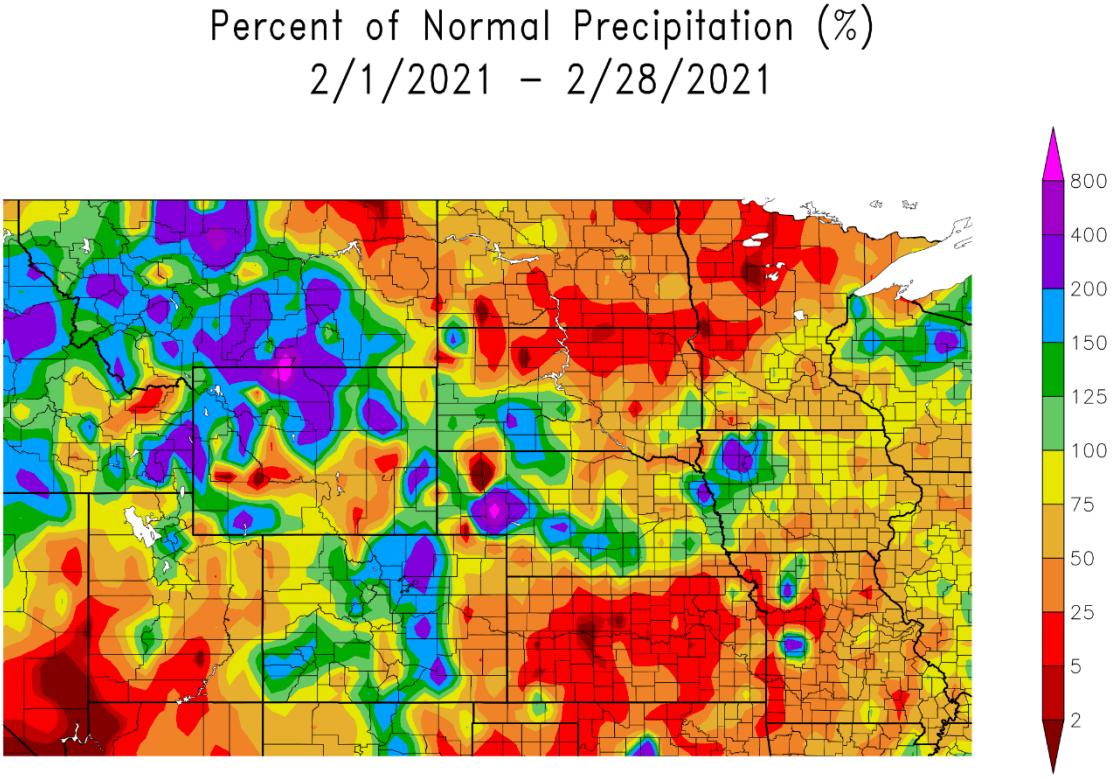


Figure 3. February 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

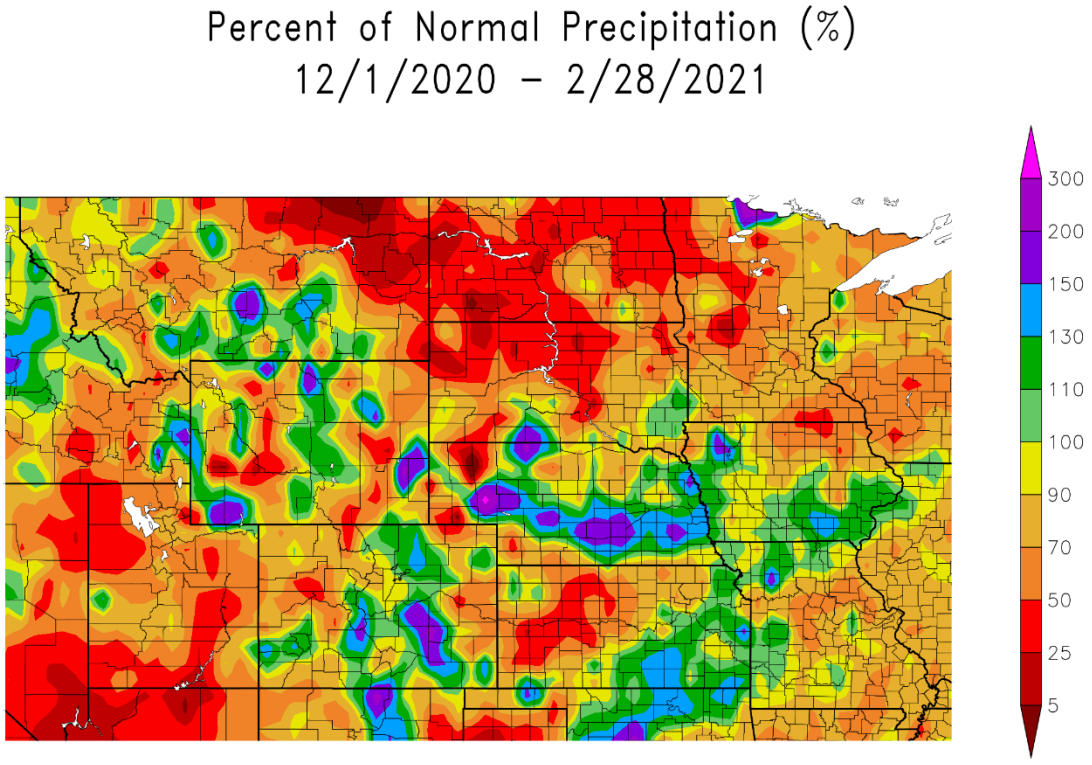


Figure 4. December 2020-February 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

February temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate colder-than-normal temperatures over most of the Basin, ranging from 6 to 15 deg F below normal. These colder-than-normal temperatures resulted in the formation of river ice and allowed most Missouri River tributaries to completely freeze during February. The colder temperatures allowed for a moderate plains snowpack to develop in Nebraska. December 2020-February 2021 temperature departures are shown in **Figure 6**. The three-month average departures remain above normal across the upper Basin despite a colder-than-normal February and slightly below normal across the lower Basin.

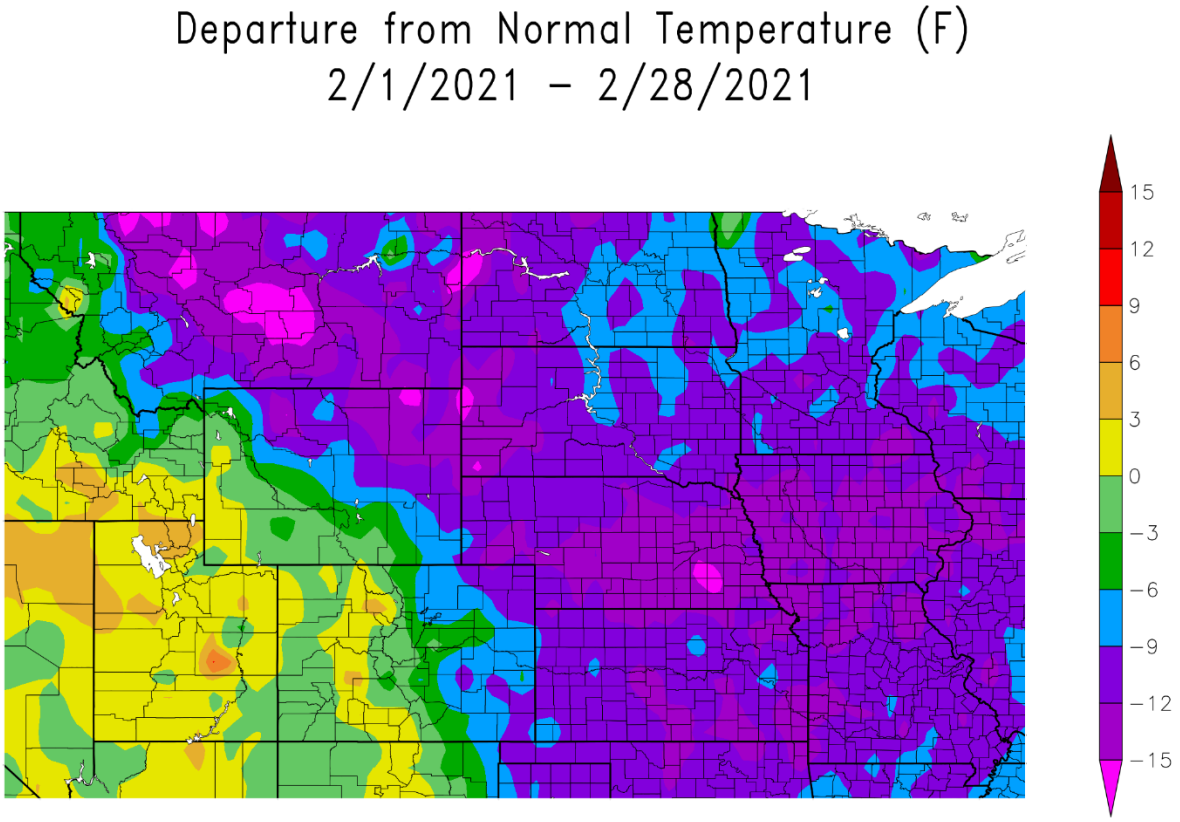


Figure 5. February 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

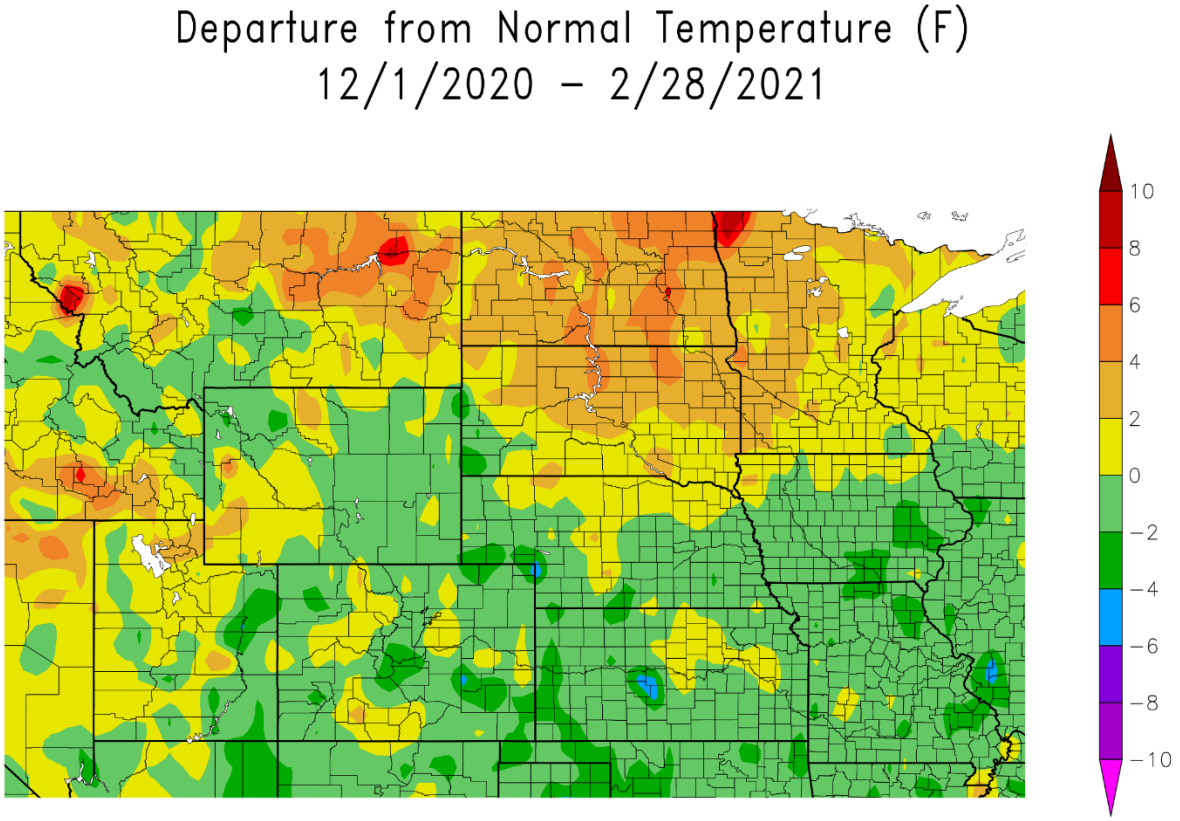


Figure 6. December 2020-February 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of March 2021 is drier than normal across much of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**. The figure indicates that beginning of March 2021 soil moisture anomalies in the Missouri River Basin are well-below normal. Furthermore, the soil moisture percentiles rank low; between the 1st and 30th percentiles. The 1st percentile indicates that soil moisture is at its driest for this time of year, compared to long-term soil moisture simulations. Generally, when soil moisture is low during the winter, the potential for high March-April runoff is lower.

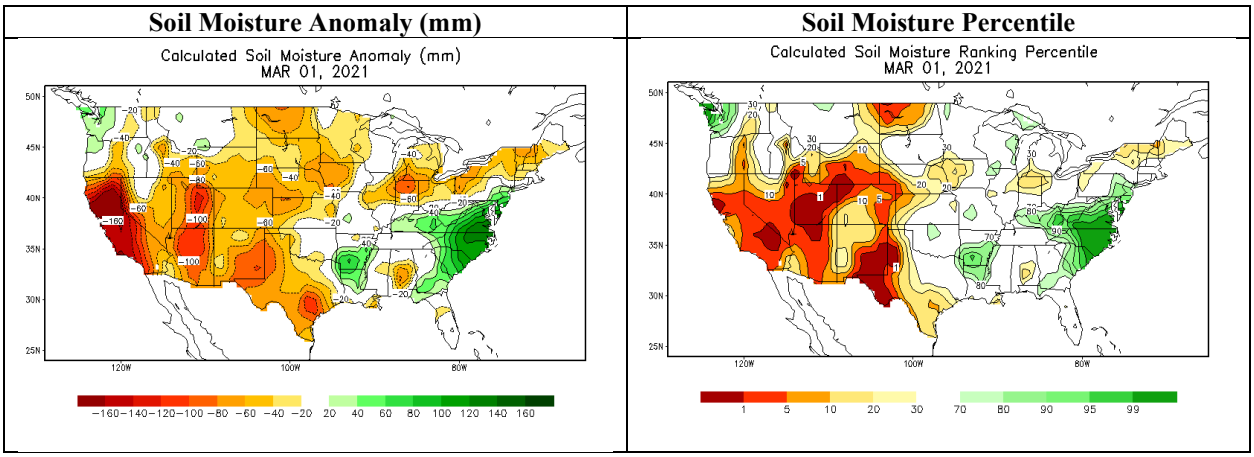


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks. At this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from March 1, shown in **Figure 8**, indicates trace amounts of liquid content over southern South Dakota, and northern North Dakota. The remainder of the Basin does not contain any measurable amount of SWE.

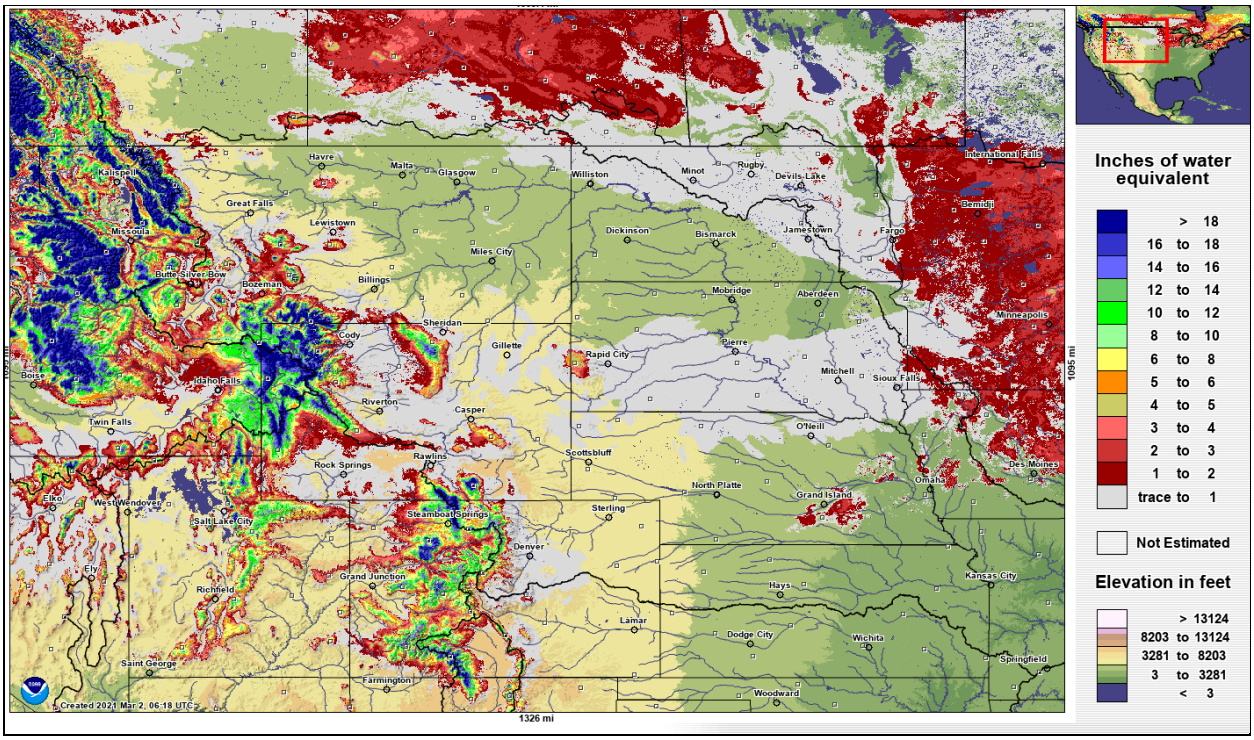


Figure 8. March 1, 2021 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has fairly good correlation to the March 1 snowpack, with approximately 80 percent of the mountain snowpack accumulating by March 1. The snowpack typically peaks in mid-April.

Figure 9 includes time series plots of the average mountain SWE beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

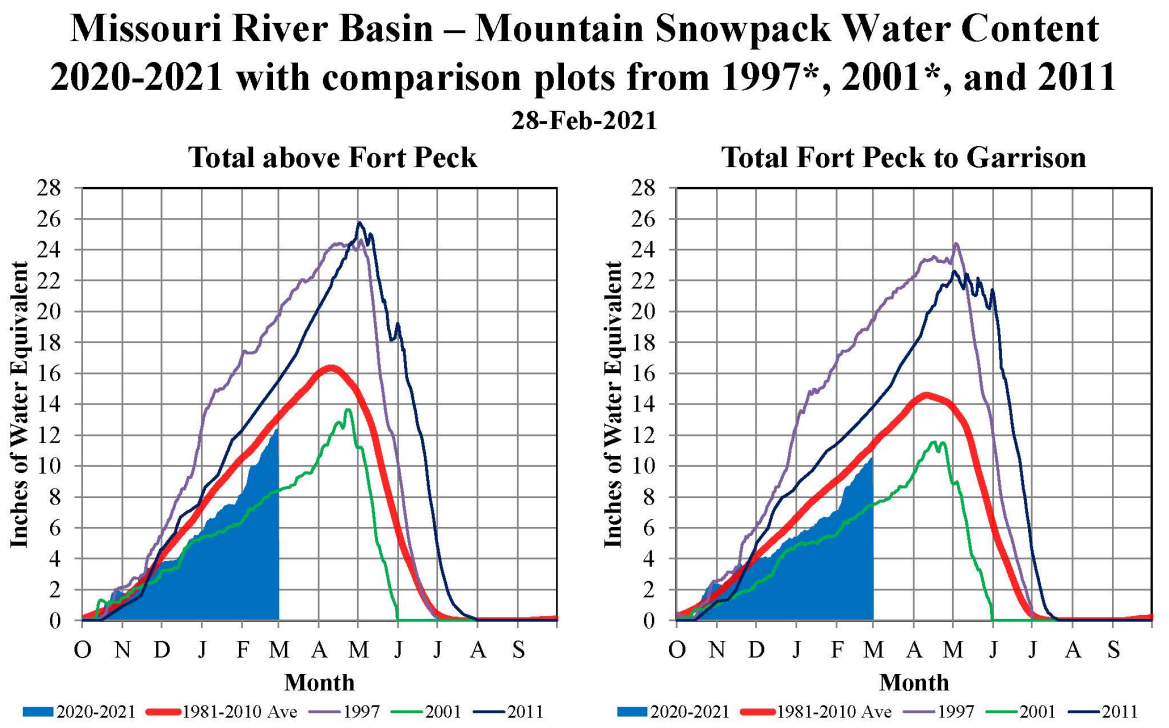


Figure 9. Mountain snowpack water content on February 28, 2021 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

As of February 28, 2021, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 12.4 inches, which is 95 percent of average based on the 1981-2010 average SWE for the Fort Peck reach. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 10.6 inches, which is 94 percent of average based on the 1981-2010 average SWE for the Garrison reach. Typically, 80 percent of the peak mountain snowpack has accumulated by March 1 and it usually peaks around April 15.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

The latest ENSO Outlook indicates that La Nina conditions are present and will likely transition to ENSO-neutral during the Northern Hemisphere spring. During La Nina conditions there are increased chances for below-normal temperatures in the upper Basin and increased chances for an above-normal mountain snowpack.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center (CPC) outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at http://www.cpc.ncep.noaa.gov/.

The CPC temperature outlook through March 15 (**Figure 10**) indicates increased chances for above-normal temperatures over eastern portions of the Basin and increased chances for below-normal temperatures over western portions of the Basin. The outlook indicates a slight increase in the chances for above-normal precipitation over the Basin.

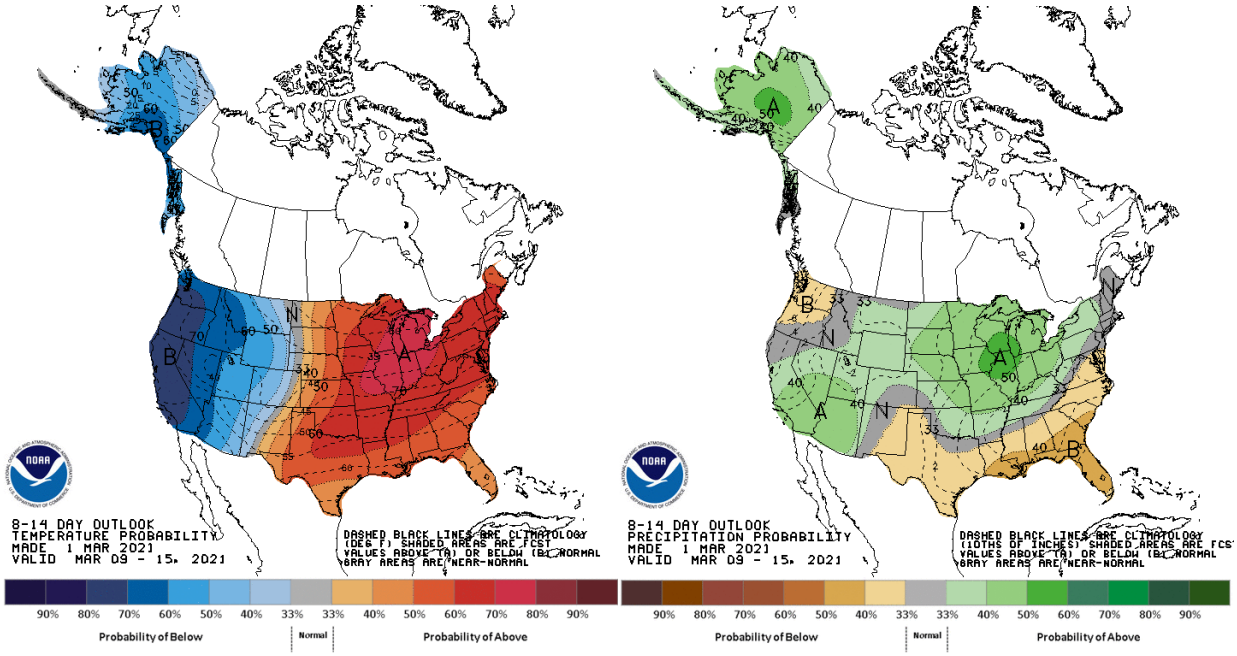


Figure 10. CPC 8-14 Day temperature and precipitation outlooks through March 15, 2021.

The March CPC outlooks in **Figure 11** indicate increased chances for above-normal temperatures over eastern portions of the Basin and below-normal precipitation over southwestern portions of the Missouri Basin.

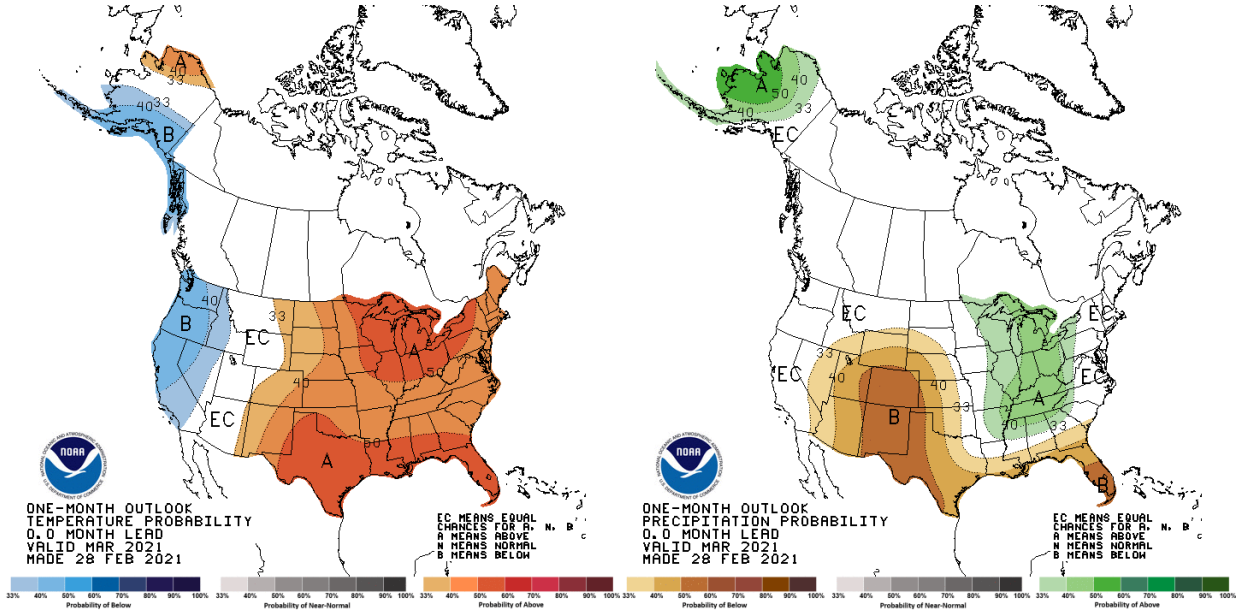


Figure 11. CPC March 2021 temperature and precipitation outlooks.

Three-month temperature and precipitation outlooks for four three-month periods in 2021 are shown below in **Figure 12-Figure 15**. During the April-May-June period (**Figure 12**), the CPC indicates increased chances for above-normal temperatures over the entire Basin. With regard to precipitation, there is an increased probability for below-normal precipitation across western portions of the Basin.

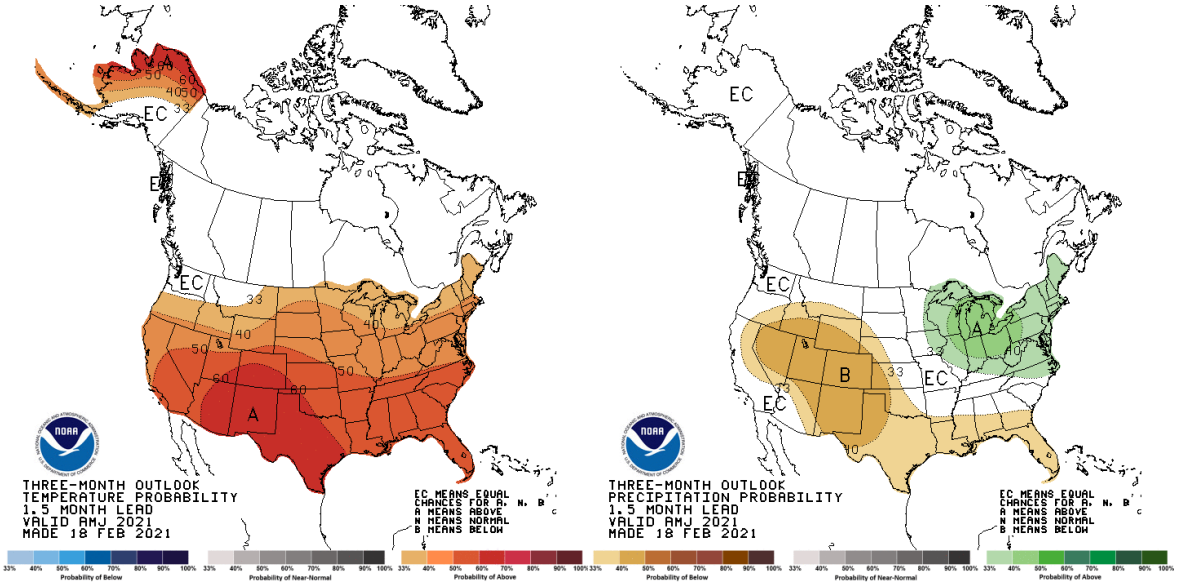


Figure 12. CPC April-May-June temperature and precipitation outlooks.

During the July-August-September forecast period (**Figure 13**), there are increased chances for above-normal temperatures across the entire Basin. Precipitation chances transition to increased chances for below-normal precipitation over northwestern portions of the Basin, with equal chances elsewhere. During the October-November-December timeframe, the increased chances for above-normal temperatures shift farther south with equal chances in North Dakota, Montana, and northern South Dakota. There are no strong indicators for precipitation during this time with equal chances occurring over the entire Basin (**Figure 14**). During January-February-March 2022, most of the Basin has increased chances for above-normal precipitation and all of the Basin has equal chances for temperature (**Figure 15**). As previously noted, though, there is limited confidence in climate outlooks beyond the winter and early spring, therefore, the climate outlooks will likely change as the calendar progresses.

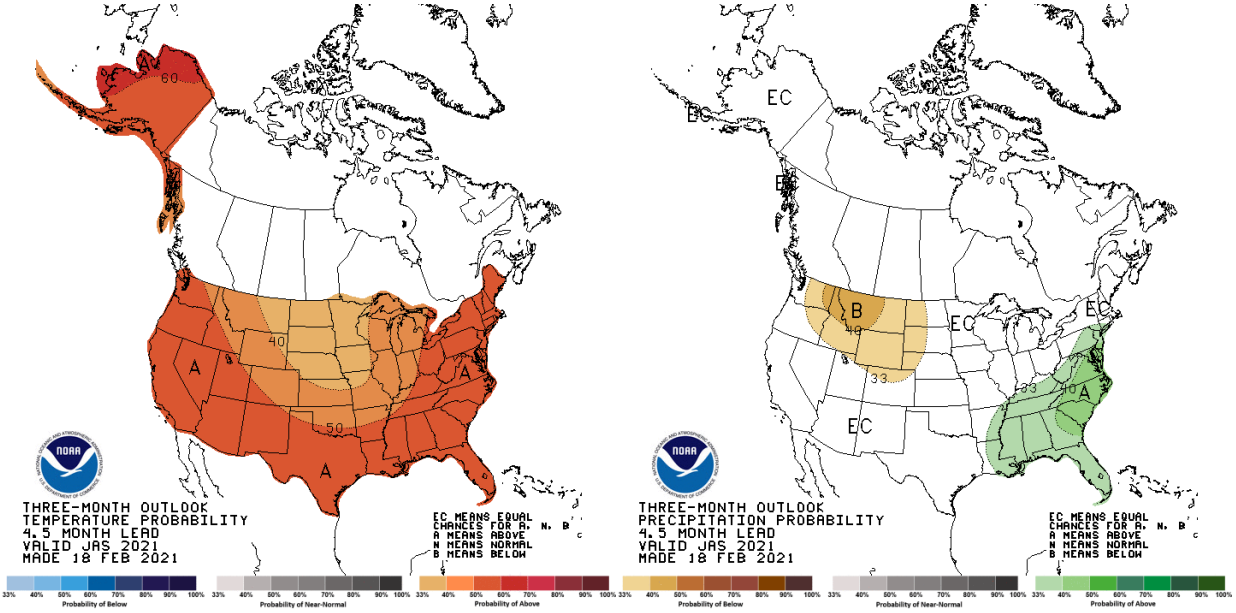


Figure 13. CPC July-August-September temperature and precipitation outlooks.

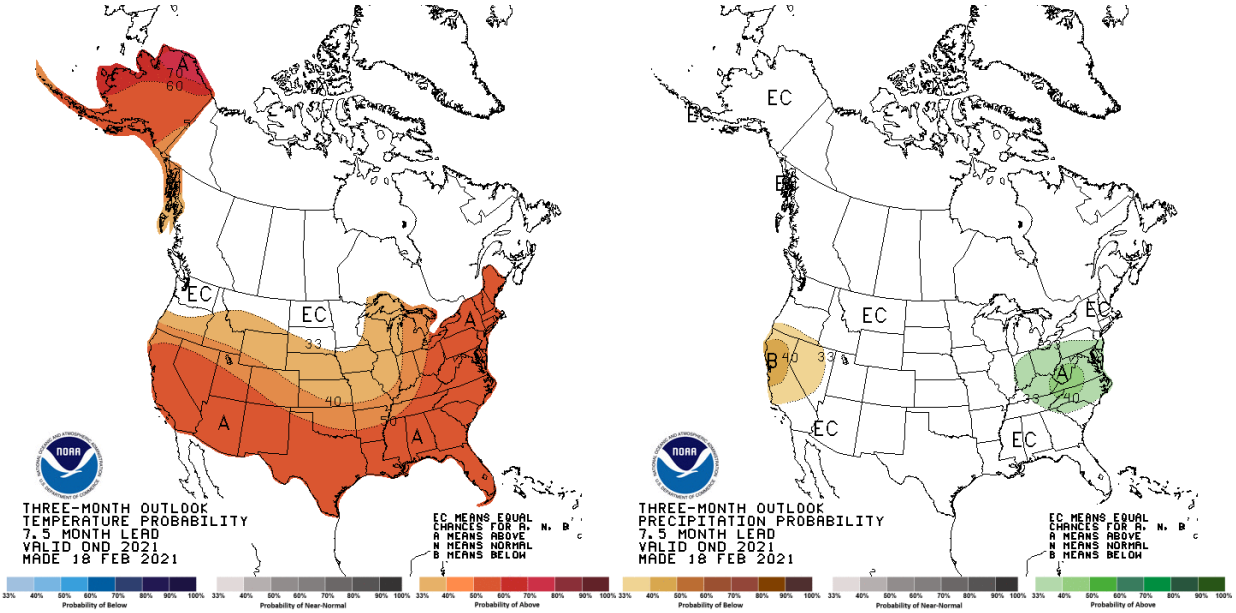


Figure 14. October-November-December temperature and precipitation outlooks.

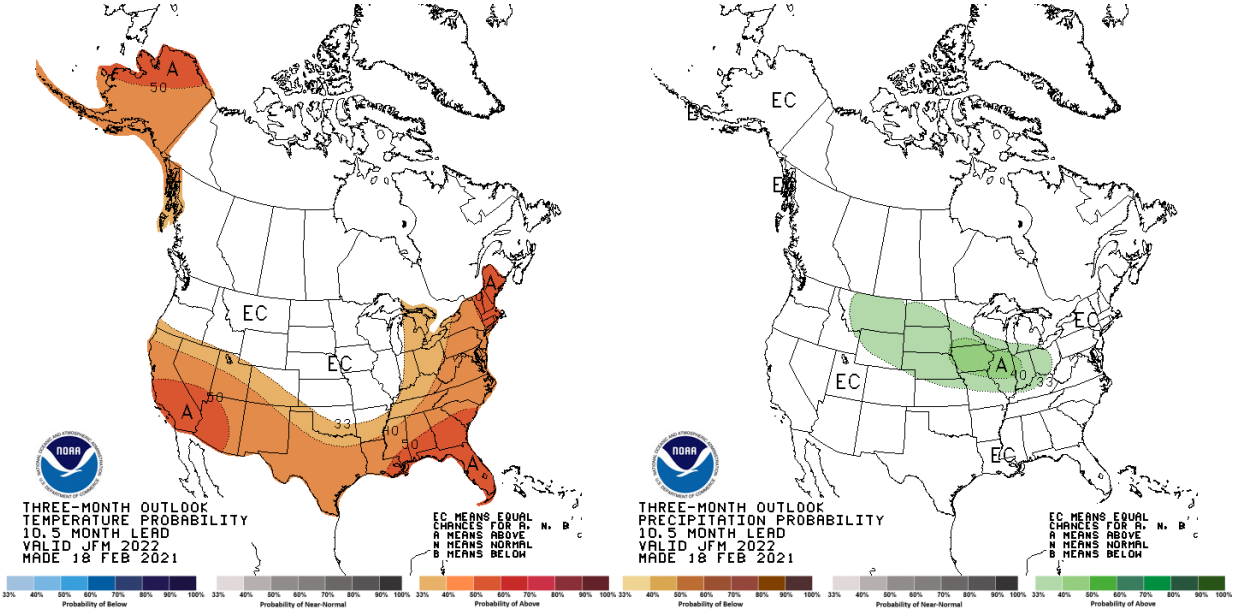


Figure 15. January-February-March 2022 temperature and precipitation outlooks.

Summary

Given the dry soil moisture conditions, moderate streamflow, and limited plains snowpack, we expect runoff to remain below average during March. March-April runoff potential is also low due to the dry soil moisture conditions, but it will depend greatly on rainfall events over the next couple months. During May, June and July, Fort Peck and Garrison runoff is forecast to be near average due to the near-normal mountain snowpack. In summary, the 2021 calendar year runoff forecast is **21.7 MAF (84% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: March 04, 2021 11:02:14 AM
   - Based on March 01, 2021 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow (2)	APR-JUL	101	104	122	110	93	81	97
	APR-SEP	116	104	139	126	107	93	112
St. Mary R at Intl Boundary (2)	APR-JUL	460	106	570	505	410	345	435
	APR-SEP	530	105	650	580	480	405	505
Lima Reservoir Inflow (2)	APR-JUL	51	68	84	64	37	17.3	75
	APR-SEP	54	68	92	69	39	16.5	80
Clark Canyon Inflow (2)	APR-JUL	55	54	116	79	31	1.01	101
	APR-SEP	70	58	141	99	41	1.20	120
Jefferson R nr Three Forks (2)	APR-JUL	690	93	1170	885	495	215	740
	APR-SEP	700	88	1190	900	500	205	800
Hebgen Lake Inflow (2)	APR-JUL	325	88	405	355	295	245	370
	APR-SEP	415	88	510	455	375	320	470
Ennis Lake Inflow (2)	APR-JUL	560	90	710	620	500	410	625
	APR-SEP	700	90	880	775	625	520	775
Missouri R at Toston (2)	APR-JUL	1740	97	2470	2030	1440	1000	1790
	APR-SEP	1980	96	2810	2310	1640	1150	2070
Smith R bl Eagle Ck (2)	APR-JUL	107	101	190	140	73	24	106
	APR-SEP	116	100	205	152	80	27	116
Gibson Reservoir Inflow (2)	APR-JUL	420	106	525	460	380	315	395
	APR-SEP	460	105	575	505	415	345	440
Marias R nr Shelby (2)	APR-JUL	360	100	510	420	300	210	360
	APR-SEP	375	100	535	440	310	215	375

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Mystic Lake Inflow	APR-JUL	62	105	72	66	59	53	59
	APR-SEP	80	108	92	85	75	67	74
Wind R ab Bull Lake Ck	APR-JUL	430	95	570	490	370	290	455
	APR-SEP	455	93	615	520	390	295	490
Bull Lake Ck nr Lenore (2)	APR-JUL	118	85	152	132	104	84	139
	APR-SEP	144	85	186	161	127	102	169
Boysen Reservoir Inflow	APR-JUL	425	70	845	595	250	0.000	610
	APR-SEP	445	67	895	630	265	0.000	665
Greybull R at Meeteetse	APR-JUL	110	84	170	135	86	50	131
	APR-SEP	147	83	220	177	118	75	177
Shell Ck nr Shell	APR-JUL	51	93	67	57	45	35	55
	APR-SEP	62	94	79	69	55	45	66
Bighorn R at Kane	APR-JUL	590	70	1220	845	340	8.4	840
	APR-SEP	615	68	1290	890	345	9.0	905
NF Shoshone R at Wapiti	APR-JUL	505	110	610	545	465	400	460
	APR-SEP	565	110	685	615	515	445	515
SF Shoshone R nr Valley	APR-JUL	225	105	280	245	205	171	215
	APR-SEP	260	106	320	285	230	195	245
Buffalo Bill Reservoir Inflow	APR-JUL	730	108	920	805	650	535	675
	APR-SEP	810	109	1020	890	725	600	745
Bighorn R nr St. Xavier	APR-JUL	1170	85	2050	1520	815	295	1380
	APR-SEP	1190	82	2150	1580	795	220	1460
Little Bighorn R nr Hardin	APR-JUL	101	103	159	125	78	44	98
	APR-SEP	114	103	178	140	88	50	111
Tongue R nr Dayton (2)	APR-JUL	89	103	120	102	77	59	86
	APR-SEP	102	104	135	115	88	68	98
Tongue River Reservoir Inflow (2)	APR-JUL	205	106	310	250	159	95	193
	APR-SEP	225	105	340	275	180	111	215
NF Powder R nr Hazelton	APR-JUL	8.6	95	12.5	10.2	7.0	4.7	9.1
	APR-SEP	9.3	94	13.3	10.9	7.7	5.3	9.9

Powder R at Moorhead	APR-JUL	168	95	315	225	109	23	177
	APR-SEP	184	94	335	245	124	35	196
Powder R nr Locate	APR-JUL	189	95	350	255	124	30	199
	APR-SEP	205	93	375	275	137	37	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAR-JUL	4.8	77	8.4	6.2	3.3	1.13	6.2
	APR-JUL	3.7	71	7.1	5.1	2.4	0.41	5.2
Pactola Reservoir Inflow (2)	MAR-JUL	14.2	57	30	21	7.8	0.25	25
	APR-JUL	11.8	54	27	17.9	5.6	0.22	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate (2)	APR-JUL	162	72	290	215	111	35	225
	APR-SEP	180	72	320	235	123	39	250
Encampment R nr Encampment (2)	APR-JUL	111	86	169	135	88	54	129
	APR-SEP	119	86	179	143	95	59	138
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	55	112	73	63	48	38	49
	APR-SEP	58	112	77	66	51	40	52
Seminoe Reservoir Inflow (2)	APR-JUL	570	80	935	720	420	205	715
	APR-SEP	615	80	1000	770	460	230	770
Sweetwater R nr Alcova	APR-JUL	18.6	32	51	32	5.4	0.59	59
	APR-SEP	21	33	56	35	6.7	0.64	64
La Prele Ck nr Douglas	APR-JUL	10.9	55	31	17.9	5.8	0.99	19.9
	APR-SEP	11.1	56	32	18.1	5.8	0.99	19.9
North Platte R bl Glendo Reservoir (2)	APR-JUL	550	67	1060	755	345	40	820
	APR-SEP	565	66	1090	780	355	42	850
North Platte R bl Guernsey Reservoir (2)	APR-JUL	540	66	1060	755	330	17.9	820
	APR-SEP	555	65	1090	775	340	17.5	850
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	102	89	160	126	79	45	115
	APR-SEP	112	89	175	137	87	50	126
Little Laramie R nr Filmore	APR-JUL	61	120	83	70	52	39	51
	APR-SEP	66	120	90	76	56	42	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
April 2021 Calendar Year Runoff Forecast
April 8, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at http://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

March runoff was 2.1 MAF, 70% of average for the Basin above Sioux City, IA. Runoff was below-average in all reaches except Gavins Point due to below-normal precipitation in March and minimal to non-existent plains snowpack.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **21.3 MAF, 83% of average**. The 2021 calendar year runoff forecast for the Missouri Basin above Gavins Point is **19.3 MAF**, **83% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 9 months, expected inflow could range from the 28.3 MAF upper basic forecast to the 15.2 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively. Given that nine months are being forecast for this April 1 forecast (3 month observed/9 months forecast), the range of possible wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is very large, and is attributed to all six reaches for

the next 9 months. The result is a range or "bracket" for each reach, and thus, for the total runoff forecast.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for April 6, 2021 is shown in **Figure 1**. The drought monitor is available at http://droughtmonitor.unl.edu/. The U.S. Drought Monitor shows Abnormally Dry (D0) conditions are present in every state in the Basin except Missouri, with Extreme Drought (D3) conditions present in the mountainous areas of Wyoming and Colorado as well as western eastern Montana, North Dakota, and northern south Dakota. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of June, indicates drought conditions are likely to persist or worsen throughout the Basin.

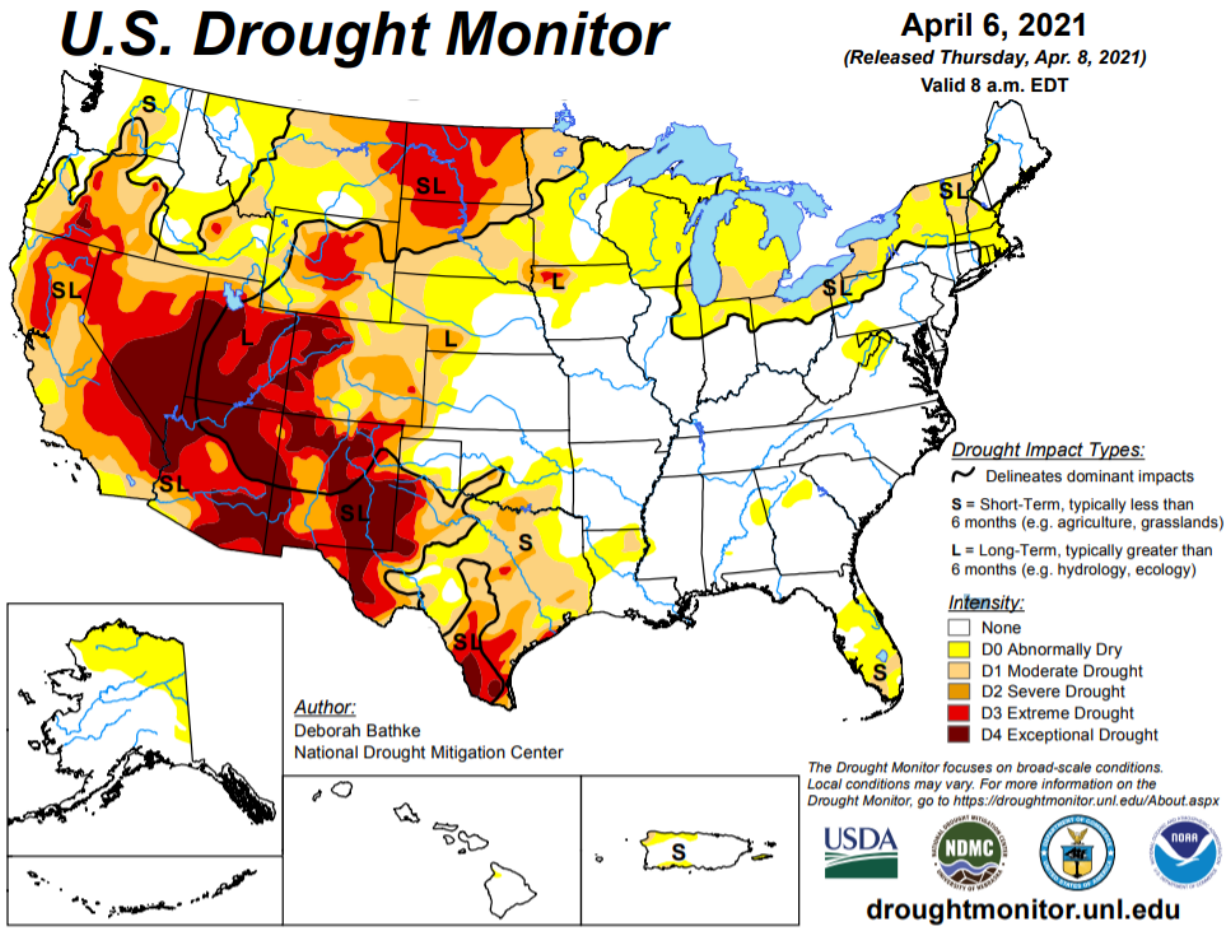


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for April 6, 2021.

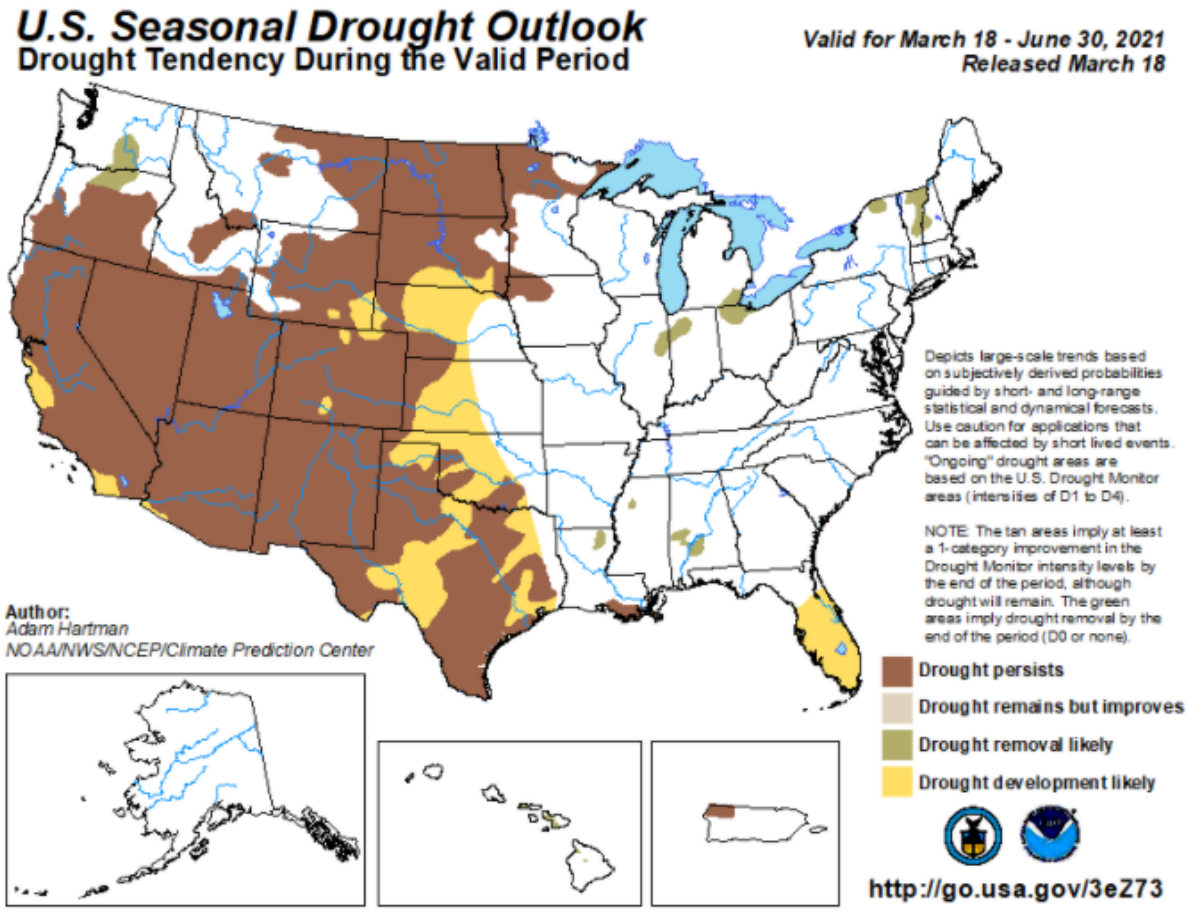


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at http://www.hprcc.unl.edu/. The March precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. March precipitation was generally below normal across Montana, North Dakota, and northern South Dakota, while it was above normal in southern South Dakota and the lower Basin. Parts of North Dakota received 2 percent or less of normal precipitation, while parts of Nebraska received 400 percent or more of normal precipitation.

Precipitation as a percent of normal for the January-February-March 2021 period was also generally below normal in the upper Basin and above normal in the lower Basin (**Figure 4**).

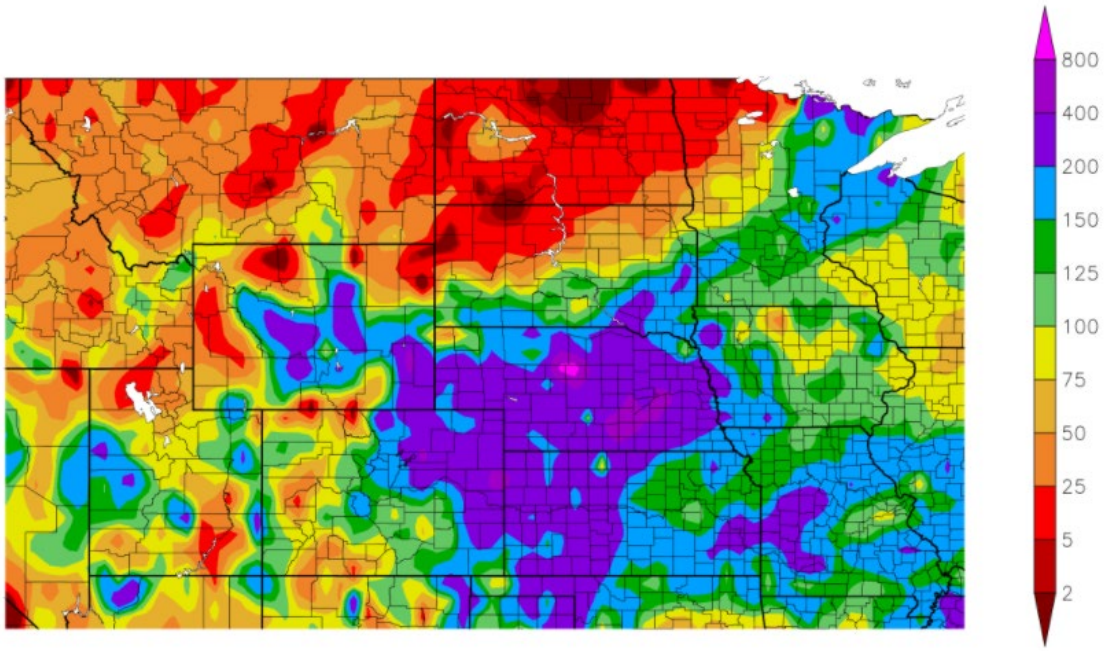


Figure 3. March 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

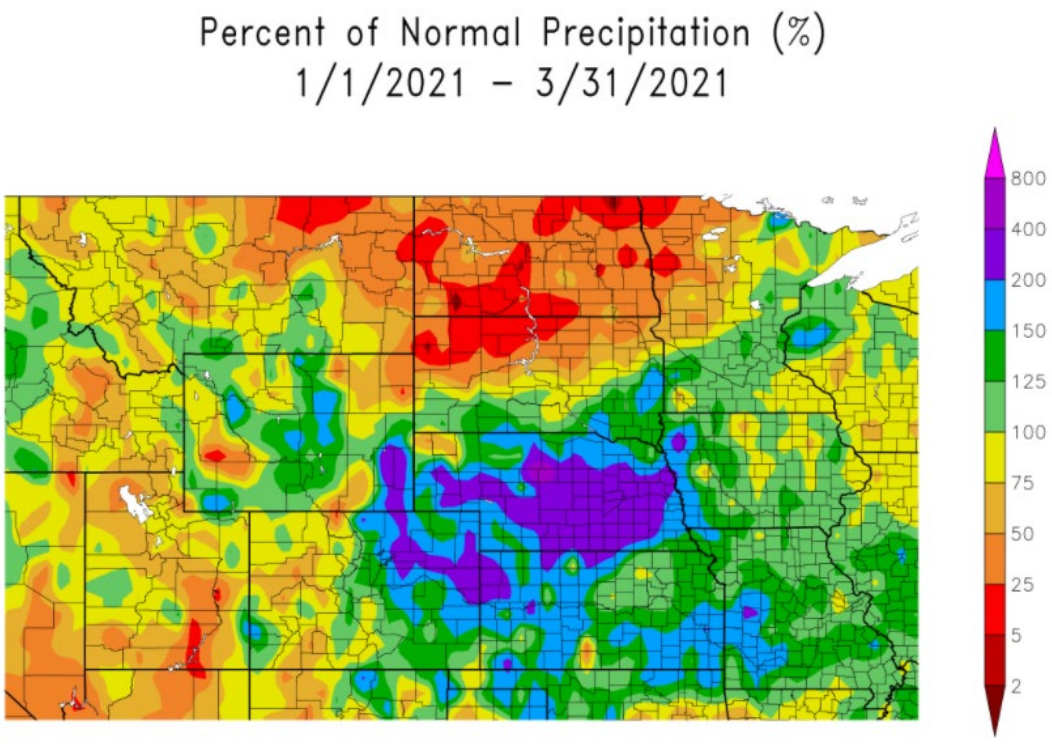


Figure 4. January-February-March 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

March temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures over most of the Basin, ranging from 3 to 12 deg F above normal. Slightly colder-than-normal temperatures occurred in the mountainous areas of the Basin, allowing for more snowpack accumulation. January-February-March 2021 temperature departures are shown in **Figure 6**. The three-month average departures remain near normal across most of the Basin, tending towards slightly warmer than normal in the upper Basin, and slightly cooler than normal in the lower Basin and mountainous areas.

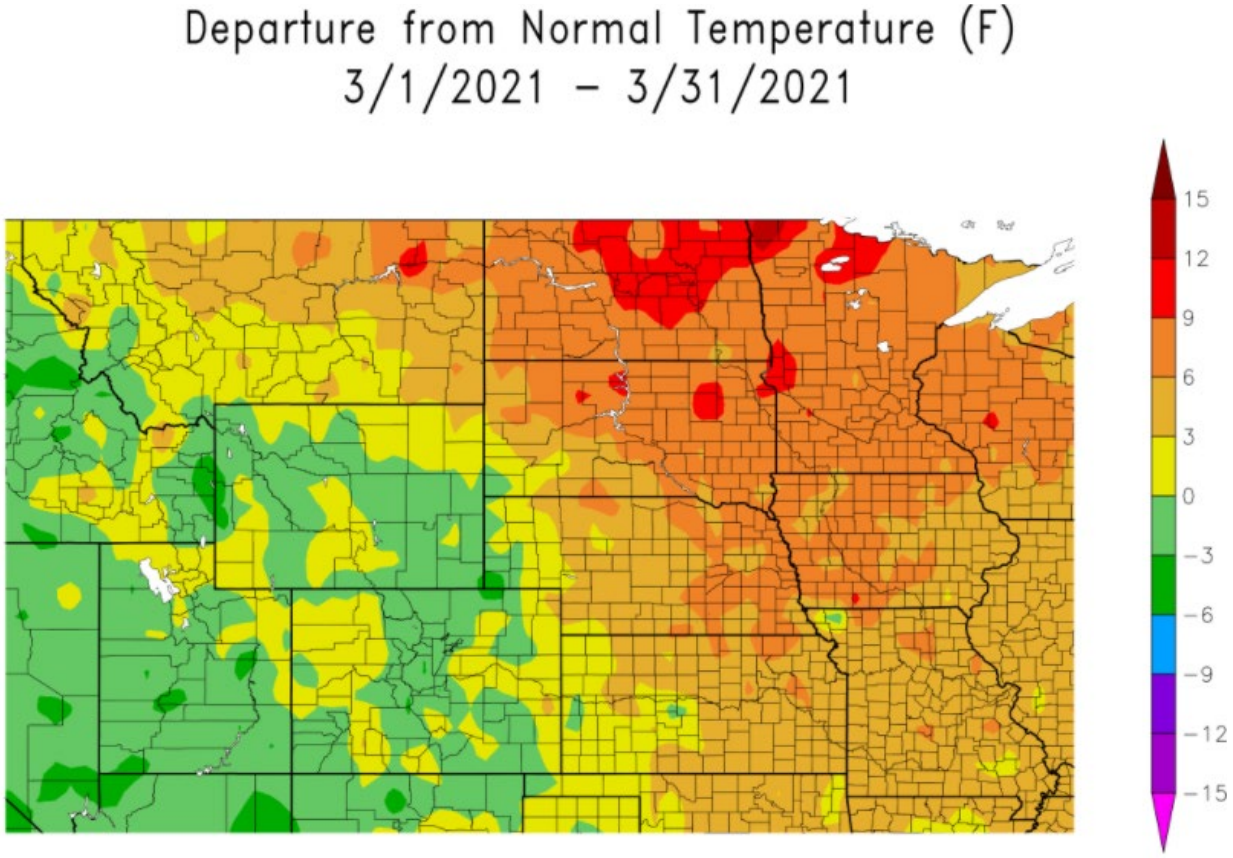


Figure 5. March 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

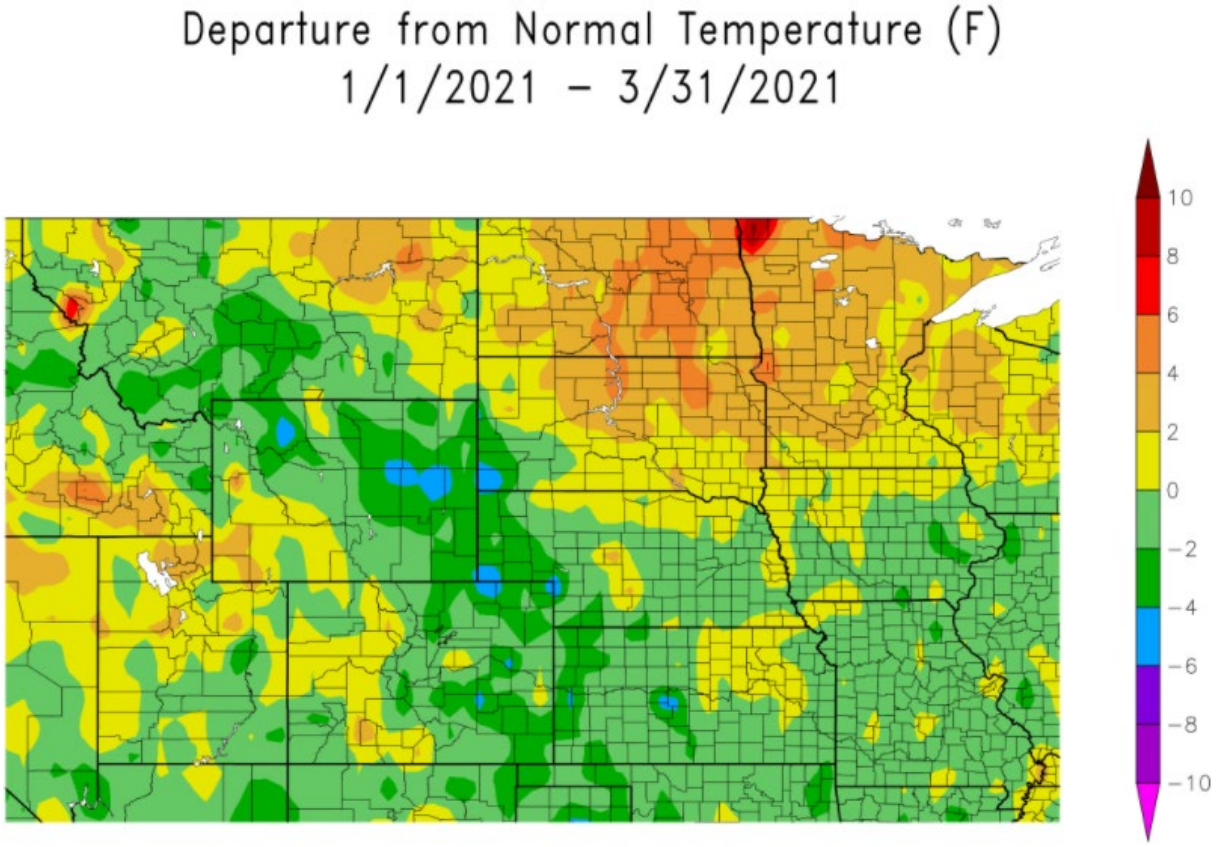


Figure 6. January-February-March 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of April 2021 is drier than normal across the western and northern portions of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**. The figure indicates that beginning of April 2021 soil moisture anomalies in the western and northern portions of the Basin are below-normal, while recent rains have increased soil moisture in the lower Basin to above-normal. Generally, when soil moisture is low during the winter, the potential for high March-April runoff is lower.

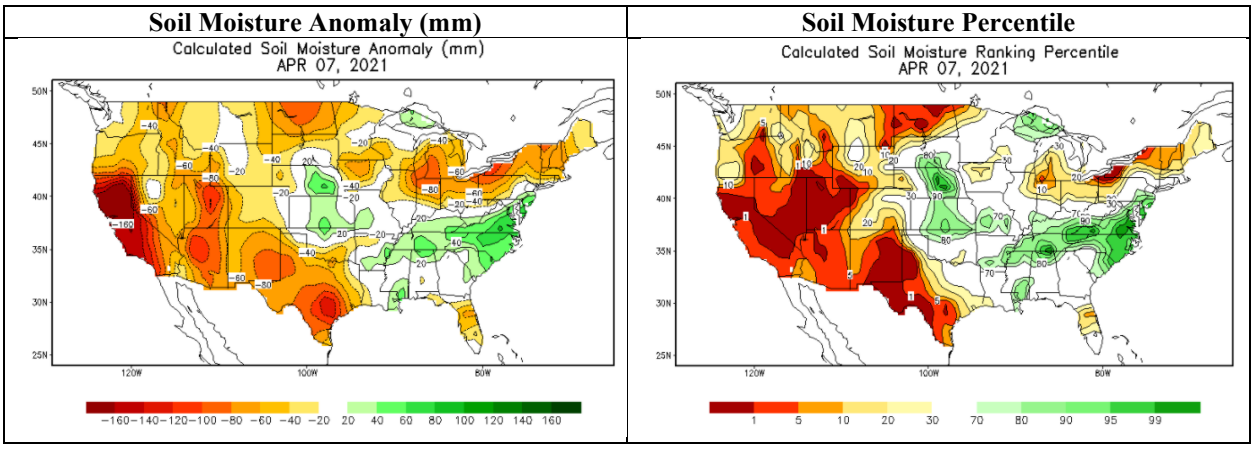


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks. At this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from April 1, shown in **Figure 8**, indicates plains snowmelt in the Basin is non-existent.

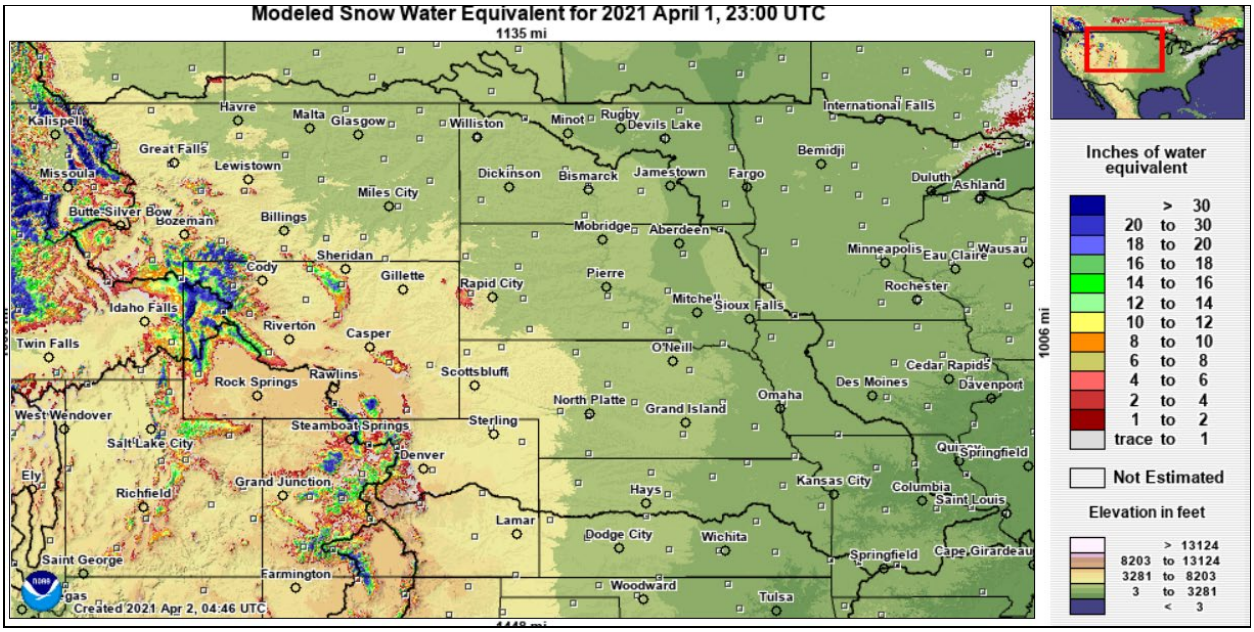


Figure 8. April 1, 2021 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the April 1 snowpack. The snowpack typically peaks in mid-April.

Figure 9 includes time series plots of the average mountain SWE beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

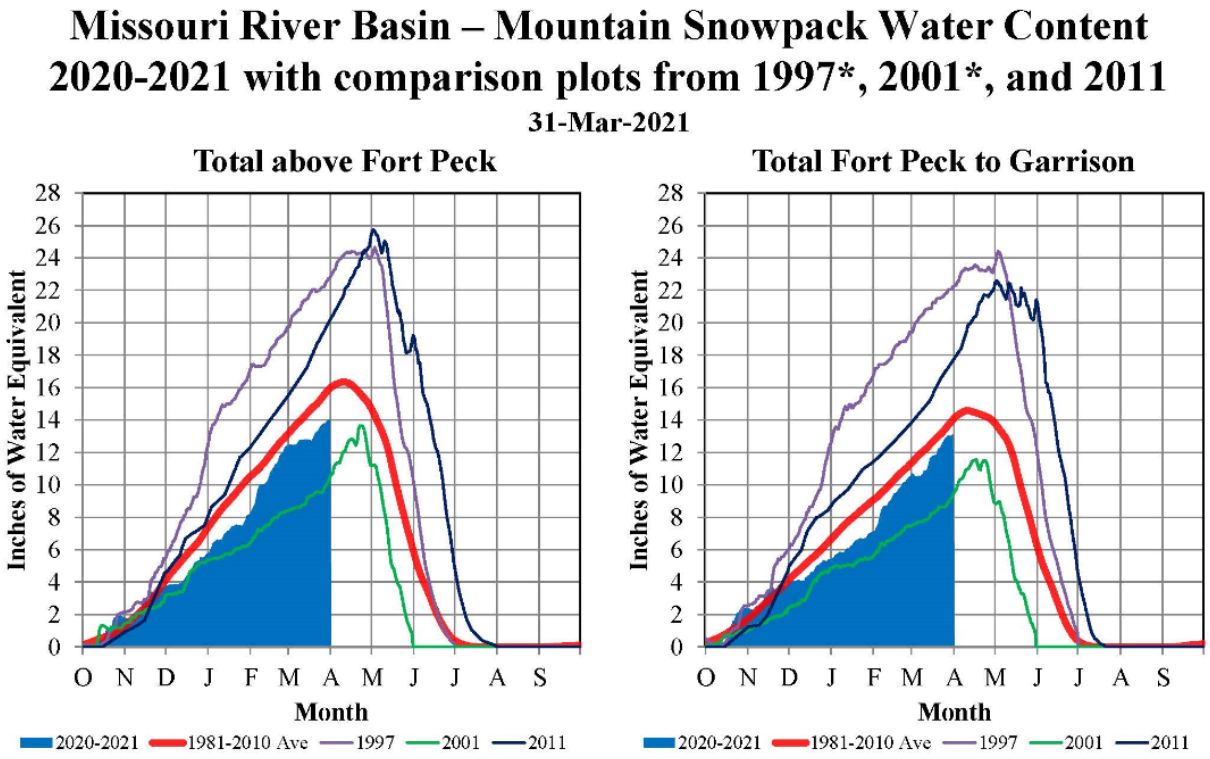


Figure 9. Mountain snowpack water content on March 31, 2021 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

As of March 31, 2021, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 14.0 inches, which is 88 percent of average based on the 1981-2010 average SWE for the Fort Peck reach. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 13.1 inches, which is 94 percent of average based on the 1981-2010 average SWE for the Garrison reach. Typically, around 90 percent of the peak mountain snowpack has accumulated by April 1 and it usually peaks around April 15.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

The latest ENSO Outlook indicates that La Nina conditions are present and will likely transition to ENSO-neutral during the Northern Hemisphere spring. During La Nina conditions there are increased chances for below-normal temperatures in the upper Basin and increased chances for an above-normal mountain snowpack.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center (CPC) outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at http://www.cpc.ncep.noaa.gov/.

The CPC temperature outlook through April 22 (**Figure 10**) indicates increased chances for above-normal temperatures over the western Basin and increased chances for below-normal temperatures over the lower Basin. The outlook indicates a slight increase in the chances for below-normal precipitation over the Basin.

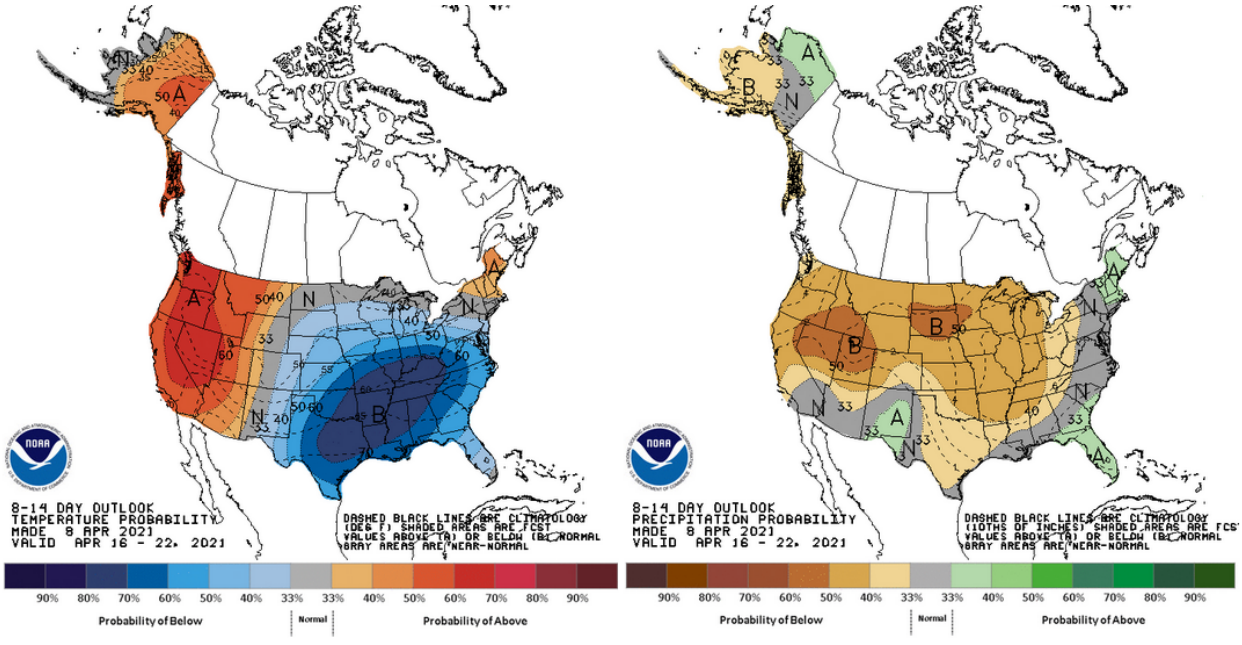


Figure 10. CPC 8-14 Day temperature and precipitation outlooks through April 22, 2021.

The April CPC outlooks in **Figure 11** indicate increased chances for above-normal temperatures over the entire Basin and below-normal precipitation over the mountainous areas of the Missouri Basin, with a slight increase in chances for above-normal precipitation in North Dakota.

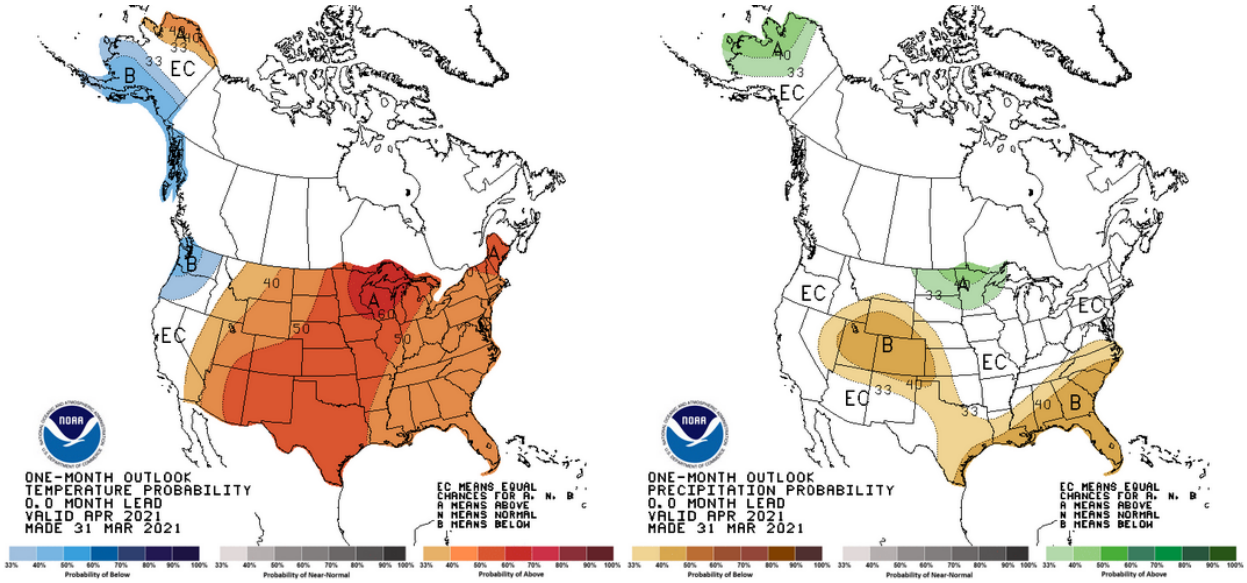


Figure 11. CPC April 2021 temperature and precipitation outlooks.

Three-month temperature and precipitation outlooks for four three-month periods in 2021 are shown below in **Figure 12-14**. During the May-June-July period (**Figure 12**), the CPC indicates increased chances for above-normal temperatures over the entire Basin. With regard to precipitation, there is an increased probability for below-normal precipitation across western portions of the Basin.

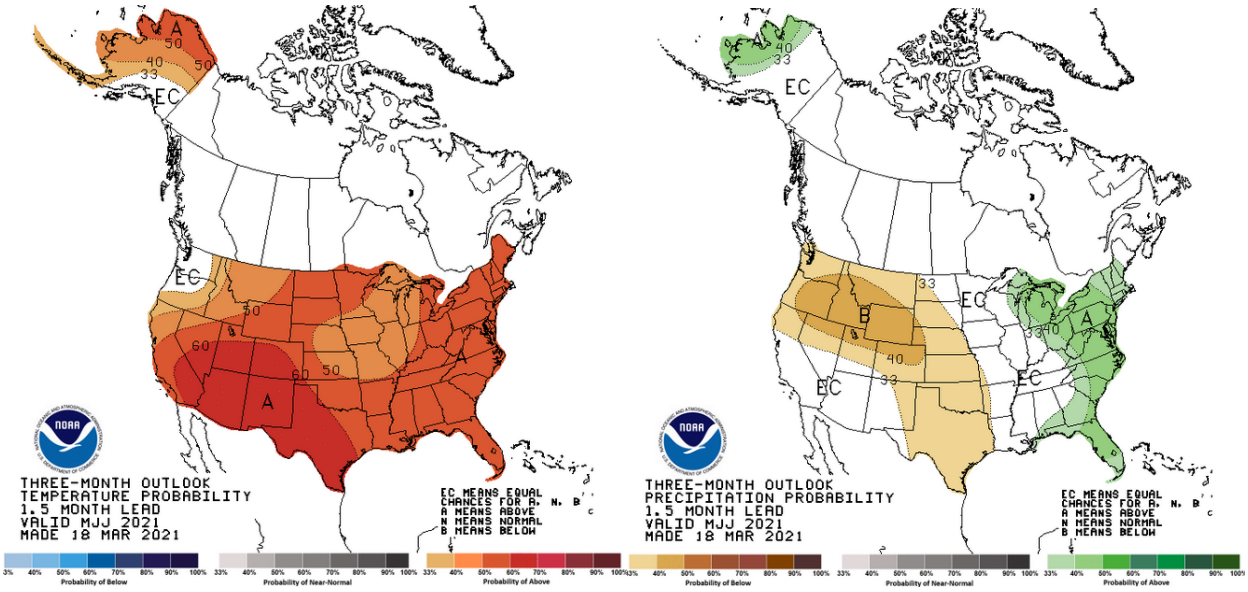


Figure 12. CPC May-June-July temperature and precipitation outlooks.

During the August-September-October forecast period (**Figure 13**), there are increased chances for above-normal temperatures across the entire Basin. Precipitation chances transition to increased chances for below-normal precipitation over the entire Basin. During the November-December 2021-January 2022 timeframe, the increased chances for above-normal temperatures shift farther south with equal chances in North Dakota, Montana, South Dakota, Iowa, and eastern Nebraska. There is a slight increase in chances for above-normal precipitation over Montana, Wyoming, western North Dakota, western South Dakota, and western Nebraska, with equal chances elsewhere (**Figure 14**). As previously noted, though, there is limited confidence in climate outlooks beyond the winter and early spring, therefore, the climate outlooks will likely change as the calendar progresses.

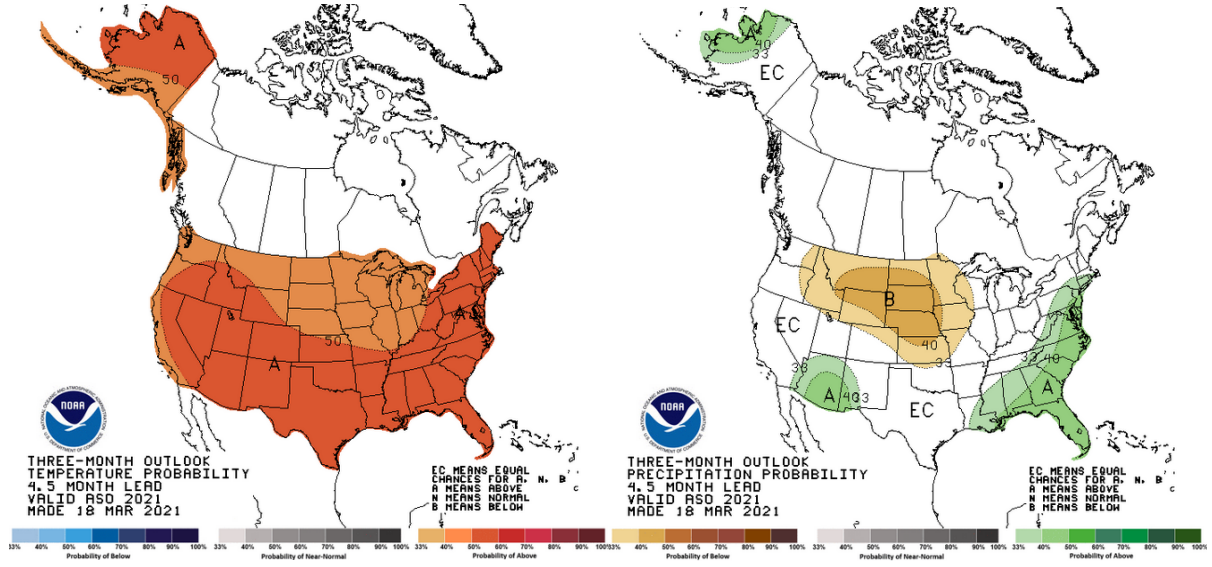


Figure 13. CPC August-September-October temperature and precipitation outlooks.

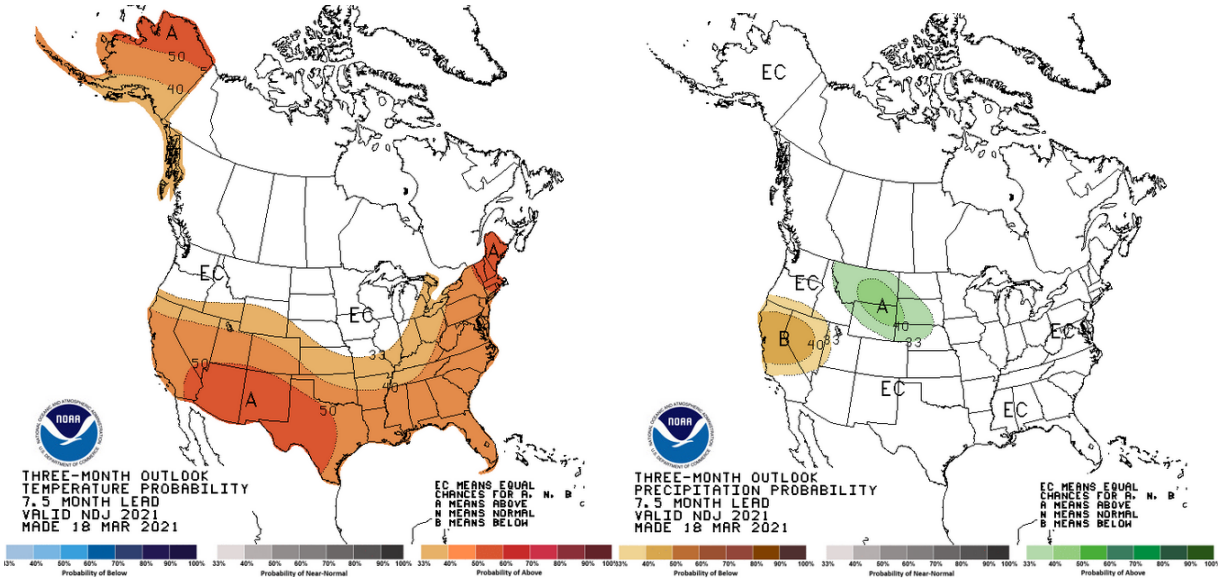


Figure 14. November-December 2021-January 2022 temperature and precipitation outlooks.

Summary

Given the dry soil moisture conditions, below-average streamflow and non-existent plains snowpack, we expect runoff to remain below average during April, but it will depend greatly on rain events. During May, June and July, Fort Peck and Garrison runoff is forecast to be slightly below average due to the slightly below-normal mountain snowpack. In summary, the 2021 calendar year runoff forecast is **21.3 MAF (83% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: April 06, 2021 03:53:57 PM
   - Based on April 01, 2021 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow (2)	APR-JUL	98	101	116	105	91	81	97
	APR-SEP	113	101	133	121	105	93	112
St. Mary R at Intl Boundary (2)	APR-JUL	440	101	535	480	400	345	435
	APR-SEP	510	101	615	555	465	400	505
Lima Reservoir Inflow (2)	APR-JUL	45	60	71	56	34	19.0	75
	APR-SEP	47	59	76	59	36	18.8	80
Clark Canyon Inflow (2)	APR-JUL	34	34	87	56	12.5	1.01	101
	APR-SEP	48	40	113	74	22	1.20	120
Jefferson R nr Three Forks (2)	APR-JUL	550	74	920	700	395	174	740
	APR-SEP	580	73	965	735	420	192	800
Hebgen Lake Inflow (2)	APR-JUL	315	85	390	345	285	240	370
	APR-SEP	405	86	495	440	370	315	470
Ennis Lake Inflow (2)	APR-JUL	530	85	665	585	475	395	625
	APR-SEP	665	86	830	730	600	500	775
Missouri R at Toston (2)	APR-JUL	1480	83	2070	1720	1240	890	1790
	APR-SEP	1690	82	2380	1970	1410	1000	2070
Smith R bl Eagle Ck (2)	APR-JUL	95	90	178	129	61	11.8	106
	APR-SEP	104	90	193	140	68	15.2	116
Gibson Reservoir Inflow (2)	APR-JUL	355	90	435	385	325	275	395
	APR-SEP	395	90	480	430	360	310	440
Marias R nr Shelby (2)	APR-JUL	340	94	465	390	290	215	360
	APR-SEP	345	92	480	400	290	210	375

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	61	103	69	64	58	53	59
	APR-SEP	77	104	88	82	73	67	74
Wind R ab Bull Lake Ck	APR-JUL	390	86	530	445	335	250	455
	APR-SEP	415	85	570	480	350	260	490
Bull Lake Ck nr Lenore (2)	APR-JUL	121	87	154	134	108	88	139
	APR-SEP	147	87	187	163	131	107	169
Boysen Reservoir Inflow (2)	APR-JUL	460	75	810	600	320	111	610
	APR-SEP	485	73	855	635	335	114	665
Greybull R at Meeteetse	APR-JUL	118	90	178	142	94	58	131
	APR-SEP	159	90	230	188	130	88	177
Shell Ck nr Shell	APR-JUL	51	93	66	57	45	36	55
	APR-SEP	62	94	79	69	55	45	66
Bighorn R at Kane (2)	APR-JUL	645	77	1160	855	435	127	840
	APR-SEP	660	73	1220	890	430	97	905
NF Shoshone R at Wapiti	APR-JUL	445	97	530	480	410	360	460
	APR-SEP	495	96	595	535	455	395	515
SF Shoshone R nr Valley	APR-JUL	196	91	245	215	177	149	215
	APR-SEP	225	92	280	245	205	170	245
Buffalo Bill Reservoir Inflow	APR-JUL	630	93	790	695	565	470	675
	APR-SEP	695	93	870	765	625	520	745
Bighorn R nr St. Xavier (2)	APR-JUL	1160	84	1800	1420	900	520	1380
	APR-SEP	1170	80	1890	1460	880	450	1460
Little Bighorn R nr Hardin	APR-JUL	99	101	149	119	79	49	98
	APR-SEP	111	100	167	134	88	55	111
Tongue R nr Dayton (2)	APR-JUL	82	95	109	93	71	55	86
	APR-SEP	93	95	123	105	81	63	98
Tongue River Reservoir Inflow (2)	APR-JUL	185	96	285	225	145	85	193
	APR-SEP	205	95	310	250	162	99	215
NF Powder R nr Hazelton	APR-JUL	10.0	110	13.5	11.4	8.6	6.5	9.1
	APR-SEP	10.7	108	14.4	12.2	9.2	7.0	9.9

Powder R at Moorhead	APR-JUL	200	113	335	255	146	66	177
	APR-SEP	220	112	355	275	165	84	196
Powder R nr Locate	APR-JUL	220	111	370	280	160	72	199
	APR-SEP	240	109	395	305	177	84	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	APR-JUL	3.8	73	6.8	5.0	2.6	0.80	5.2
Pactola Reservoir Inflow (2)	APR-JUL	12.5	57	25	17.6	7.4	0.22	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate (2)	APR-JUL	167	74	285	215	120	50	225
	APR-SEP	186	74	315	240	133	56	250
Encampment R nr Encampment (2)	APR-JUL	104	81	156	125	83	52	129
	APR-SEP	111	80	165	133	89	57	138
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	53	108	67	59	47	39	49
	APR-SEP	56	108	71	62	50	41	52
Seminoe Reservoir Inflow (2)	APR-JUL	550	77	875	680	420	225	715
	APR-SEP	595	77	940	735	455	250	770
Sweetwater R nr Alcova	APR-JUL	33	56	64	46	19.9	1.07	59
	APR-SEP	36	56	70	49	22	1.78	64
La Prele Ck nr Douglas	APR-JUL	24	121	37	29	18.9	11.3	19.9
	APR-SEP	24	121	37	29	18.8	11.0	19.9
North Platte R bl Glendo Reservoir (2)	APR-JUL	570	70	1030	755	385	116	820
	APR-SEP	590	69	1060	780	400	120	850
North Platte R bl Guernsey Reservoir (2)	APR-JUL	560	68	1030	750	370	91	820
	APR-SEP	580	68	1070	775	385	98	850
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	121	105	171	141	101	71	115
	APR-SEP	131	104	185	153	109	77	126
Little Laramie R nr Filmore	APR-JUL	59	116	77	66	52	41	51
	APR-SEP	63	115	82	71	55	44	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
May 2021 Calendar Year Runoff Forecast
May 6, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at http://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

April runoff was 1.3 MAF, 44% of average for the Basin above Sioux City, IA. April's runoff was the 8th lowest April in 123 years of record-keeping. Runoff was well-below average in all reaches except the Fort Randall to Gavins Point reach, which was 142% of average. Observed precipitation in April was 5% to 50% of normal over most of the upper Basin.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **17.8 MAF, 69% of average**. The 2021 calendar year runoff forecast for the Missouri Basin above Gavins Point is **16.0 MAF**, **69% of average**. The extremely dry April, current soil conditions, and NOAA's latest outlooks calling for warmer-than-normal temperature and drier-than-normal precipitation has resulted in our office significantly lowering our 2021 calendar year runoff forecast from last month's forecast.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 8 months, expected inflow could range from the 22.5 MAF upper basic forecast to the 13.7 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term

regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively. Given that eight months are being forecast for this May 1 forecast (4 month observed/8 months forecast), the range of possible wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is very large, and is attributed to all six reaches for the next 8 months. The result is a range or "bracket" for each reach, and thus, for the total runoff forecast.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for April 27, 2021 is shown in **Figure 1**. The drought monitor is available at http://droughtmonitor.unl.edu/. The U.S. Drought Monitor shows Abnormally Dry (D0) conditions are present in every state in the Basin except Missouri, with Extreme Drought (D3) conditions present in eastern Montana, North Dakota, and northern South Dakota. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of July, indicates drought conditions are likely to persist or expand throughout the Basin.

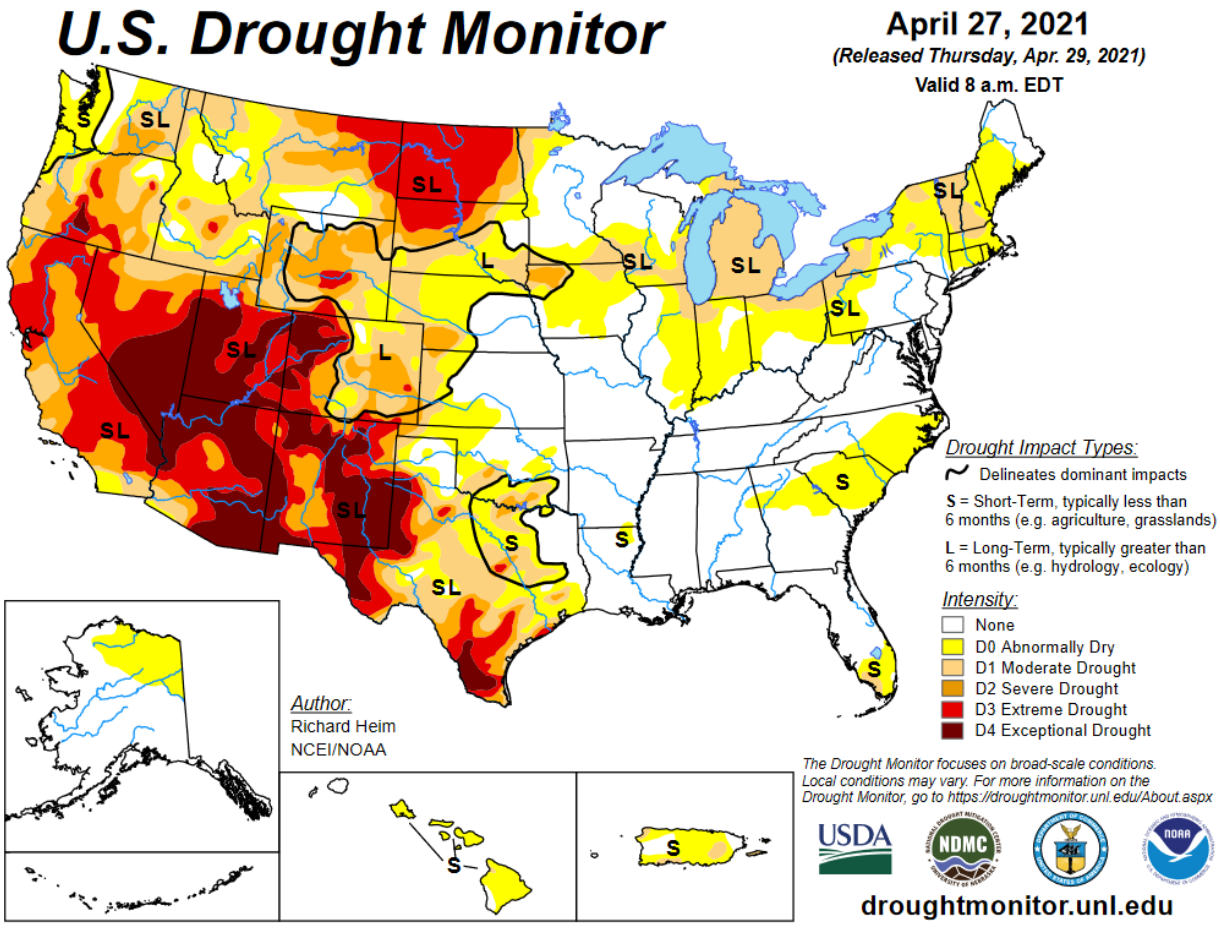


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for April 27, 2021.

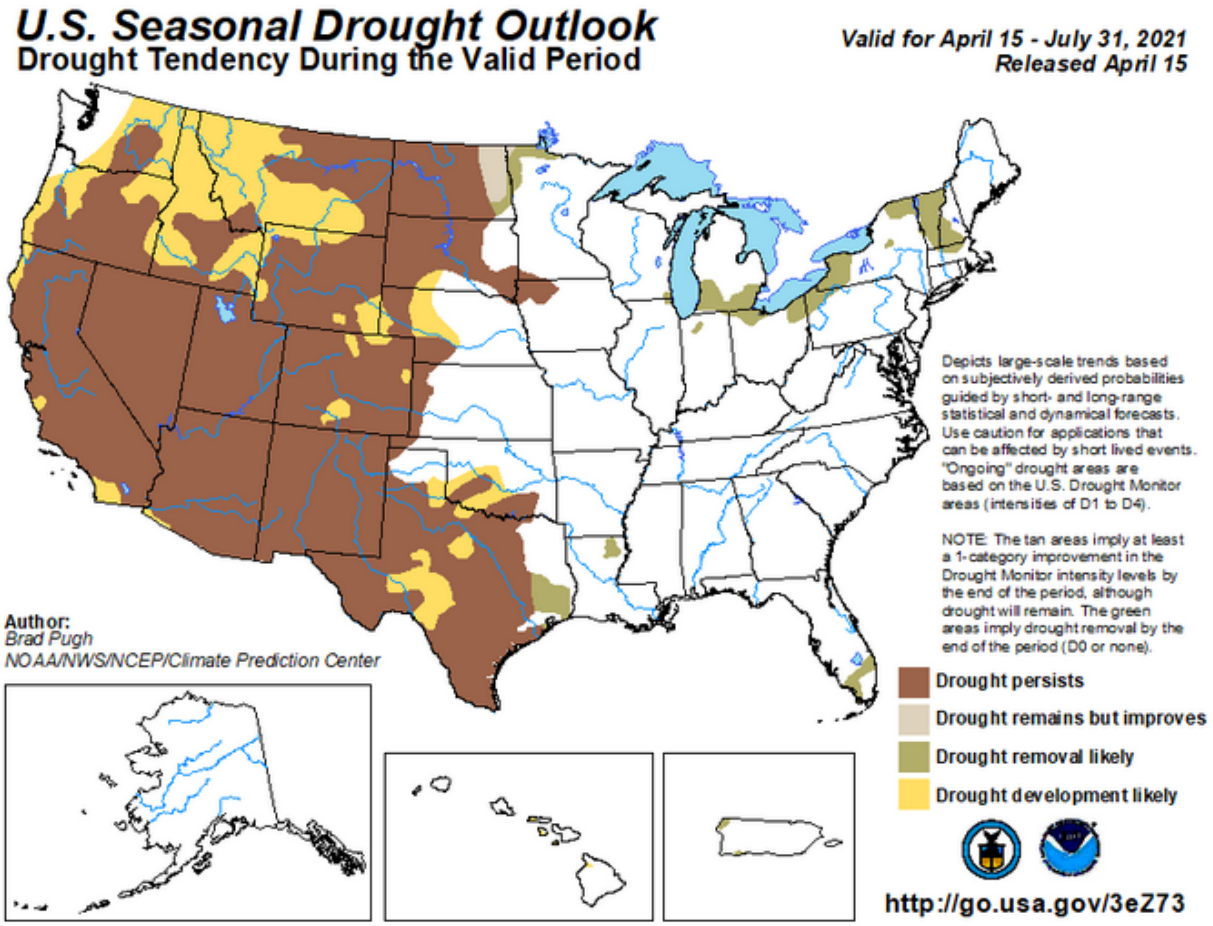


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at http://www.hprcc.unl.edu/. The April precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. April precipitation was well below normal over the entire Basin, except for a few small areas in Colorado, Wyoming, and Missouri. Most of Montana, North Dakota, and South Dakota received 5 to 50 percent of normal precipitation.

Precipitation as a percent of normal for the February-March-April 2021 period was also below normal in the upper Basin, but above normal in the lower Basin (**Figure 4**).

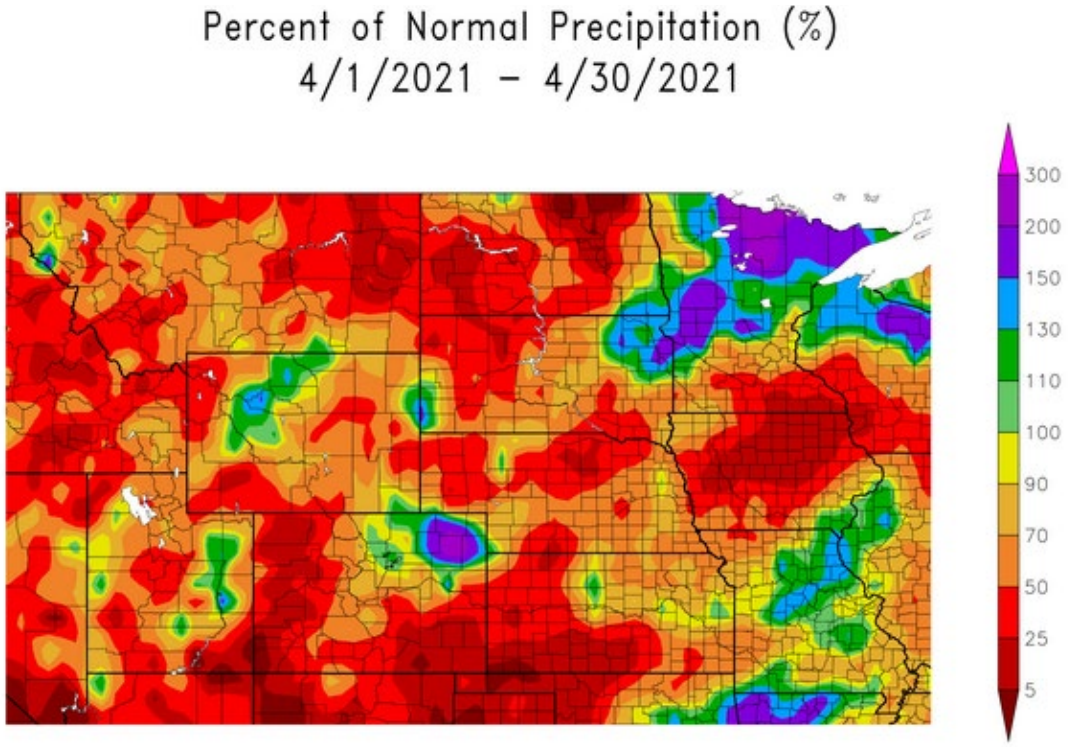


Figure 3. April 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

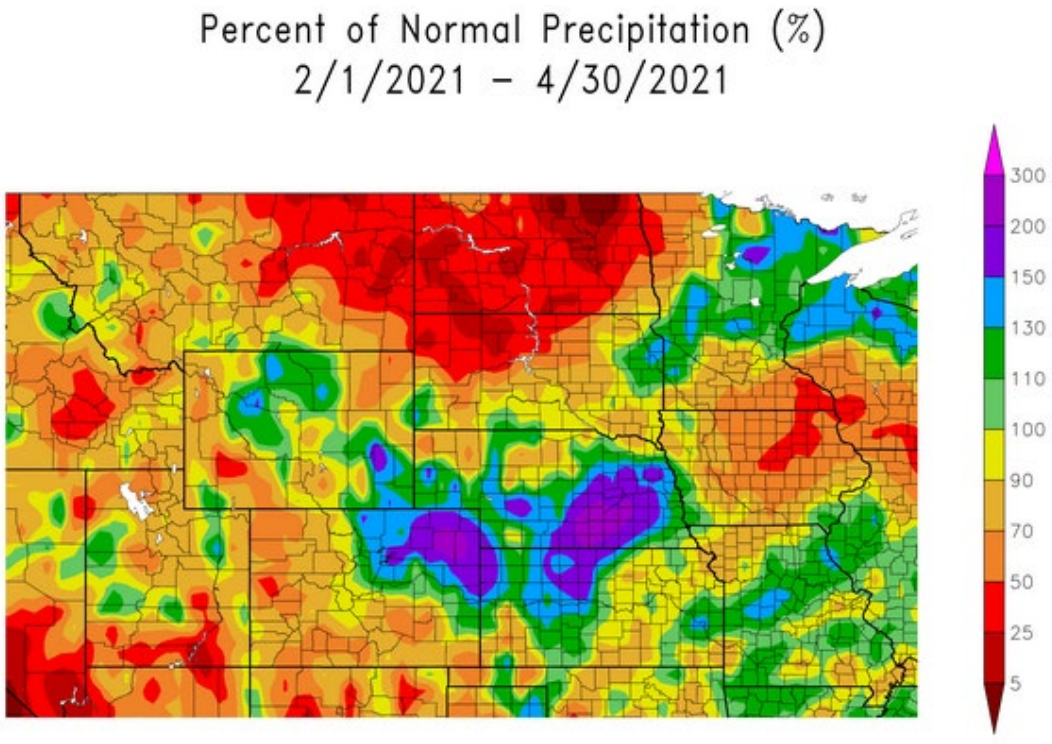
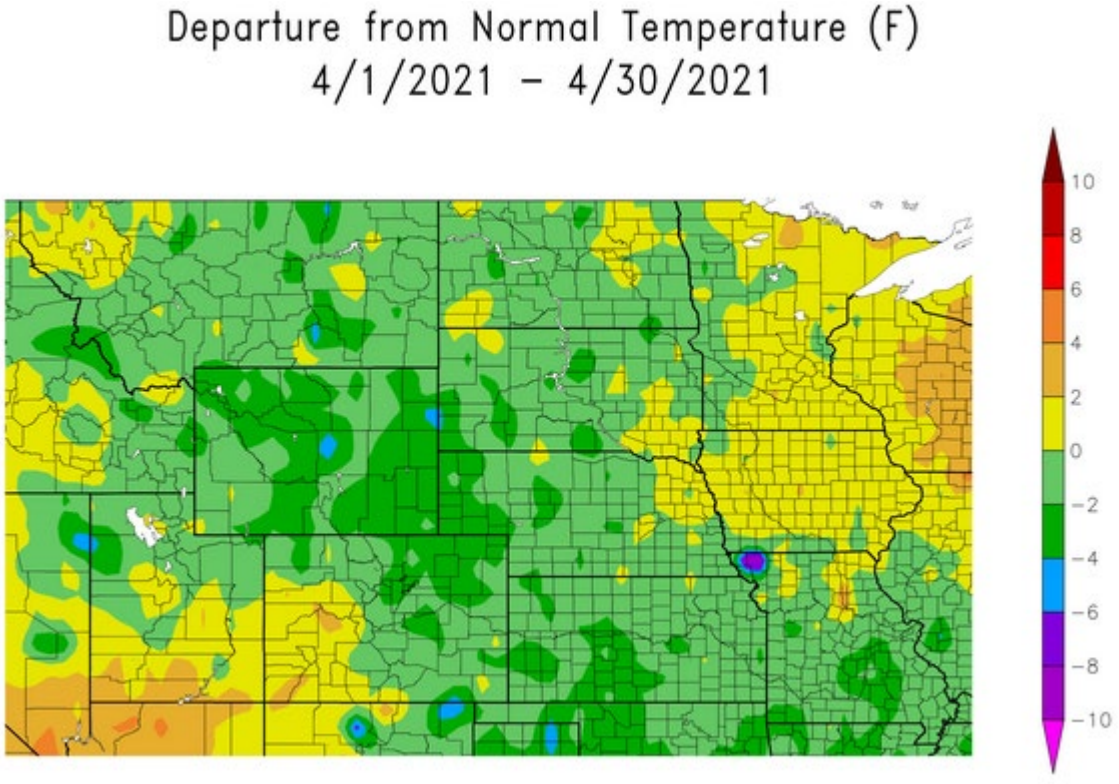


Figure 4. February-March-April 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

April temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate slightly cooler-than-normal temperatures over most of the Basin, ranging from 2 to 4 deg F below normal. Slightly warmer-than-normal temperatures occurred in small areas of Montana, North Dakota, South Dakota, and Nebraska. Most of Iowa was up to 2 degrees warmer than normal in April. February-March-April 2021 temperature departures are shown in **Figure 6**. The three-month average departures remain near normal across most of the Basin, tending towards slightly warmer than normal in the eastern Dakotas, and slightly cooler than normal in the rest of the Basin. Large areas of Wyoming were up to 6 degrees below normal over the past three months.



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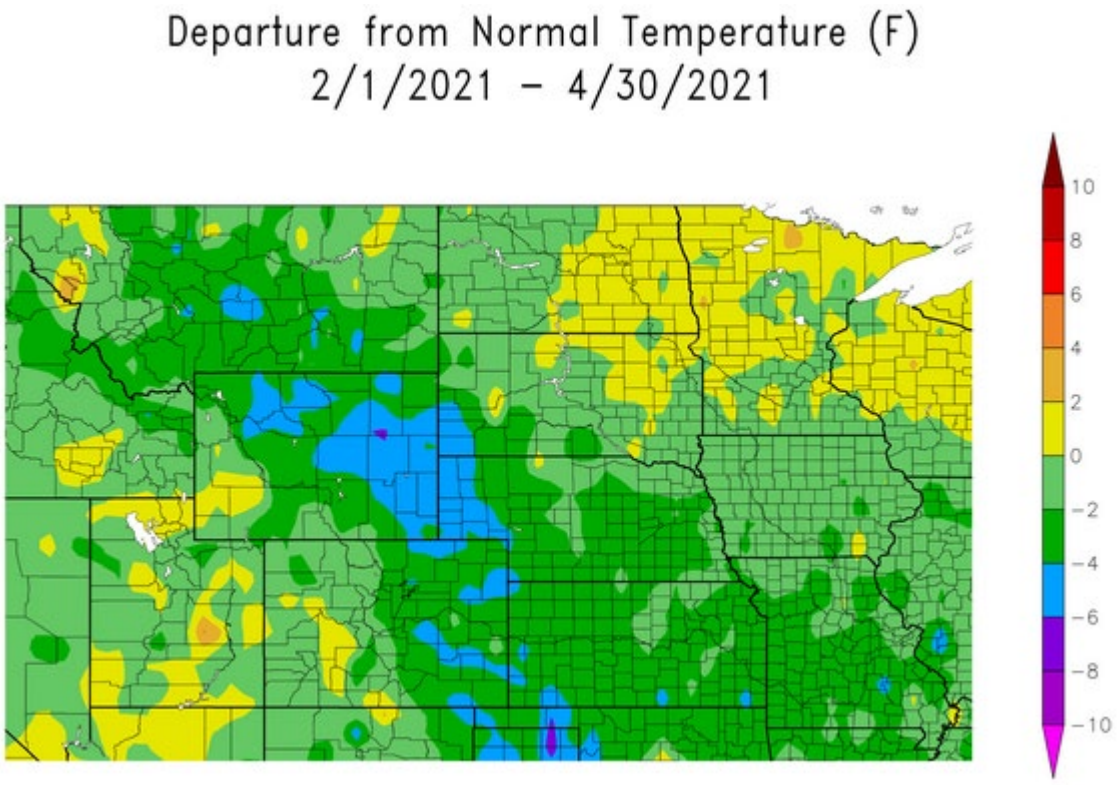


Figure 6. February-March-April 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of May 2021 is drier than normal across the western and northern portions of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**. The figure indicates that beginning of May 2021 soil moisture anomalies in the western and northern portions of the Basin are below normal, while soil moisture in the lower Basin is still near normal to slightly above normal from March rains. Soil moisture ranking percentile over most of North Dakota is below the first percentile, meaning soils are extremely dry.

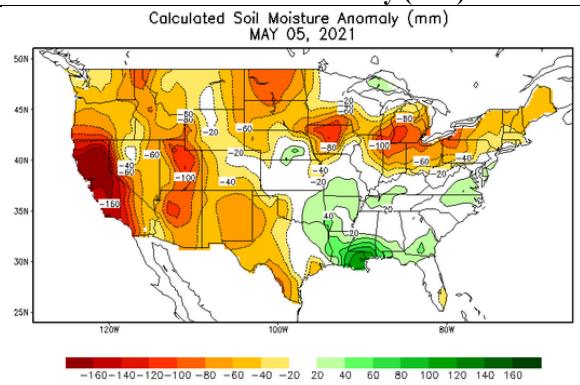
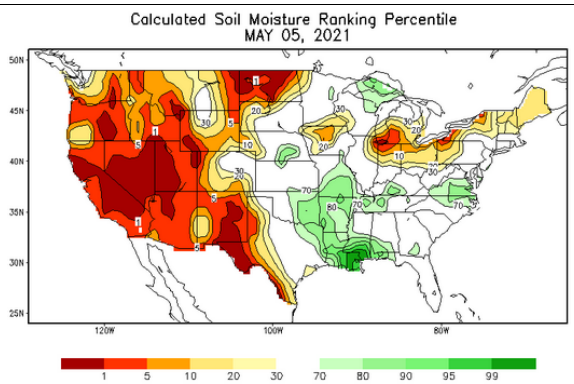
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
	

Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks. At this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack in the Basin has been nonexistent since before April 1, so was not factored into this May 1 forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the May 1 snowpack. The snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

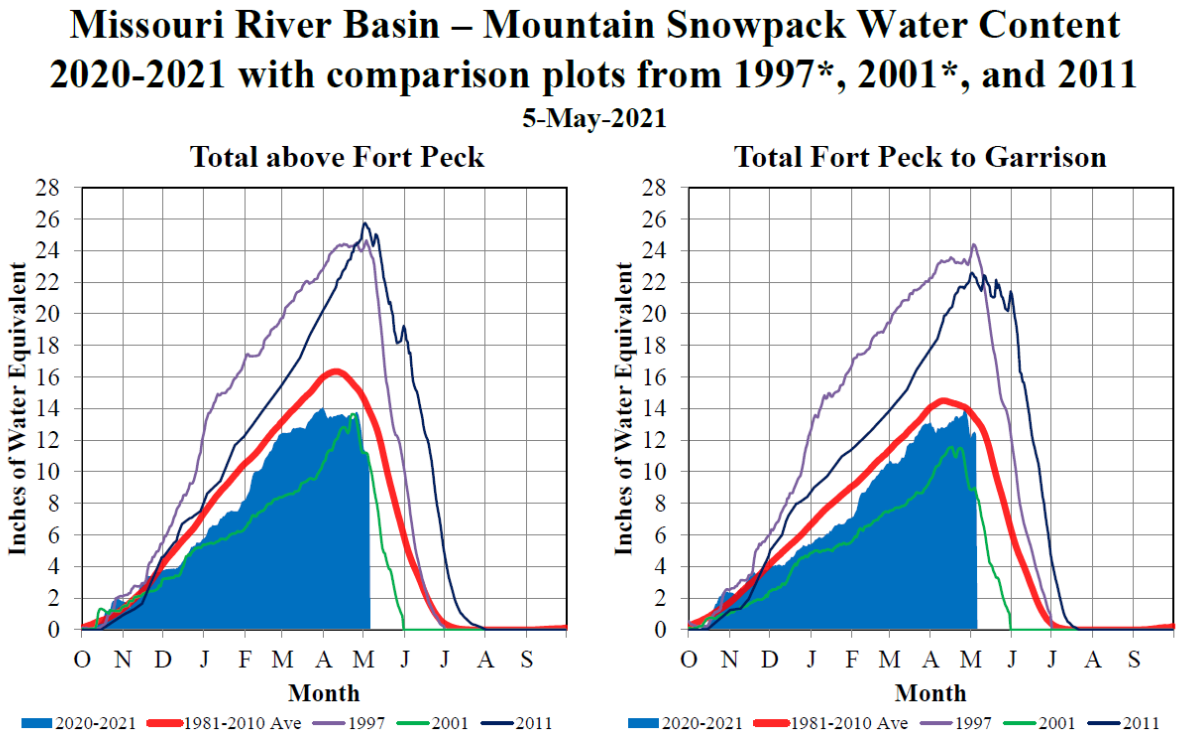


Figure 8. Mountain snowpack water content on May 5, 2021 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

As of May 5, 2021, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 10.6 inches, which is 77 percent of average based on the 1981-2010 average SWE for the Fort Peck reach. Mountain snowpack in the Fort Peck reach peaked on March 31 at 14.1", which is 86% of the normal peak. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 12.4 inches, which is 93 percent of average based on the 1981-2010 average SWE for the Garrison reach. Mountain snowpack in the Garrison reach peaked on April 26 at 14.0", which is 96% of the normal peak.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

The latest ENSO Outlook indicates that La Nina conditions are present and will likely transition to ENSO-neutral in the next month or so, with an 80% chance of ENSO-neutral conditions during May-July 2021. During La Nina conditions there are increased chances for below-normal temperatures in the upper Basin and increased chances for an above-normal mountain snowpack.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center (CPC) outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at http://www.cpc.ncep.noaa.gov/.

The CPC temperature outlook through May 19 (**Figure 9**) indicates equal chances for above-normal, normal, and below-normal temperatures across the entire Basin. The outlook indicates a slight increase in the chances for above-normal precipitation over most of the Basin.

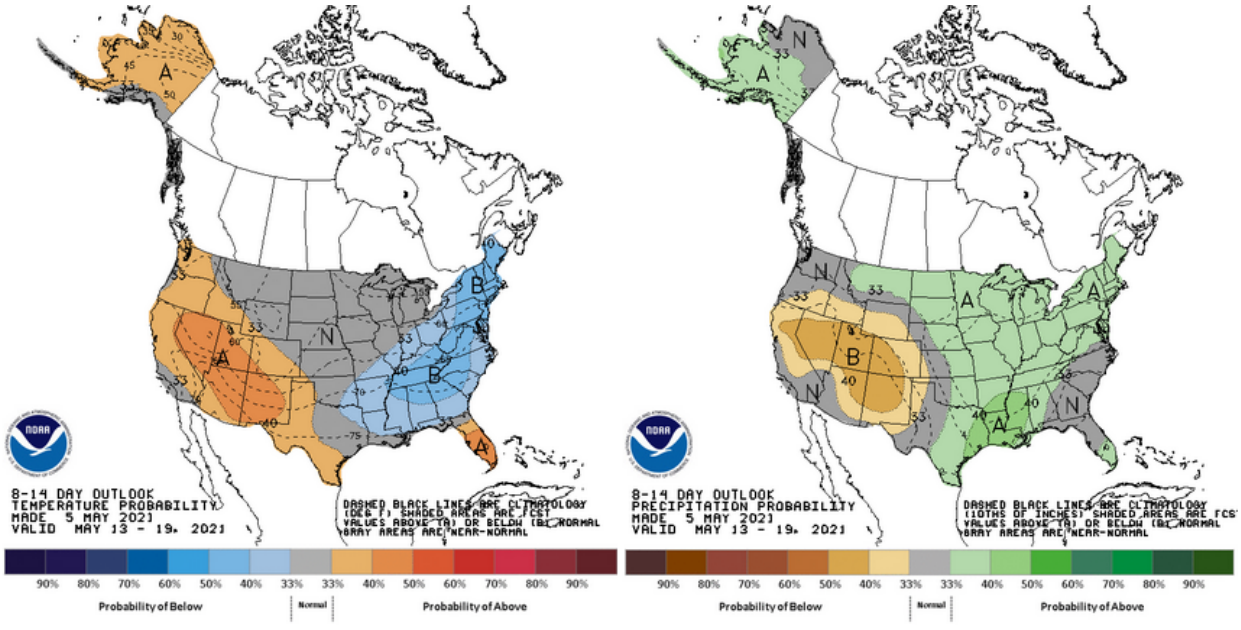


Figure 9. CPC 8-14 Day temperature and precipitation outlooks through May 19, 2021.

The May CPC outlooks in **Figure 10** indicate increased chances for above-normal temperatures over the southern portion of the Basin and equal chances for precipitation over most of the Basin, with a slight increase in chances for above-normal precipitation in northern Montana.

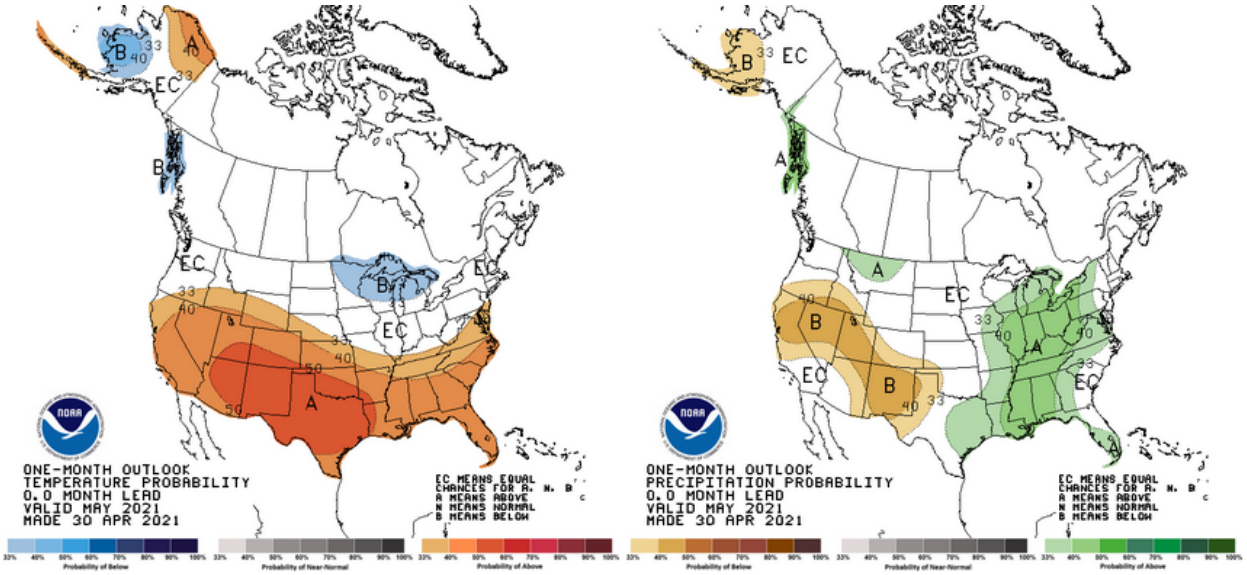


Figure 10. CPC May 2021 temperature and precipitation outlooks.

Three-month temperature and precipitation outlooks for three three-month periods in 2021 are shown below in **Figure 11-13**. During the May-June-July period (**Figure 11**), the CPC indicates increased chances for above-normal temperatures and below-normal precipitation over the entire Basin.

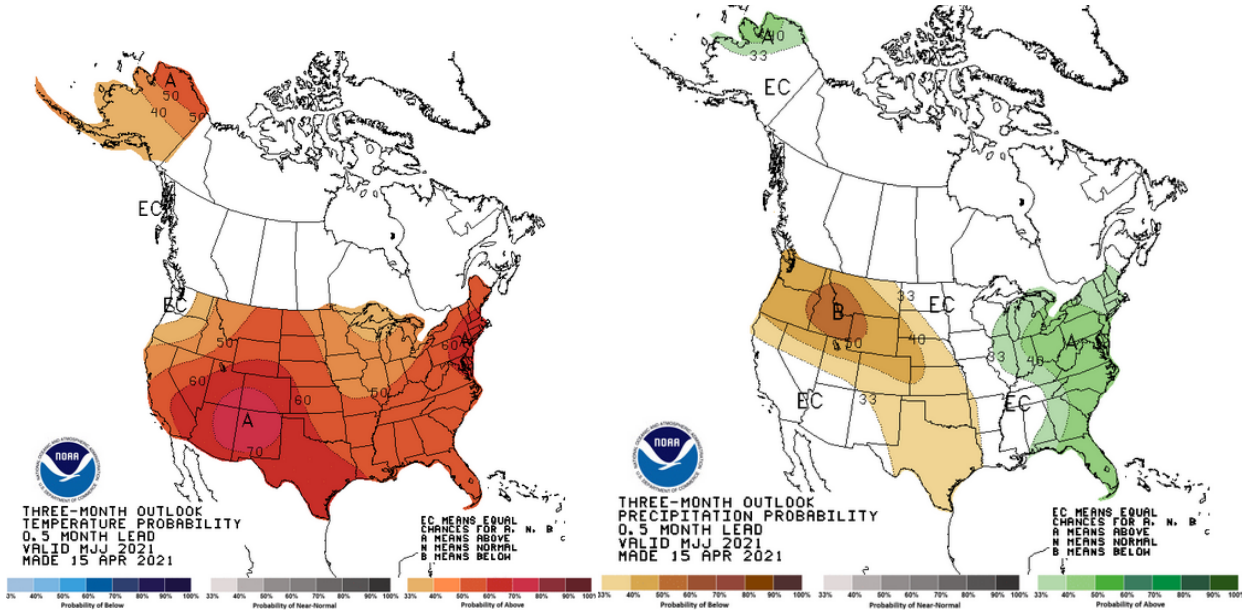


Figure 8. CPC May-June-July temperature and precipitation outlooks.

The increased chances for above-normal temperatures and below-normal precipitation over the entire Basin extend through October (**Figure 12**). During the November-December 2021-January 2022 timeframe, the increased chances for above-normal temperatures shift farther south with equal chances in North Dakota, Montana, South Dakota, Iowa, and eastern Nebraska. There is a slight increase in chances for above-normal precipitation over Montana, Wyoming, western North Dakota, western South Dakota, and western Nebraska, with equal chances elsewhere (**Figure 13**). As previously noted, though, there is limited confidence in climate outlooks beyond the winter and early spring, therefore, the climate outlooks will likely change as the calendar progresses.

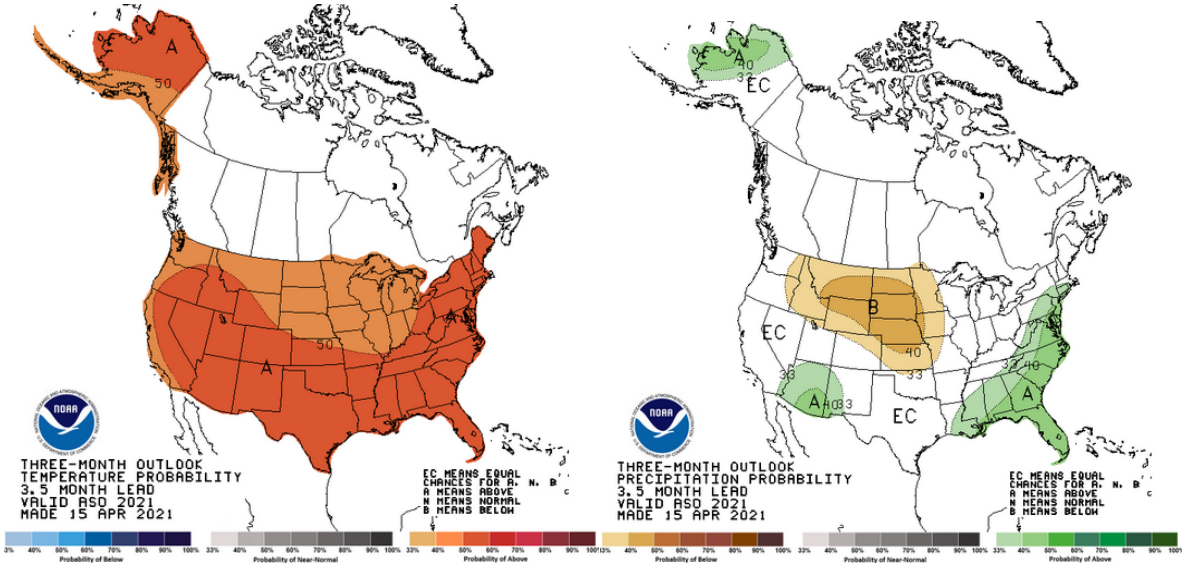


Figure 9. CPC August-September-October temperature and precipitation outlooks.

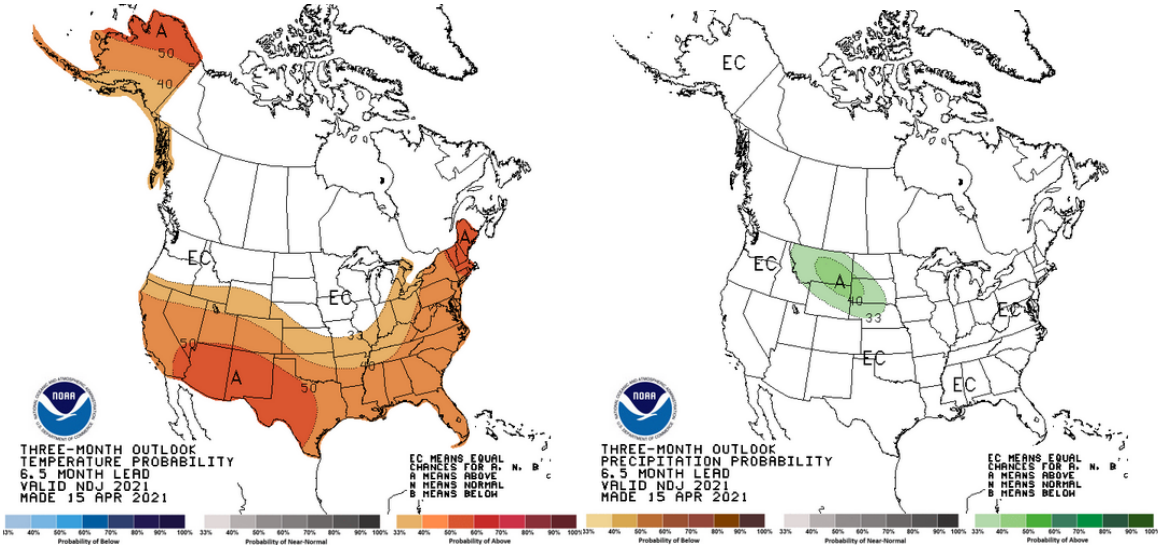


Figure 10. November-December 2021-January 2022 temperature and precipitation outlooks.

Summary

Given the dry soil moisture conditions and below-average streamflow, we expect runoff to remain below average during May, but it will depend greatly on rain events. During May, June and July, Fort Peck and Garrison runoff is forecast to be below average due to the slightly below-normal mountain snowpack, dry soil moisture conditions, and extended warm and dry outlooks. In summary, the 2021 calendar year runoff forecast is **17.8 MAF (69% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: May 06, 2021 12:36:41 PM
   - Based on May 01, 2021 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow (2)	MAY-JUL	90	105	107	97	83	73	86
	MAY-SEP	105	104	124	113	97	86	101
St. Mary R at Intl Boundary (2)	MAY-JUL	420	105	515	460	380	325	400
	MAY-SEP	495	105	600	535	455	390	470
Lima Reservoir Inflow (2)	MAY-JUL	18.5	37	42	28	9.0	0.000	50
	MAY-SEP	19.6	35	45	30	9.1	0.000	56
Clark Canyon Inflow (2)	MAY-JUL	3.8	6	53	24	0.000	-12.8	64
	MAY-SEP	11.6	14	72	36	0.000	-25	83
Jefferson R nr Three Forks (2)	MAY-JUL	305	53	660	445	159	0.000	575
	MAY-SEP	315	50	680	460	166	0.000	635
Hebgen Lake Inflow (2)	MAY-JUL	245	80	310	270	220	178	305
	MAY-SEP	330	81	415	365	295	245	405
Ennis Lake Inflow (2)	MAY-JUL	400	75	520	450	350	280	530
	MAY-SEP	525	77	670	585	465	380	680
Missouri R at Toston (2)	MAY-JUL	1070	72	1650	1310	840	495	1480
	MAY-SEP	1270	72	1950	1550	995	590	1760
Smith R bl Eagle Ck (2)	MAY-JUL	66	74	120	88	44	11.9	89
	MAY-SEP	73	74	135	98	48	10.5	99
Gibson Reservoir Inflow (2)	MAY-JUL	340	96	405	365	315	275	355
	MAY-SEP	375	95	450	405	345	300	395
Marias R nr Shelby (2)	MAY-JUL	245	82	360	290	199	132	300
	MAY-SEP	260	83	385	310	210	137	315

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Mystic Lake Inflow (2)	MAY-JUL	57	100	64	60	54	49	57
	MAY-SEP	72	100	82	76	68	63	72
Wind R ab Bull Lake Ck	MAY-JUL	395	92	500	435	355	290	430
	MAY-SEP	430	92	545	475	385	315	465
Bull Lake Ck nr Lenore (2)	MAY-JUL	122	90	144	131	113	100	135
	MAY-SEP	149	90	175	160	138	123	166
Boysen Reservoir Inflow (2)	MAY-JUL	470	84	745	580	360	195	560
	MAY-SEP	505	82	785	620	390	225	615
Greybull R at Meeteetse	MAY-JUL	127	102	168	144	111	87	124
	MAY-SEP	175	103	225	195	155	125	170
Shell Ck nr Shell	MAY-JUL	50	96	64	56	44	36	52
	MAY-SEP	61	97	77	67	55	45	63
Bighorn R at Kane (2)	MAY-JUL	660	86	1010	800	520	315	770
	MAY-SEP	705	85	1070	850	560	345	830
NF Shoshone R at Wapiti	MAY-JUL	380	88	460	415	345	300	430
	MAY-SEP	425	88	520	465	385	330	485
SF Shoshone R nr Valley	MAY-JUL	180	90	220	196	164	141	200
	MAY-SEP	210	89	255	230	192	166	235
Buffalo Bill Reservoir Inflow	MAY-JUL	545	87	680	600	495	415	630
	MAY-SEP	610	87	755	670	550	465	700
Bighorn R nr St. Xavier (2)	MAY-JUL	1100	87	1680	1340	865	515	1260
	MAY-SEP	1150	86	1780	1400	895	520	1340
Little Bighorn R nr Hardin	MAY-JUL	94	111	137	111	77	51	85
	MAY-SEP	107	110	156	127	87	58	97
Tongue R nr Dayton (2)	MAY-JUL	90	113	114	100	80	65	80
	MAY-SEP	103	112	130	114	92	75	92
Tongue River Reservoir Inflow (2)	MAY-JUL	205	117	290	240	168	116	175
	MAY-SEP	230	116	325	270	192	137	198
NF Powder R nr Hazelton	MAY-JUL	10.4	125	13.5	11.7	9.1	7.3	8.3
	MAY-SEP	11.2	124	14.5	12.5	9.9	7.9	9.0

Powder R at Moorhead	MAY-JUL	196	130	305	240	153	89	151
	MAY-SEP	215	126	320	260	172	108	170
Powder R nr Locate	MAY-JUL	210	128	310	250	170	112	164
	MAY-SEP	235	127	335	275	194	133	185

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAY-JUL	3.1	79	5.5	4.1	2.1	0.61	3.9
Pactola Reservoir Inflow (2)	MAY-JUL	10.4	59	22	15.0	5.8	0.180	17.5

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate (2)	MAY-JUL	120	64	215	158	82	27	187
	MAY-SEP	134	64	240	177	91	29	210
Encampment R nr Encampment (2)	MAY-JUL	77	65	118	94	60	36	118
	MAY-SEP	80	63	123	97	63	37	127
Rock Ck ab King Canyon Cnl nr Arlington	MAY-JUL	43	90	55	48	38	31	48
	MAY-SEP	45	90	57	50	40	33	50
Seminoe Reservoir Inflow (2)	MAY-JUL	415	67	650	510	320	177	615
	MAY-SEP	445	66	695	545	340	192	670
Sweetwater R nr Alcova	MAY-JUL	29	63	52	38	19.3	5.4	46
	MAY-SEP	32	64	58	42	22	6.7	50
La Prele Ck nr Douglas	MAY-JUL	17.5	117	25	21	14.3	9.6	14.9
	MAY-SEP	18.0	122	26	21	14.8	10.1	14.8
North Platte R bl Glendo Reservoir (2)	MAY-JUL	415	62	745	550	285	89	670
	MAY-SEP	420	60	755	555	285	81	700
North Platte R bl Guernsey Reservoir (2)	MAY-JUL	405	60	750	545	270	64	670
	MAY-SEP	410	59	760	550	270	60	700
Laramie R and Pioneer Cnl nr Woods Lg (2)	MAY-JUL	103	95	141	119	87	65	108
	MAY-SEP	114	96	156	131	97	72	119
Little Laramie R nr Filmore	MAY-JUL	48	100	63	54	42	32	48
	MAY-SEP	52	100	68	59	45	35	52

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
June 2021 Calendar Year Runoff Forecast
June 2, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

May runoff was 2.1 MAF, 61% of average for the Basin above Sioux City, IA. Runoff was well-below average in all reaches except the Fort Randall to Gavins Point reach, which was 120% of average. Observed precipitation in May was slightly below normal overall in the upper Basin with pockets of above normal precipitation and pockets of below normal precipitation.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Basin above Sioux City, IA is **17.9 MAF, 69% of average**. The 2021 calendar year runoff forecast for the Basin above Gavins Point is **16.4 MAF**, **70% of average**. Persisting dry weather and soil conditions, and the below-normal runoff observed in May, has resulted in no significant change to the 2021 calendar year runoff forecast from last month's forecast.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 7 months, expected inflow could range from the 21.8 MAF upper basic forecast to the 14.5 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier

conditions, respectively. Given that seven months are being forecast for this June 1 forecast (5 months observed/7 months forecast), the range of possible wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is very large, and is attributed to all six reaches for the next 7 months. The result is a range or "bracket" for each reach, and thus, for the total runoff forecast.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for May 25, 2021 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor shows at least Abnormally Dry (D0) conditions are present in much of the entire Missouri Basin (Basin), with Extreme Drought (D3) conditions present in eastern Montana, North Dakota, and northern South Dakota. In addition, Exceptional Drought (D4) conditions are present in central North Dakota. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of August, indicates drought conditions are likely to persist or expand throughout most of the Basin.

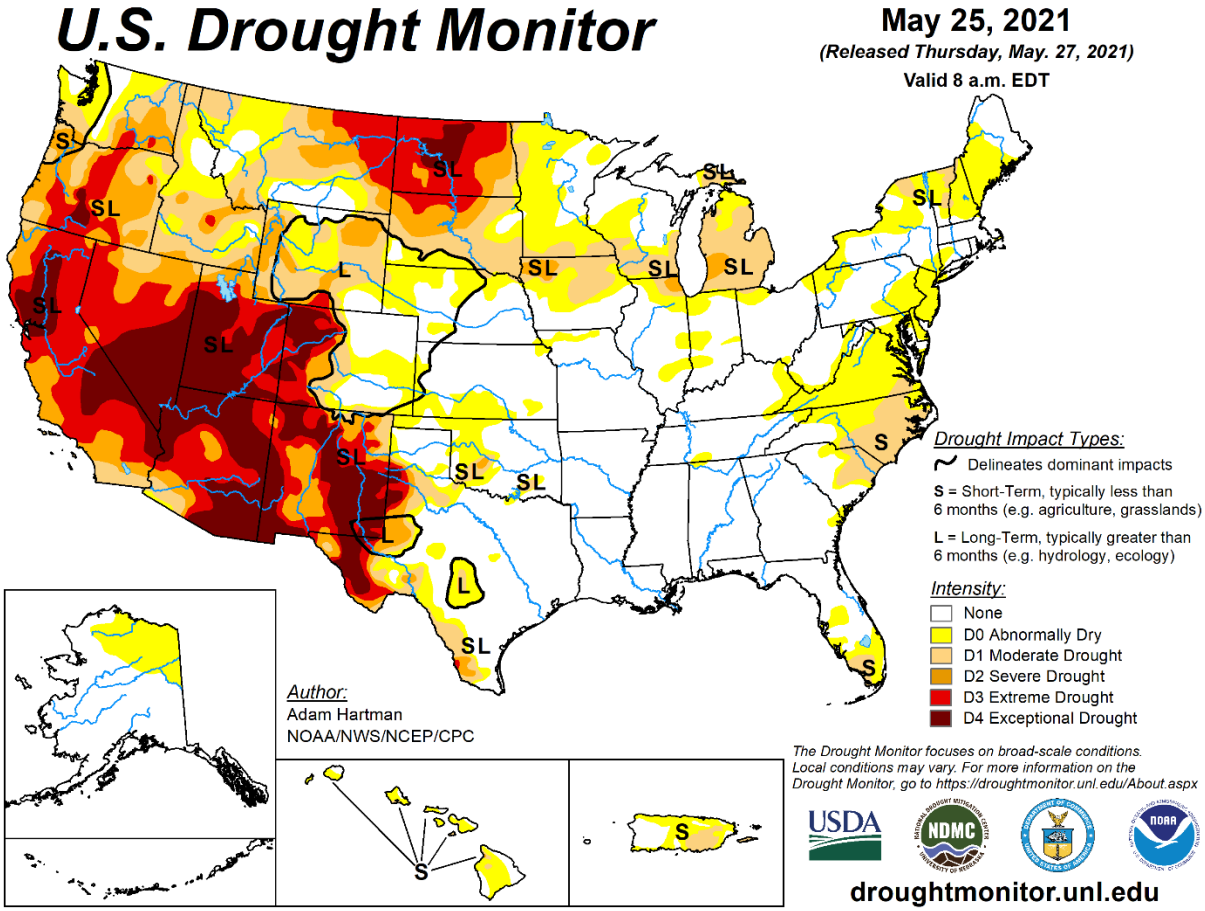


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

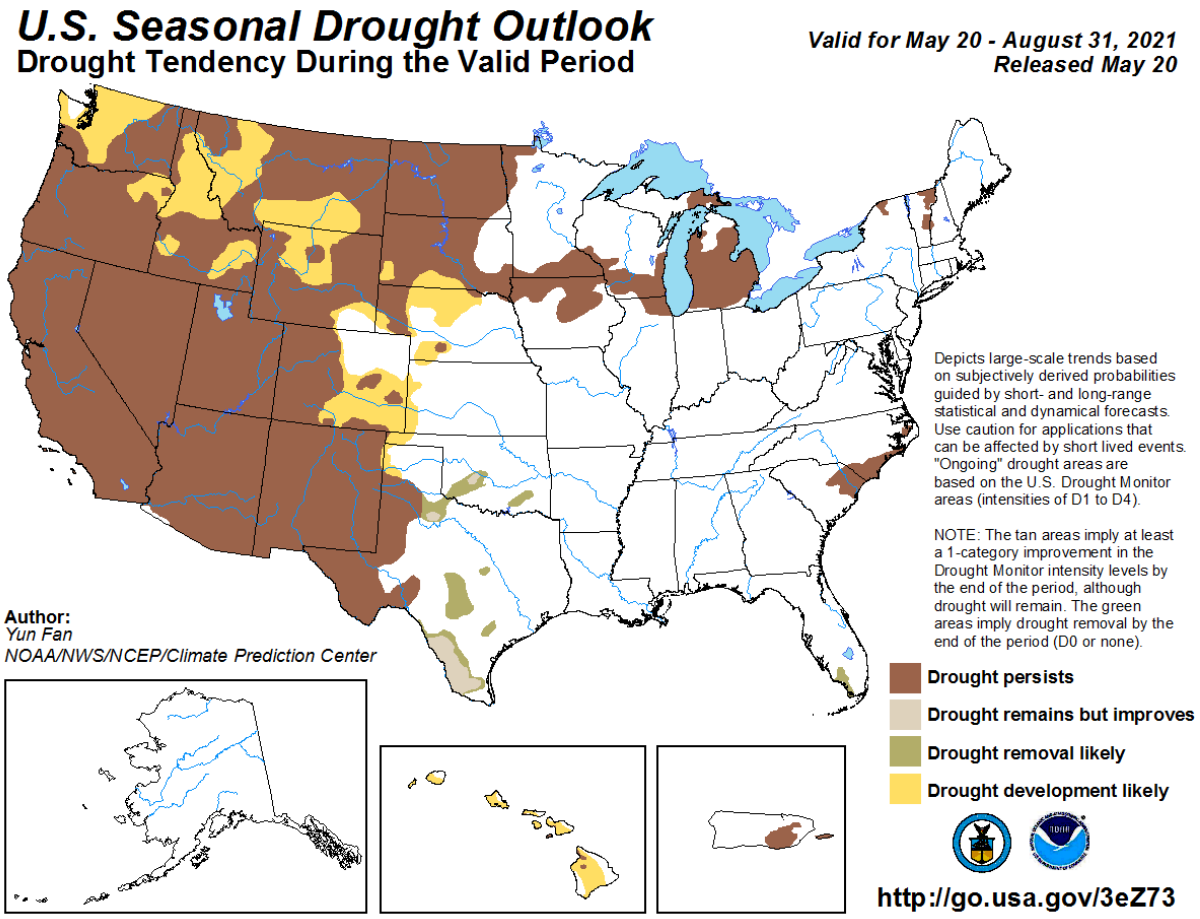


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The May precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. May precipitation was near normal overall in the Basin. Large pockets of below-normal precipitation were observed in Montana, Wyoming, the Dakotas, and eastern Nebraska and western Iowa. Above-normal precipitation was observed in portions of the western Dakotas, eastern Montana, Colorado, western Nebraska, and into northern Kansas and much of Missouri.

Precipitation as a percent of normal for the March-April-May 2021 period was below normal for the northern portion of the Basin, and normal to above normal for the southern portion of the Basin (**Figure 4**).

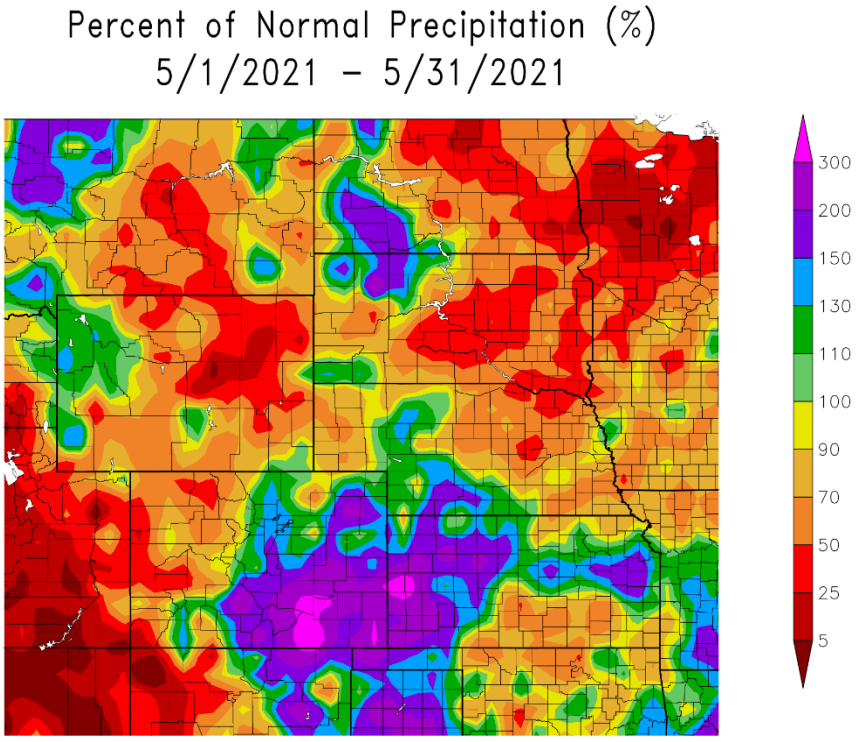


Figure 3. HPRCC May 2021 Percent of Normal Precipitation.

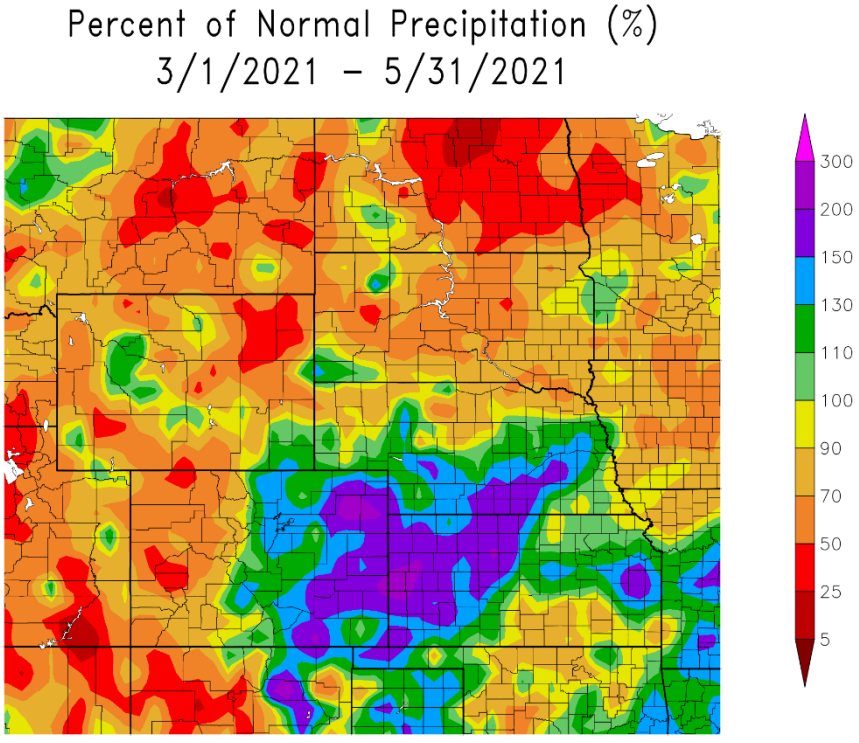


Figure 4. HPRCC March-April-May 2021 Percent of Normal Precipitation.

Temperature

May temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate slightly cooler-than-normal temperatures over most of the Basin, ranging from normal to 5 deg F below normal. Slightly warmer-than-normal temperatures portions of eastern South Dakota, eastern Nebraska, and Wyoming. March-April-May 2021 temperature departures are shown in **Figure 6**. The three-month average departures were above normal for most of Montana, the Dakotas, Nebraska, Iowa, and into northern Kansas and Missouri. The three-month departures were normal to below normal for the rest of the Basin.

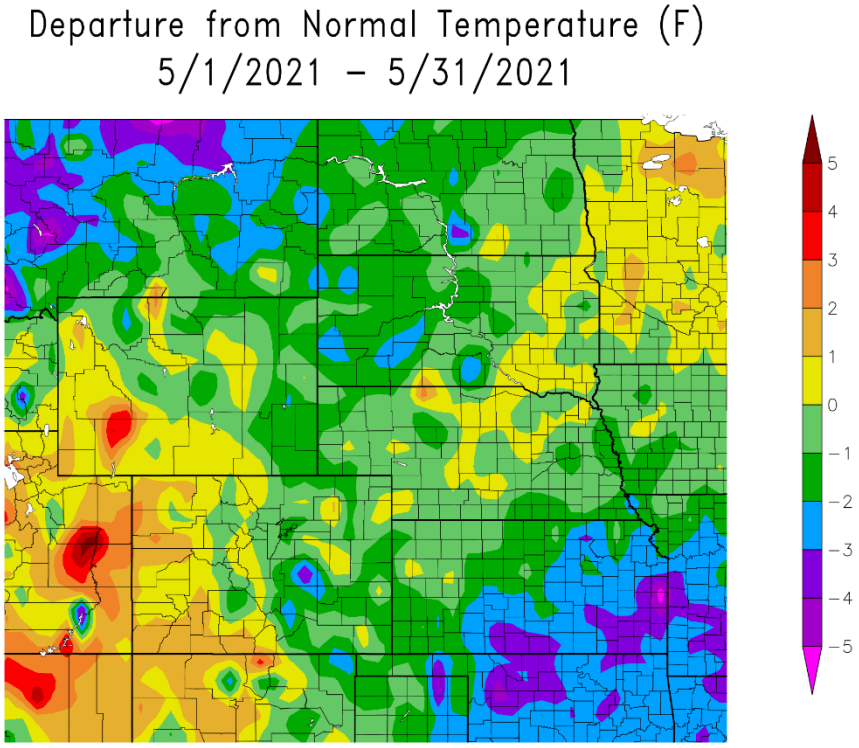


Figure 5. HPRCC May 2021 Departure from Normal Temperature.

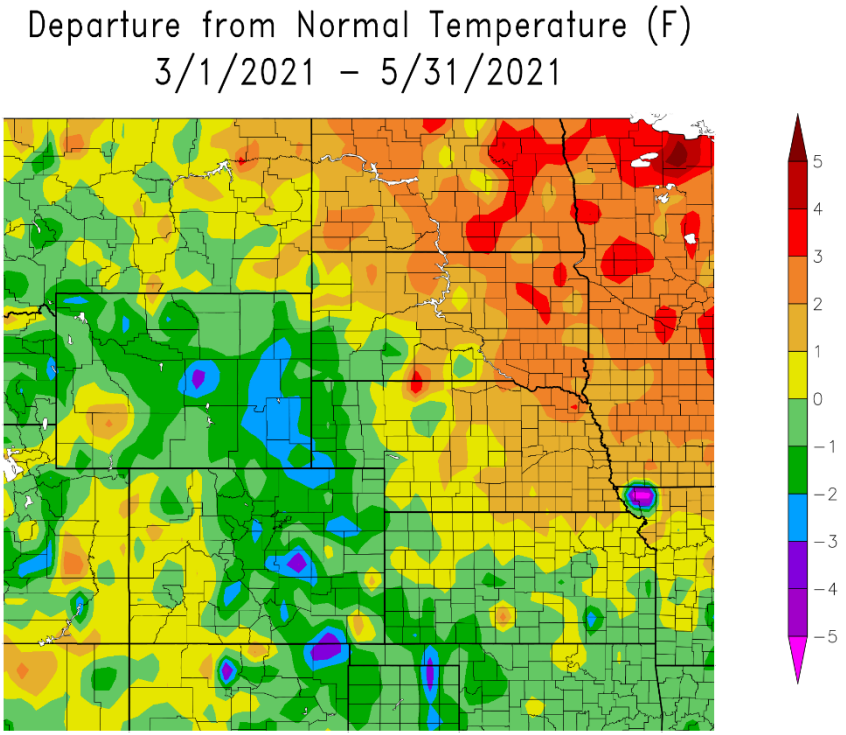


Figure 6. HPRCC March-April-May 2021 Departure from Normal Temperature.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of June 2021 is drier than normal across the Dakotas, northern Nebraska, Iowa, and Wyoming, and near normal in Montana, Colorado, and southern Nebraska into parts of Kansas and Missouri. Some pockets of above-normal soil moisture exist in Kansas and Missouri from the recent wet pattern moving across the southern portions of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**. Soil moisture ranking percentile over most of North Dakota is below the fifth percentile, meaning soils are extremely dry.

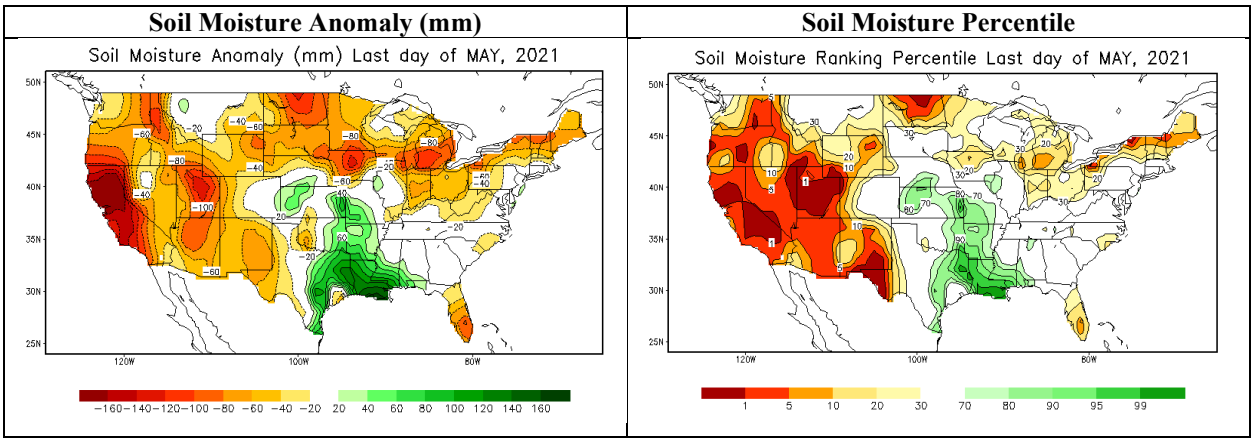


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

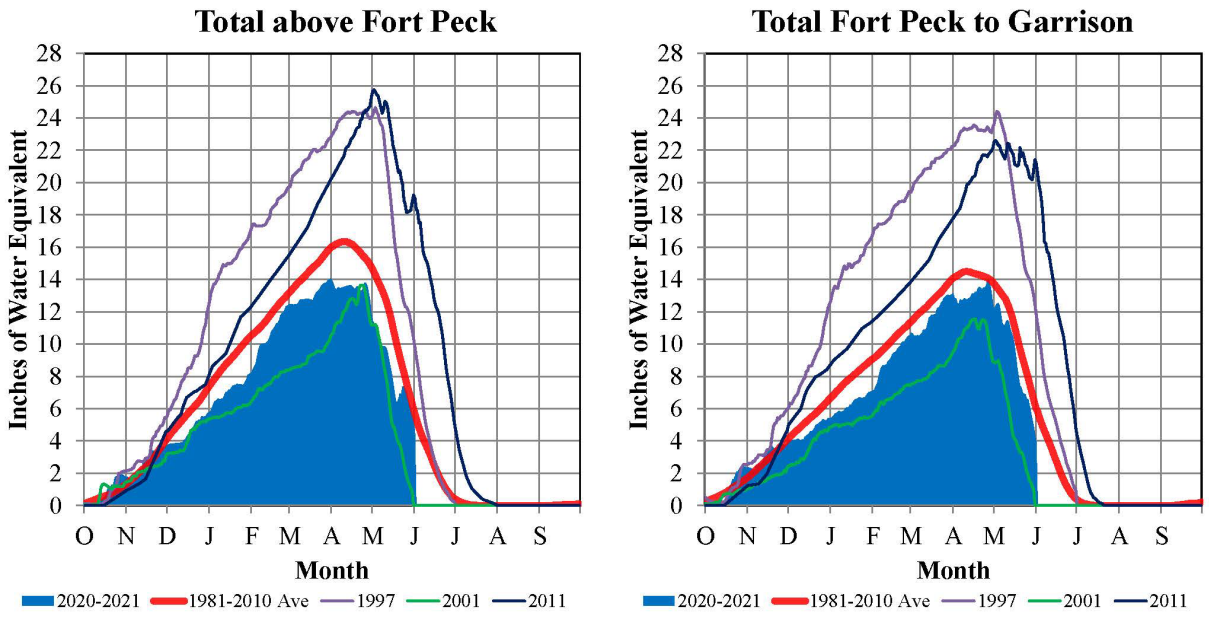
Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which primarily includes long-term precipitation outlooks. As the plains snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack in the Basin has been nonexistent since before April 1, so was not factored into the June 1 forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the June 1 snowpack. The snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain snow water equivalent (SWE) beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current year's average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).



On June 1, 2021 the mountain Snow Water Equivalent (SWE) in the "Total above Fort Peck" reach was 4.5", 80% of the June 1 average. The "Total above Fort Peck" reach peaked on March 31, 2021, at 14.1" SWE and 86% of the normal peak. On June 1, 2021 the mountain SWE in the "Fort Peck to Garrison" reach was 3.9", 65% of the June 1 average. The "Fort Peck to Garrison" reach peaked on April 26, 2021, at 14.0" of SWE and 96% of the normal peak.

Figure 8. Mountain snowpack water content on June 1, 2021 compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of June 1, 2021, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 4.5", which is 80% of average based on the 1981-2010 average SWE for the Fort Peck reach. Mountain snowpack in the Fort Peck reach peaked on March 31 at 14.1", which is 86% of the normal peak. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 3.9", which is 65% of average based on the 1981-2010 average SWE for the Garrison reach. Mountain snowpack in the Garrison reach peaked on April 26 at 14.0", which is 96% of the normal peak.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates that ENSO-neutral conditions are present and will likely continue into the summer, with a 67% chance of continuing in June-August 2021.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The CPC temperature outlook through June 16 (**Figure 9**, left) indicates increased chances for above-normal temperatures across the entire Basin. The CPC precipitation outlook (**Figure 9**, right) indicates a slight increase in the chances for blow-normal precipitation over most of the Basin.

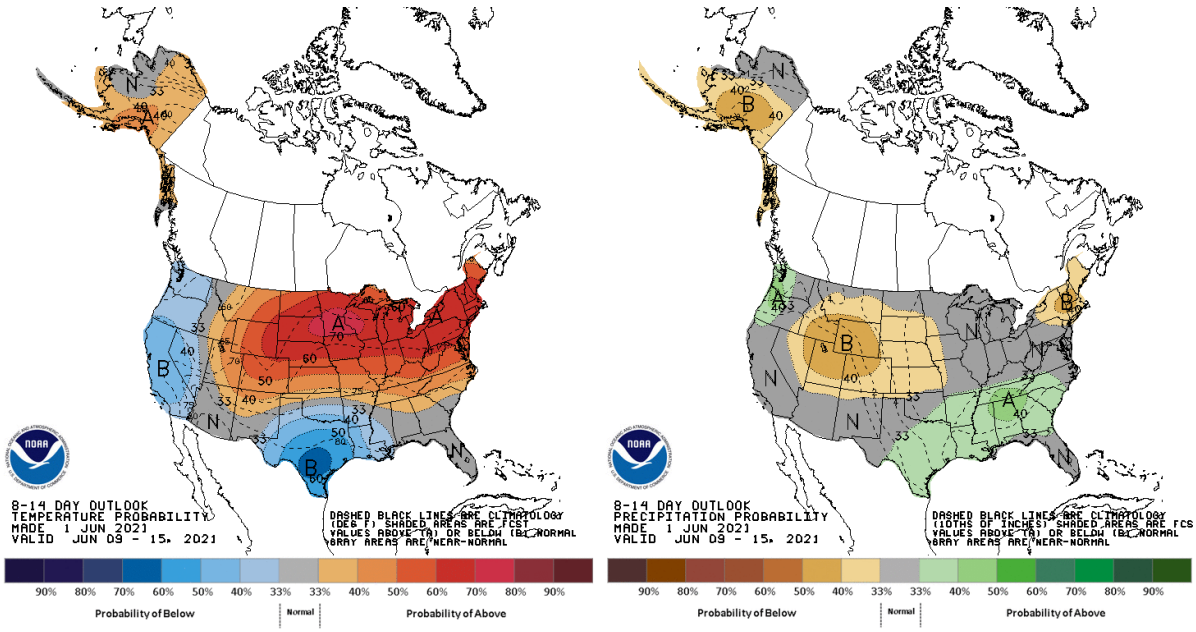


Figure 9. NOAA CPC 8-14 Day Temperature and Precipitation Outlooks.

The June CPC outlooks in **Figure 10** indicate increased chances for above-normal temperatures over the northern portion of the Basin and equal chances for above-normal, normal, or below-normal temperatures in the southern portion of the Basin. Increased chances of below-normal

precipitation are indicated in Wyoming, Colorado, western Montana, and into southwestern South Dakota and western Nebraska. The rest of the Basin shows equal chances for below-normal, normal, or above-normal precipitation.

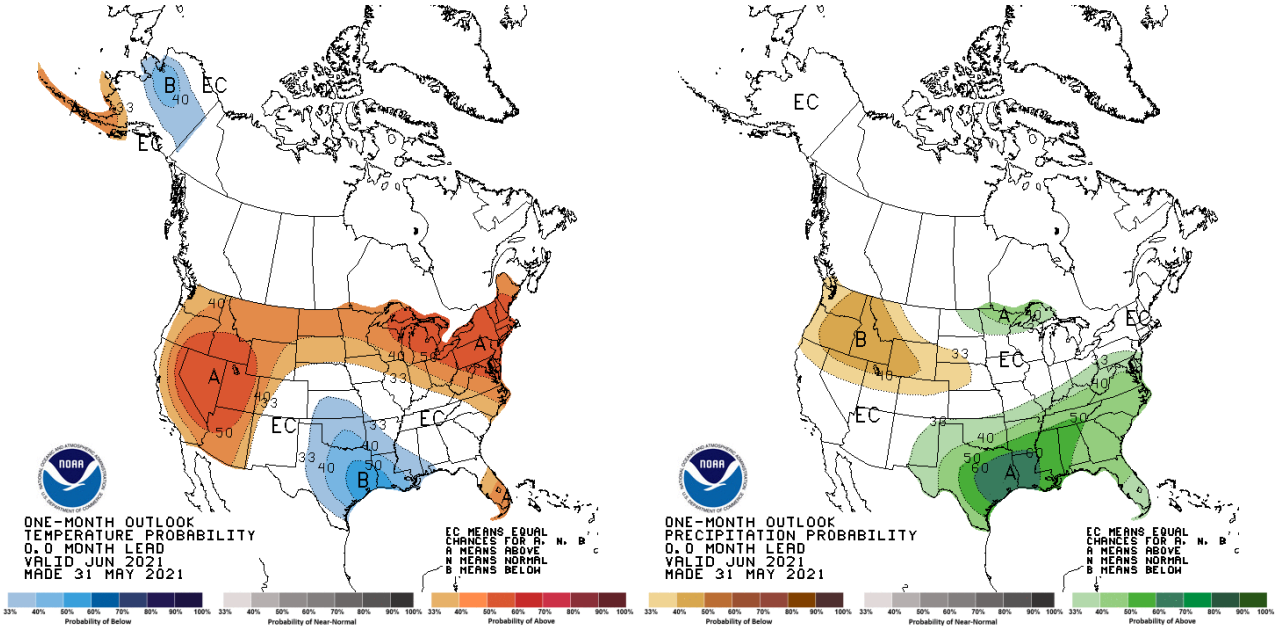


Figure 10. NOAA CPC May 2021 Temperature and Precipitation Outlooks.

Three-month temperature and precipitation outlooks for July-August-September and October-November-December in 2021 are shown below in **Figures 11-12**. During the July-August-September period (**Figure 11**), the CPC indicates increased chances for above-normal temperatures and below-normal precipitation over most of the Basin.

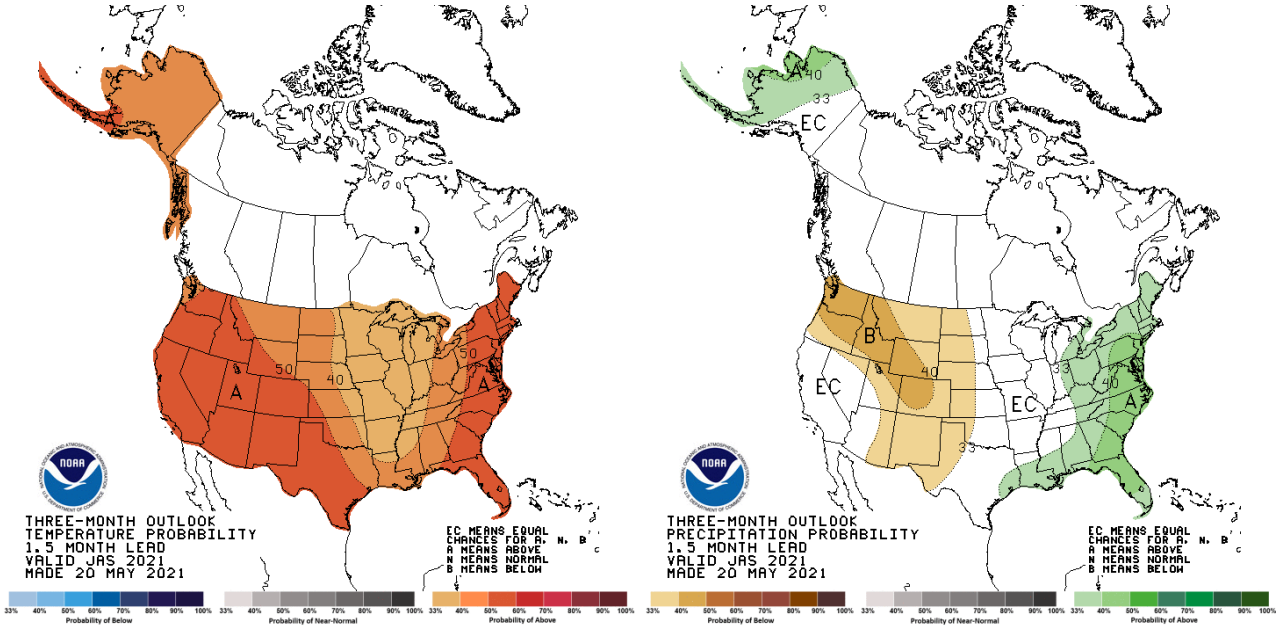


Figure 8. NOAA CPC July-August-September Temperature and Precipitation Outlooks.

For the remainder of the 2021 calendar year (October-November-December), CPC outlooks show equal chances for above-normal, normal, or below-normal temperatures in much of the Basin. Wyoming, Colorado, Nebraska, Kansas, and Missouri indicate increased chances for above-normal temperatures. Equal chances for above-normal, normal, or below-normal precipitation are indicated in most of the Basin except for a small pocket of increased chances for below-normal precipitation in southern Wyoming and Colorado (**Figure 12**).

As previously noted, there is limited confidence in long-term climate outlooks; therefore, the climate outlooks will likely change as the calendar progresses.

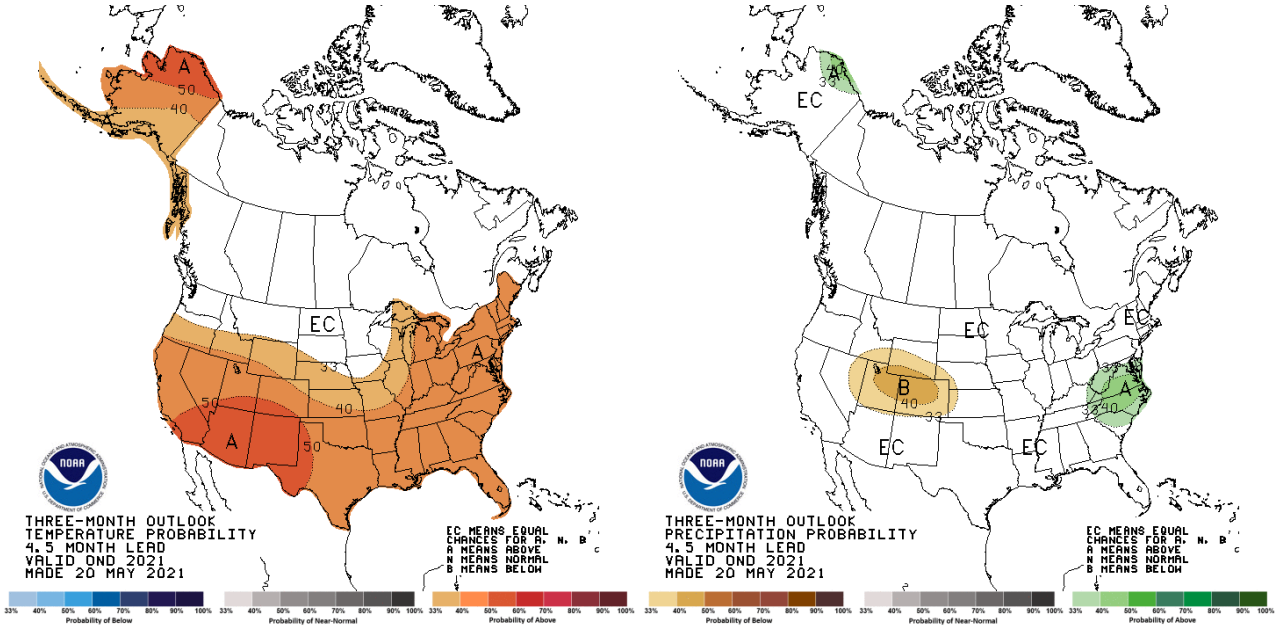


Figure 9. NOAA CPC October-November-December Temperature and Precipitation Outlooks.

Summary

Given the dry soil moisture conditions and the forecast for persisting drought conditions in much of the upper Basin, we expect runoff to remain below average during June, but it will depend greatly on rain events. In summary, the 2021 calendar year runoff forecast is **17.9 MAF, 69% of average**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: June 03, 2021 04:47:52 PM
   - Based on June 01, 2021 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow (2)	JUN-JUL	54	96	69	60	48	39	56
	JUN-SEP	69	97	87	76	61	50	71
St. Mary R at Intl Boundary (2)	JUN-JUL	265	96	355	300	230	173	275
	JUN-SEP	330	96	435	375	290	230	345
Lima Reservoir Inflow (2)	JUN-JUL	8.9	33	21	13.7	4.1	0.27	27
	JUN-SEP	11.2	34	26	17.1	5.3	0.33	33
Clark Canyon Reservoir Inflow (2)	JUN-JUL	1.80	5	33	14.4	-10.8	-29	35
	JUN-SEP	7.8	14	50	25	-9.3	-34	55
Jefferson R nr Three Forks (2)	JUN-JUL	193	54	405	280	107	3.6	355
	JUN-SEP	210	51	475	315	101	4.2	415
Hebgen Lake Inflow (2)	JUN-JUL	144	81	184	160	128	104	178
	JUN-SEP	235	84	295	260	210	176	280
Ennis Lake Inflow (2)	JUN-JUL	250	76	325	280	220	175	330
	JUN-SEP	385	79	485	425	345	285	485
Missouri R at Toston (2)	JUN-JUL	705	75	1060	850	560	350	940
	JUN-SEP	915	75	1400	1110	720	435	1220
Smith R bl Eagle Ck (2)	JUN-JUL	46	85	80	60	32	12.3	54
	JUN-SEP	52	80	98	70	34	6.3	65
Gibson Reservoir Inflow (2)	JUN-JUL	210	100	255	230	192	166	210
	JUN-SEP	250	100	300	270	230	199	250
Marias R nr Shelby (2)	JUN-JUL	131	84	215	165	97	46	156
	JUN-SEP	143	83	245	184	102	42	172

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	JUN-JUL	45	96	52	48	42	38	47
	JUN-SEP	60	95	70	64	56	50	63
Wind R ab Bull Lake Ck	JUN-JUL	330	100	415	365	295	245	330
	JUN-SEP	360	99	465	405	315	255	365
Bull Lake Ck nr Lenore (2)	JUN-JUL	98	91	115	105	91	81	108
	JUN-SEP	126	91	148	135	117	103	139
Boysen Reservoir Inflow (2)	JUN-JUL	360	85	500	415	305	220	425
	JUN-SEP	405	84	580	475	335	230	485
Greybull R at Meeteetse	JUN-JUL	98	102	134	113	84	63	96
	JUN-SEP	145	102	189	163	127	100	142
Shell Ck nr Shell	JUN-JUL	32	91	42	36	28	22	35
	JUN-SEP	41	89	52	46	36	30	46
Bighorn R at Kane (2)	JUN-JUL	490	86	740	590	390	240	570
	JUN-SEP	535	85	835	655	415	235	630
NF Shoshone R at Wapiti	JUN-JUL	280	92	345	305	255	215	305
	JUN-SEP	325	90	400	355	295	250	360
SF Shoshone R nr Valley	JUN-JUL	148	94	179	161	135	117	157
	JUN-SEP	176	93	215	191	161	138	189
Buffalo Bill Reservoir Inflow	JUN-JUL	415	89	525	460	375	310	465
	JUN-SEP	475	89	600	525	425	355	535
Bighorn R nr St. Xavier (2)	JUN-JUL	780	85	1120	920	640	440	920
	JUN-SEP	825	82	1240	995	660	415	1010
Little Bighorn R nr Hardin	JUN-JUL	50	94	78	61	39	22	53
	JUN-SEP	63	95	97	77	49	29	66
Tongue R nr Dayton (2)	JUN-JUL	48	98	64	55	42	33	49
	JUN-SEP	61	98	79	68	53	42	62
Tongue River Reservoir Inflow (2)	JUN-JUL	109	99	156	128	90	61	110
	JUN-SEP	132	99	189	155	109	75	134
NF Powder R nr Hazelton	JUN-JUL	4.1	91	6.2	4.9	3.3	2.0	4.5
	JUN-SEP	4.8	92	7.1	5.7	3.9	2.5	5.2

Powder R at Moorhead	JUN-JUL	84	91	141	107	61	27	92
	JUN-SEP	99	90	165	126	72	33	110
Powder R nr Locate	JUN-JUL	91	90	166	121	61	15.9	101
	JUN-SEP	109	89	197	144	74	21	122

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	JUN-JUL	1.76	77	3.5	2.5	1.07	0.040	2.3
Pactola Reservoir Inflow (2)	JUN-JUL	6.1	58	15.4	9.8	2.3	0.100	10.5

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate (2)	JUN-JUL	58	47	101	75	40	14.1	123
	JUN-SEP	71	49	122	92	51	21	146
Encampment R nr Encampment (2)	JUN-JUL	30	40	55	40	20	5.4	75
	JUN-SEP	33	39	59	43	23	7.4	84
Rock Ck ab King Canyon Cnl nr Arlington	JUN-JUL	27	84	37	31	24	18.0	32
	JUN-SEP	30	86	40	34	26	19.8	35
Seminoe Reservoir Inflow (2)	JUN-JUL	199	51	330	250	146	67	390
	JUN-SEP	235	53	375	290	178	96	445
Sweetwater R nr Alcova	JUN-JUL	11.4	44	22	15.5	7.3	1.30	26
	JUN-SEP	14.0	45	26	18.9	9.1	1.80	31
La Prele Ck nr Douglas	JUN-JUL	3.6	80	7.5	5.2	2.0	0.040	4.5
	JUN-SEP	3.9	81	7.9	5.5	2.3	0.050	4.8
North Platte R bl Glendo Reservoir (2)	JUN-JUL	154	41	285	210	100	21	375
	JUN-SEP	162	40	305	220	103	16.7	405
North Platte R bl Guernsey Reservoir (2)	JUN-JUL	142	38	280	197	86	4.3	370
	JUN-SEP	149	37	295	210	89	4.0	400
Laramie R and Pioneer Cnl nr Woods Lg (2)	JUN-JUL	57	80	81	67	48	34	71
	JUN-SEP	67	82	93	77	56	41	82
Little Laramie R nr Filmore	JUN-JUL	31	89	41	35	27	21	35
	JUN-SEP	34	87	45	38	30	23	39

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
July 2021 Calendar Year Runoff Forecast
July 6, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

June runoff was 2.9 MAF, 52% of average for the Basin above Sioux City, IA. Runoff was well-below average in all reaches. Observed precipitation in June was well below normal in the majority of the upper Basin. Mountain snowpack melted completely in June several weeks earlier than normal. Runoff from that snowmelt has already been realized into Fort Peck and Garrison reservoirs.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Basin (above Sioux City, IA) is **15.6 MAF, 60% of average**. The 2021 calendar year runoff forecast for the Basin above Gavins Point is **14.3 MAF**, **61% of average**. Current and forecasted drier-than-normal and warmer-than-normal conditions has led to a 2.3-MAF reduction from the June 1 annual runoff forecast of 17.9 MAF.

Due to the variability in precipitation and other hydrologic factors that can occur over the next 6 months, expected inflow could range from the 17.3 MAF upper basic forecast to the 14.0 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation

planning models to "bracket" the range of expected runoff given wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for June 29, 2021 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 74% of the Basin, with Extreme (D3) or Exceptional (D4) Drought present in pockets of the northern half of the Basin. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of September, indicates drought conditions are likely to persist or expand throughout the upper Basin.

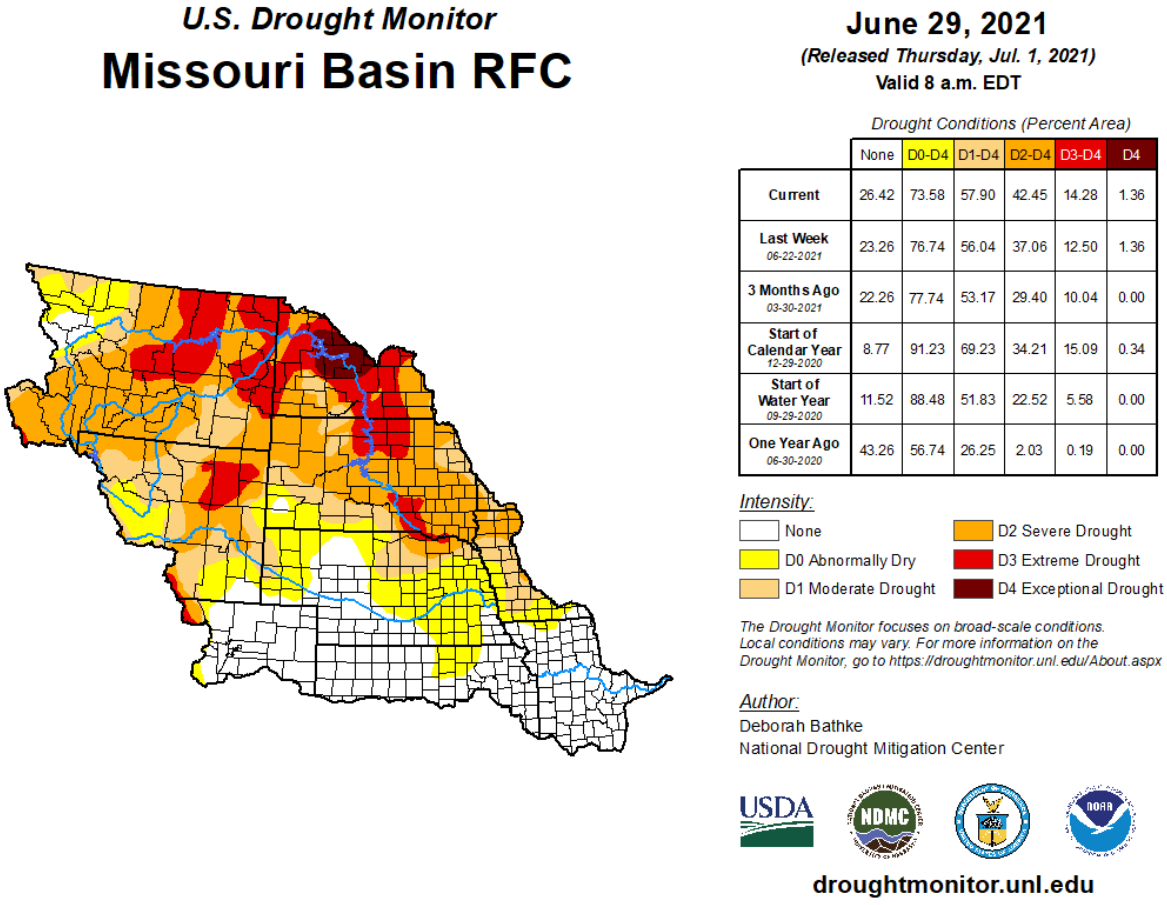


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

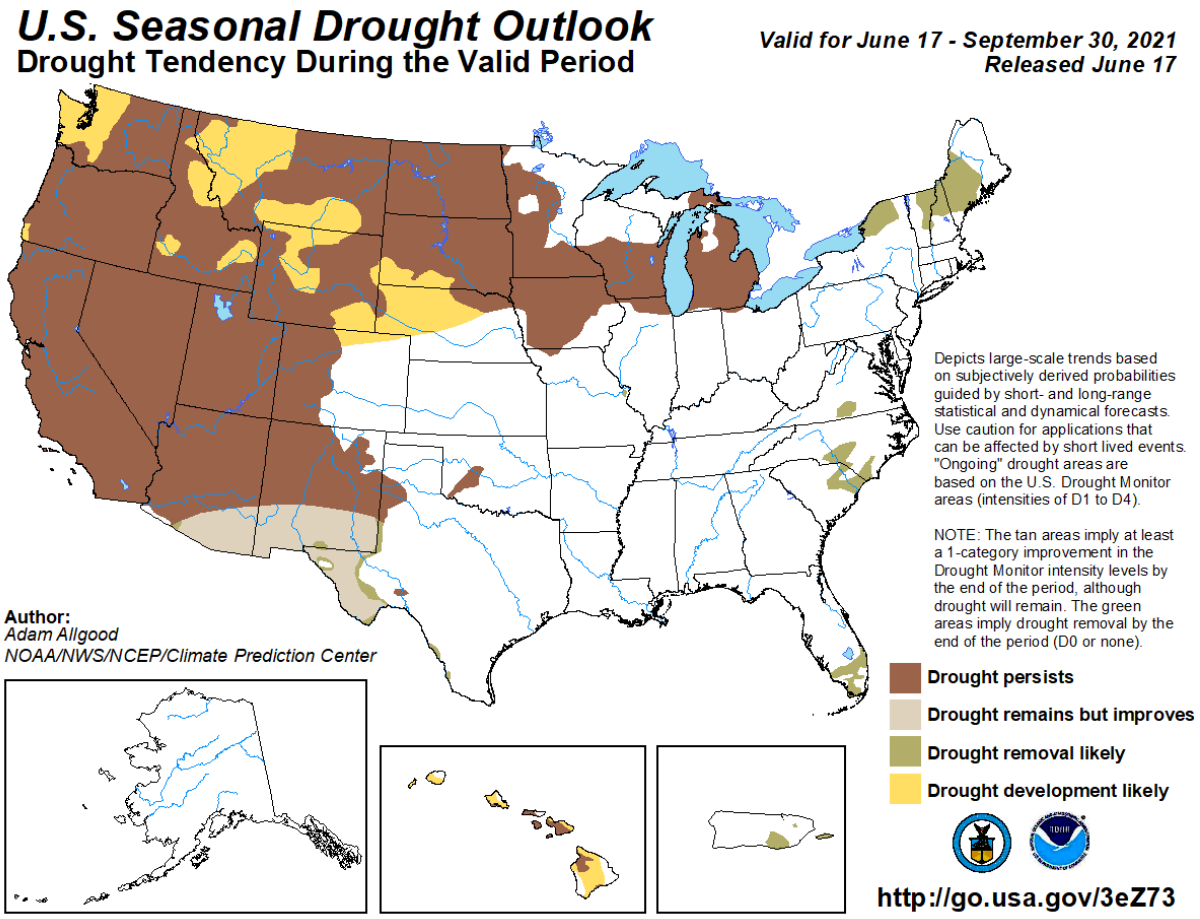


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The June precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. June precipitation was below normal overall in the Basin, with most of the Basin seeing less than 50% of its normal precipitation accumulation.

Precipitation as a percent of normal for the April-May-June 2021 period was also below normal for most of the Basin except for portions of the lower Basin (**Figure 4**). Much of the upper Basin saw less than 70% of its normal precipitation accumulation over the latest 3-month period.

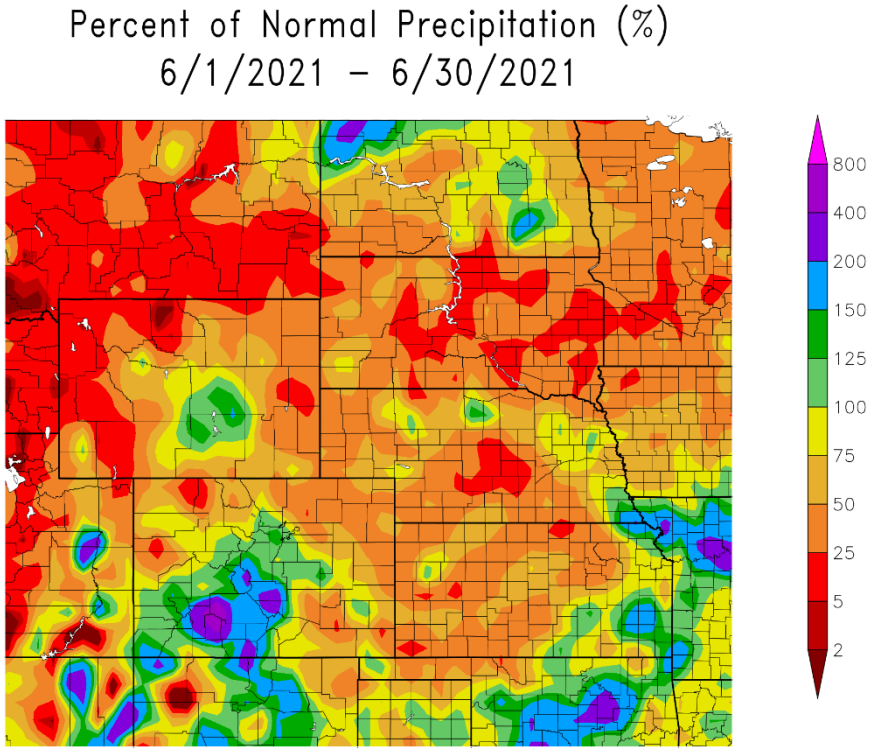


Figure 3. HPRCC June 2021 Percent of Normal Precipitation.

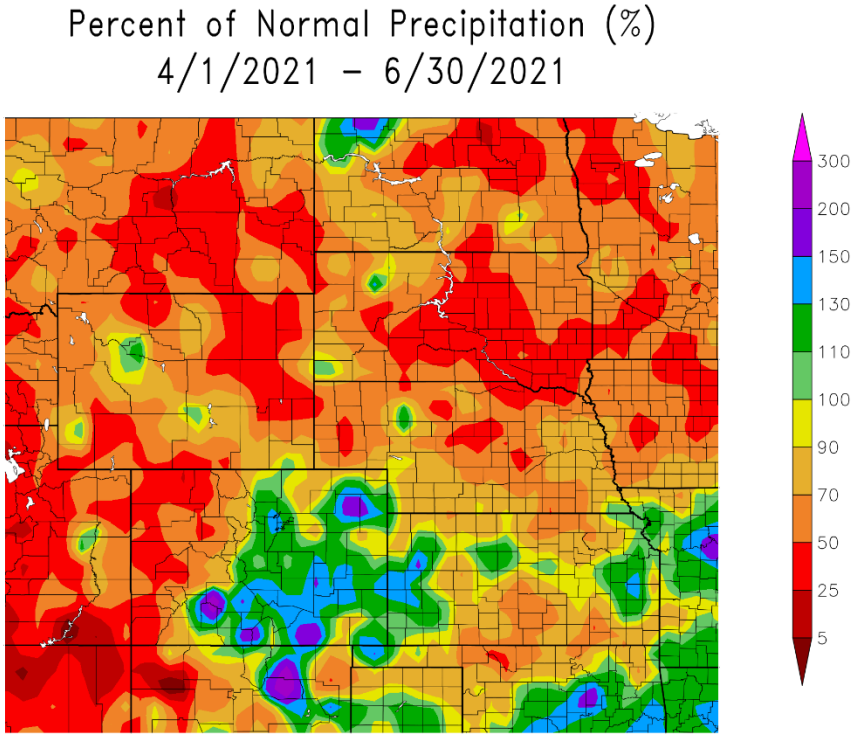


Figure 4. HPRCC April-May-June 2021 Percent of Normal Precipitation.

Temperature

June temperature departures in degrees Fahrenheit (deg F) in **Figure 5** were warmer-than-normal over most of the Basin. In the upper Basin, temperature departures ranged from 4-10 deg F above normal. April-May-June 2021 temperature departures are shown in **Figure 6**. The three-month average departures were slightly above normal for most of the upper Basin into Iowa and Nebraska, and slightly below normal for Colorado, Kansas, and Missouri.

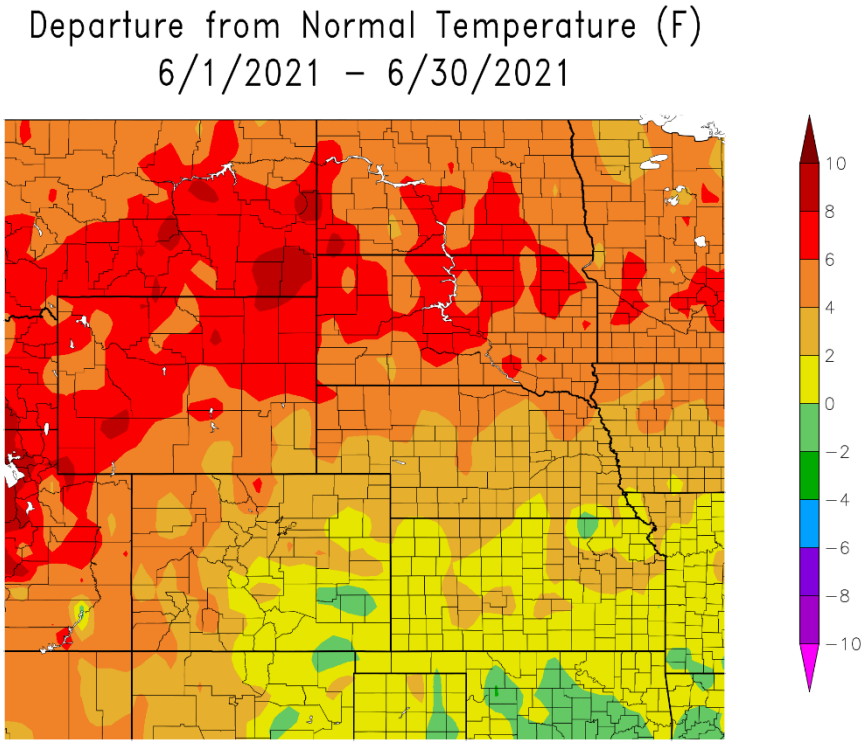


Figure 5. HPRCC June 2021 Departure from Normal Temperature.

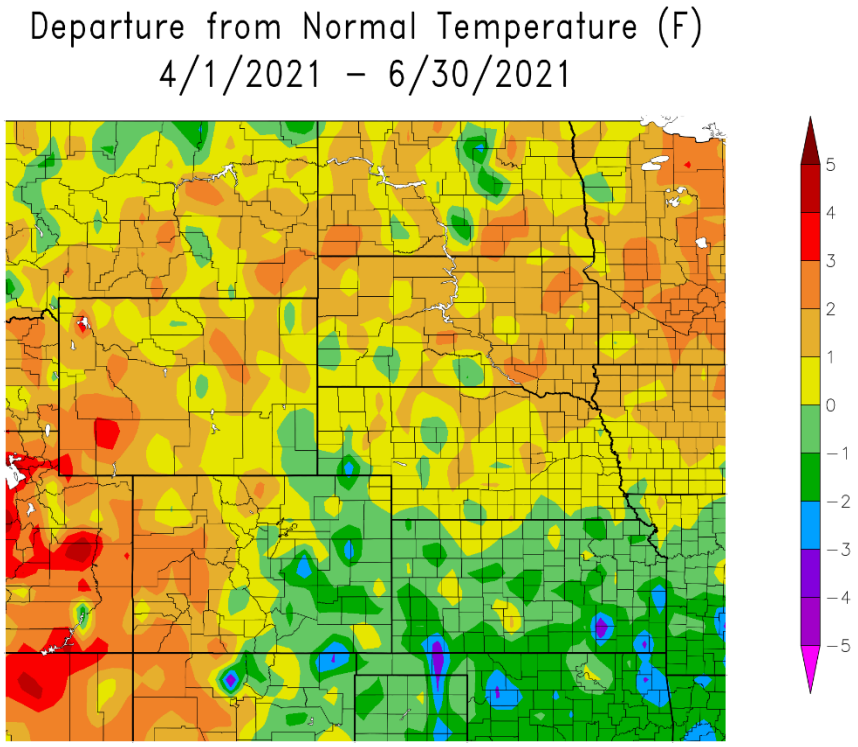


Figure 6. HPRCC April-May-June 2021 Departure from Normal Temperature.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of July 2021 is drier than normal across the upper Basin as well as into Nebraska, Iowa, and parts of central Kansas. Some pockets of above-normal soil moisture exist in southeastern Kansas and in Missouri from the recent wet pattern moving across the southern portions of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**.

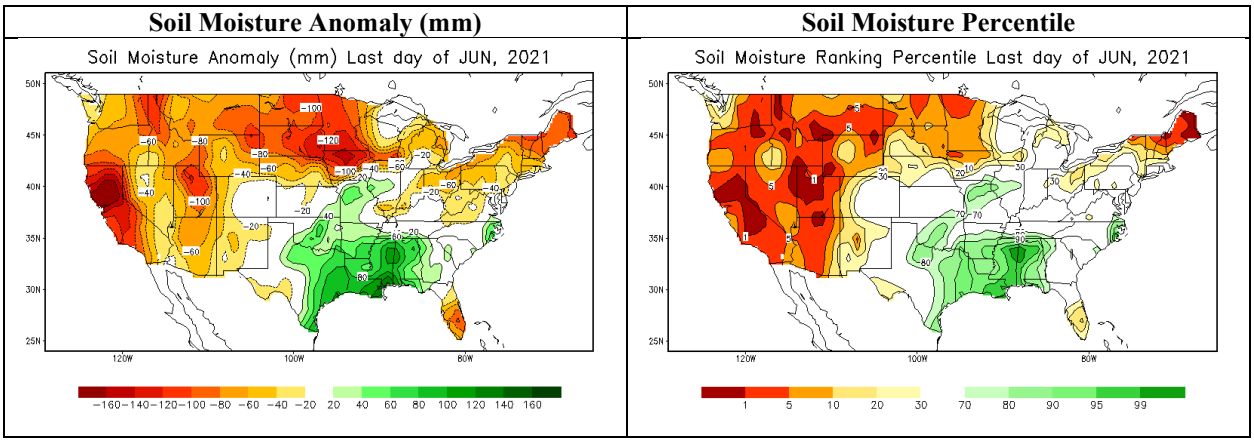


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which primarily includes long-term precipitation outlooks. As the plains snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack in the Basin has been nonexistent since before April 1, so was not factored into the July 1 forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the June 1 snowpack. The snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain snow water equivalent (SWE) beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current year's average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

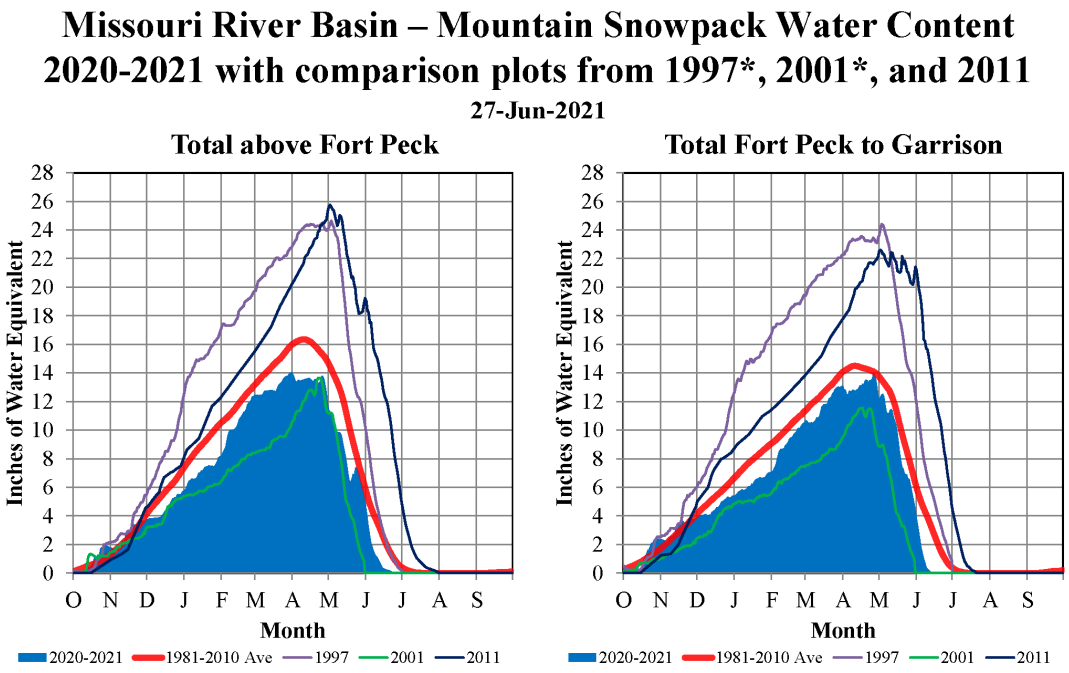


Figure 8. Mountain snowpack water content on June 27, 2021 compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of June 27, 2021, the mountain snowpack in the Fort Peck reach and the Garrison reach had both completely melted. Mountain snowpack in the Fort Peck reach peaked on March 31 at 14.1", which is 86% of the normal peak. Mountain snowpack in the Garrison reach peaked on April 26 at 14.0", which is 96% of the normal peak. Mountain snowpack melted out several weeks earlier than normal, and runoff from that snowmelt had already been realized into Fort Peck and Garrison reservoirs before July 1.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates that ENSO-neutral conditions are present and have a 78% chance of continuing through the rest of the summer (through August 2021). ENSO-neutral conditions are also favored through the fall with a 50% chance for the September-November season.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The CPC temperature outlook through July 19 (**Figure 9**, left) indicates increased chances for above-normal temperatures across most of the Basin. The CPC precipitation outlook (**Figure 9**, right) indicates increased chances for below-normal precipitation over most of the Basin.

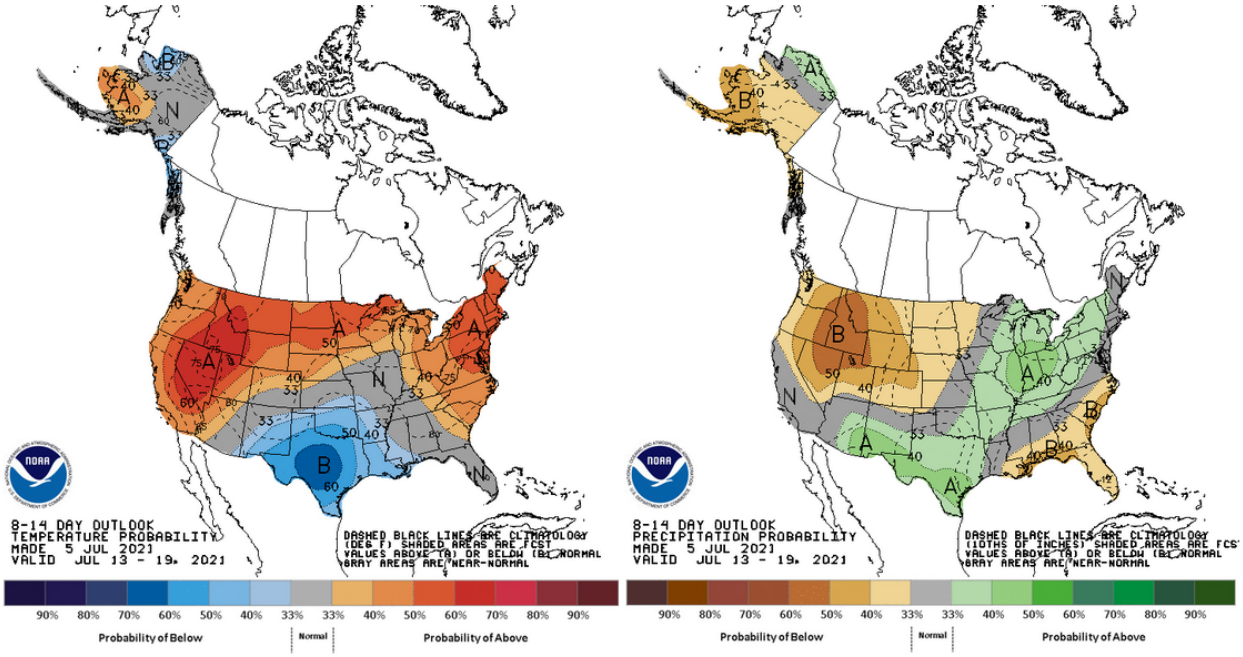


Figure 9. NOAA CPC 8-14 Day Temperature and Precipitation Outlooks.

The July CPC outlooks in **Figure 10** indicate increased chances for above-normal temperatures and below-normal precipitation over most of the Basin. Equal chances of above-normal, normal, or below-normal temperature and precipitation are possible in parts of southern Nebraska and Iowa and northern Kansas and Missouri. A slight increase in chances for below-normal temperatures and above-normal precipitation are possible in southern Kansas and Missouri.

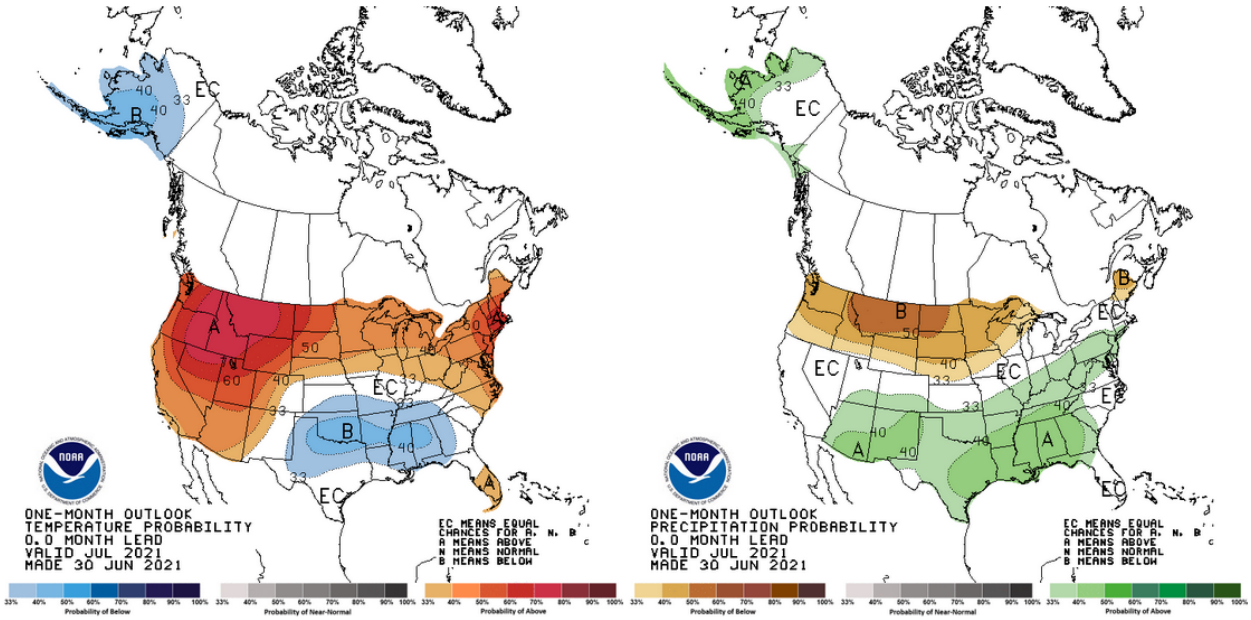


Figure 10. NOAA CPC One-Month Temperature and Precipitation Outlooks.

Three-month temperature and precipitation outlooks for August-September-October 2021 and November-December-January 2021-2022 are shown below in **Figure 11** and **Figure 12**. During the August-September-October period (**Figure 11**), the CPC indicates increased chances for above-normal temperatures and below-normal precipitation over most of the Basin.

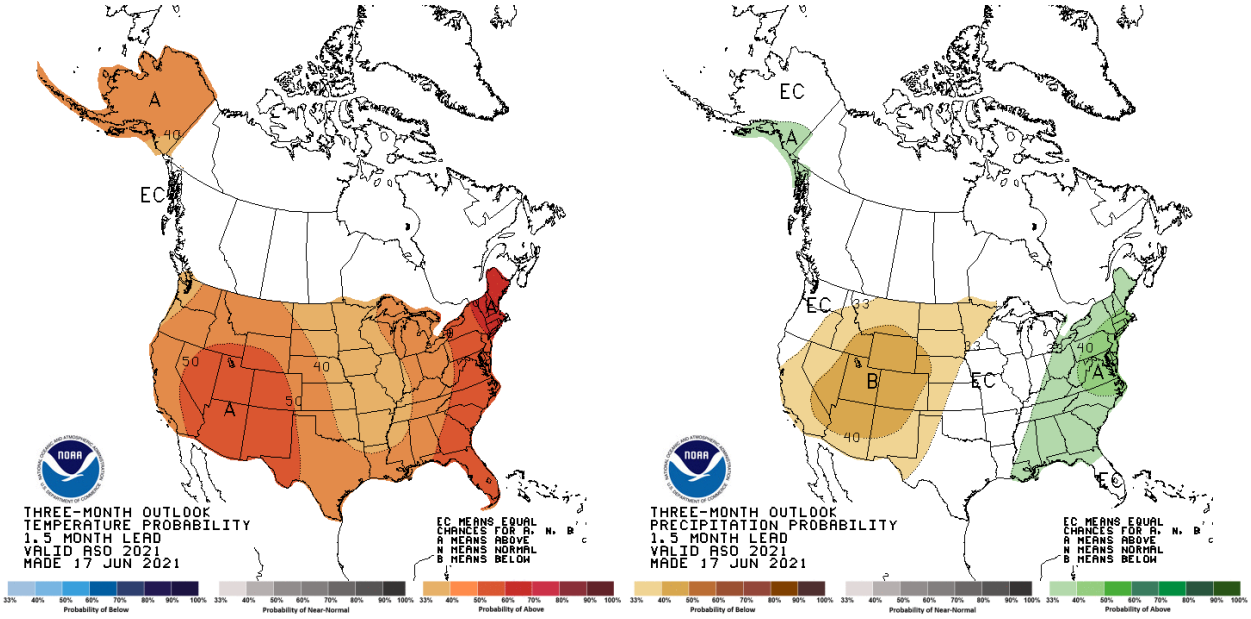


Figure 8. NOAA CPC Three-Month Temperature and Precipitation Outlooks (August-September-October).

For the remainder of the 2021 calendar year into January 2022, CPC outlooks show equal chances for above-normal, normal, or below-normal temperatures in much of the Basin. Wyoming, Colorado, western Nebraska, and Kansas indicate increased chances for above-

normal temperatures. Equal chances for above-normal, normal, or below-normal precipitation are indicated throughout the Basin (**Figure 12**).

As previously noted, there is limited confidence in long-term climate outlooks; therefore, the climate outlooks will likely change as the calendar progresses.

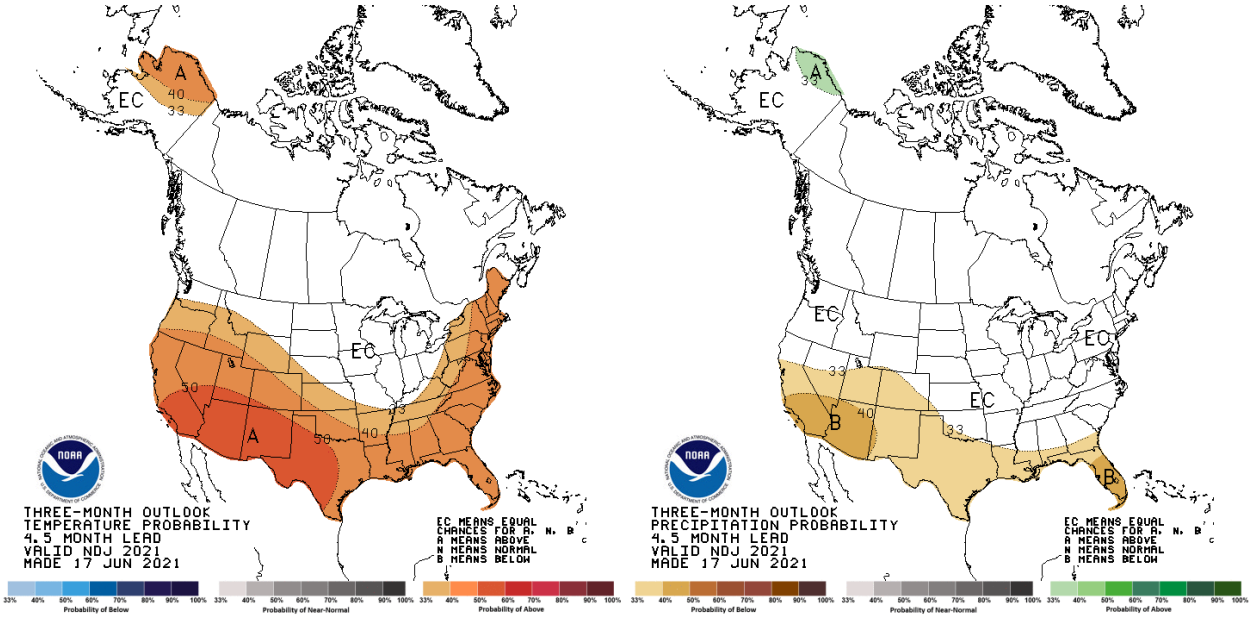


Figure 9. NOAA CPC Three-Month Temperature and Precipitation Outlooks (November-December-January).

Summary

Given the current and forecasted dry soil conditions and dry climate conditions, and the absence of any snowmelt runoff in July, we expect runoff to remain below average during July. In summary, the 2021 calendar year runoff forecast is **15.6 MAF, 60% of average**.

Upper Missouri River Basin
August 2021 Calendar Year Runoff Forecast
August 5, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

July runoff was 1.1 MAF, 34% of average for the Basin above Sioux City, IA. Runoff was well-below average in the upper three reaches (Fort Peck, Garrison, and Oahe). Runoff in the Fort Peck reach was the record lowest for July in 123 years of record-keeping. Observed precipitation in July was below normal in the majority of the upper Basin.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Basin (above Sioux City, IA) is **14.6 MAF, 57% of average**. If realized, this runoff amount would be the 10th lowest runoff in 123 years of record-keeping. The 2021 calendar year runoff forecast for the Basin above Gavins Point is **13.2 MAF**, **56% of average**. Current and forecasted drier-than-normal and warmer-than-normal conditions has led to a 1.0-MAF reduction from the July 1 annual runoff forecast of 15.6 MAF.

Due to the variability in precipitation and other hydrologic factors that can occur over the next 6 months, expected inflow could range from the 15.5 MAF upper basic forecast to the 13.8 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation

planning models to “bracket” the range of expected runoff given wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center’s drought monitor for August 3, 2021 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 79% of the Basin, with Extreme (D3) or Exceptional (D4) Drought present in 30% of the Basin, mostly in Montana and into the Dakotas. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of October, indicates drought conditions are likely to persist or expand throughout the upper Basin.

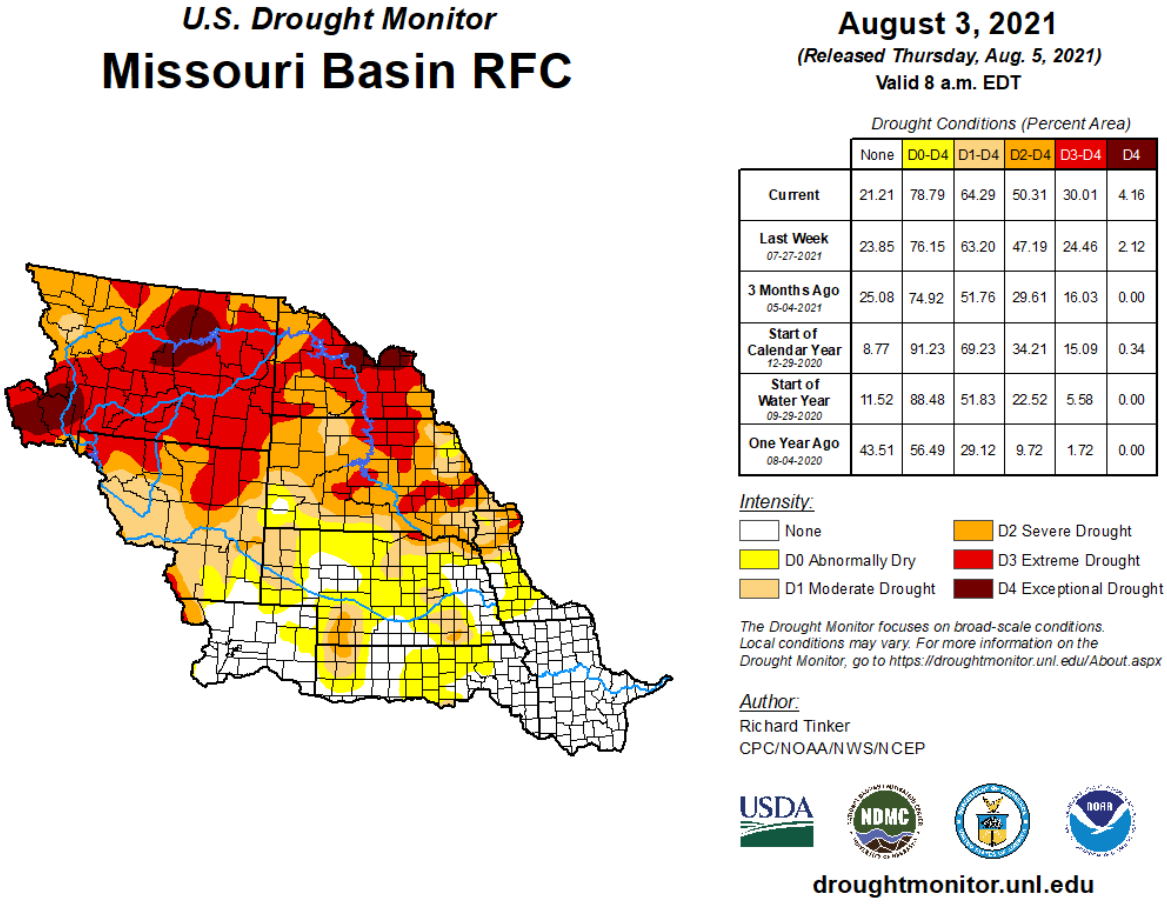


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

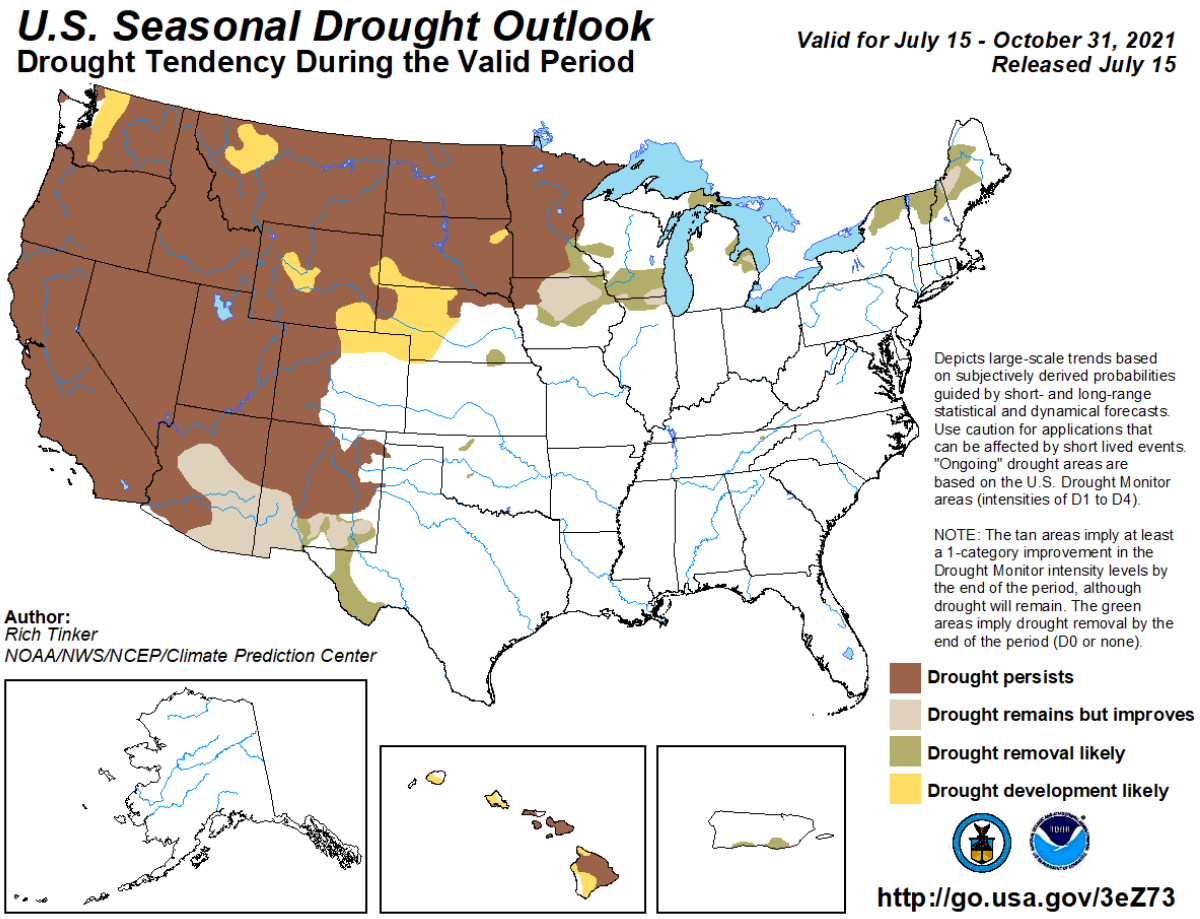


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The July precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. July precipitation was below normal in the Basin except for small pockets of normal to above-normal precipitation. Much of Montana and North Dakota saw less than 50% of their normal precipitation accumulation over the last month.

Precipitation as a percent of normal for the May-June-July 2021 period was below normal for most of the Basin except for pockets in Kansas and into Missouri (**Figure 4**). Much of the Basin saw less than 70% of its normal precipitation accumulation over the latest 3-month period; large areas of Montana, northern Wyoming, and the eastern Dakotas saw less than 50% of their normal precipitation accumulation.

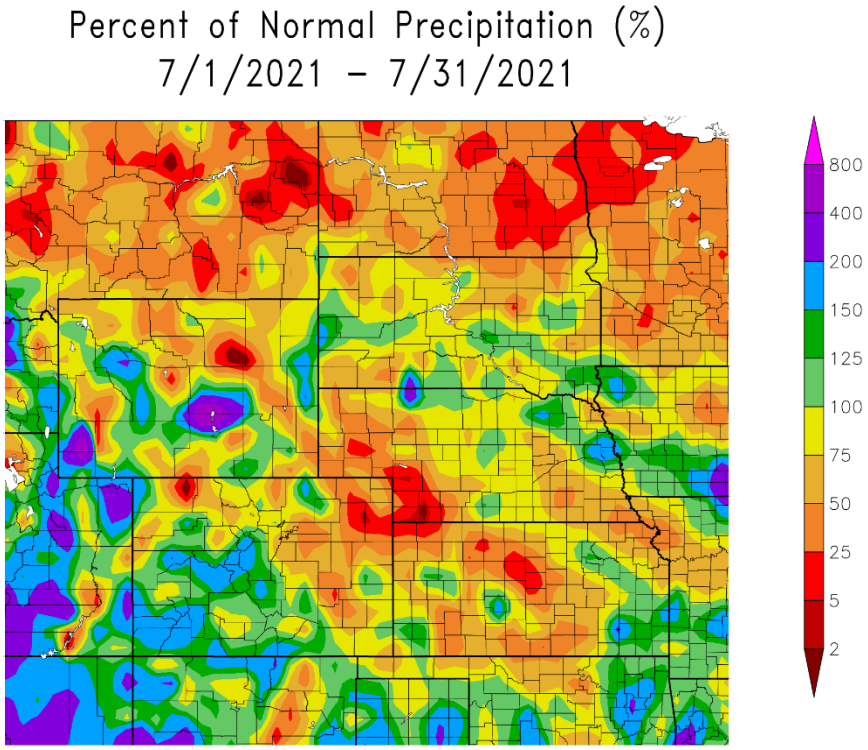


Figure 3. HPRCC July 2021 Percent of Normal Precipitation.

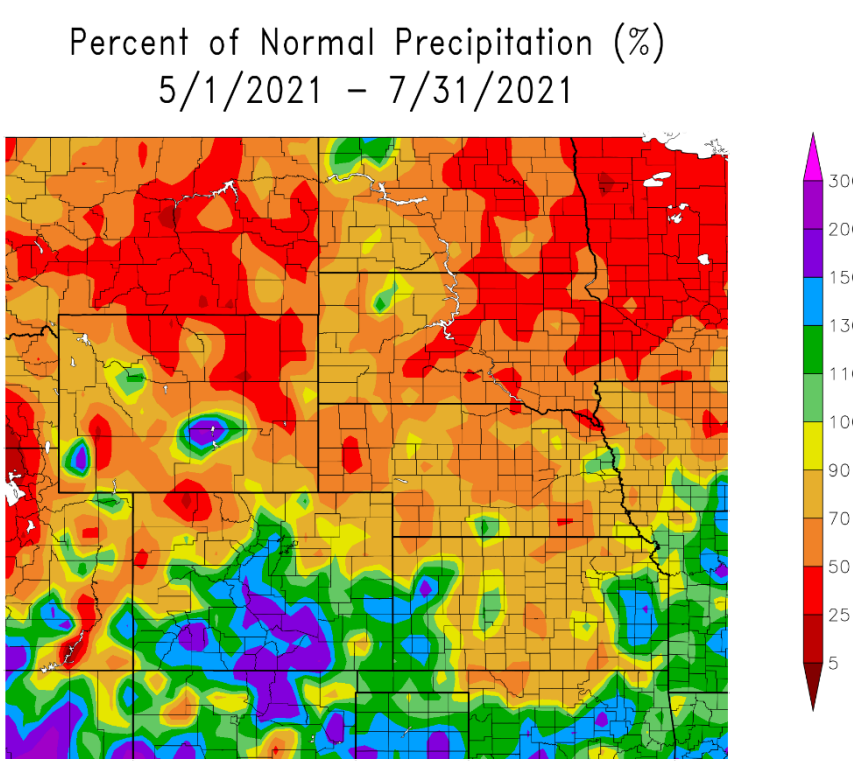


Figure 4. HPRCC May-June-July 2021 Percent of Normal Precipitation.

Temperature

July temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate that temperatures were warmer than normal over the upper Basin and cooler than normal in the lower Basin. In the Montana and North Dakota, temperature departures ranged from 4-8 deg F above normal. May-June-July 2021 temperature departures are shown in **Figure 6**. The three-month average departures were slightly above normal for most of the Basin, and slightly below normal for Kansas and Missouri.

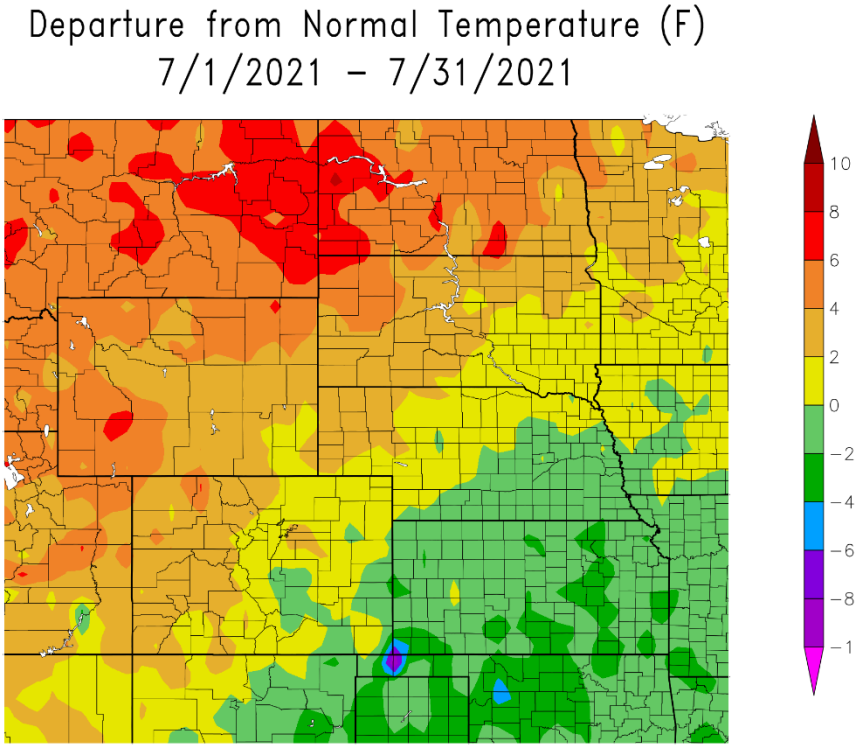


Figure 5. HPRCC June 2021 Departure from Normal Temperature.

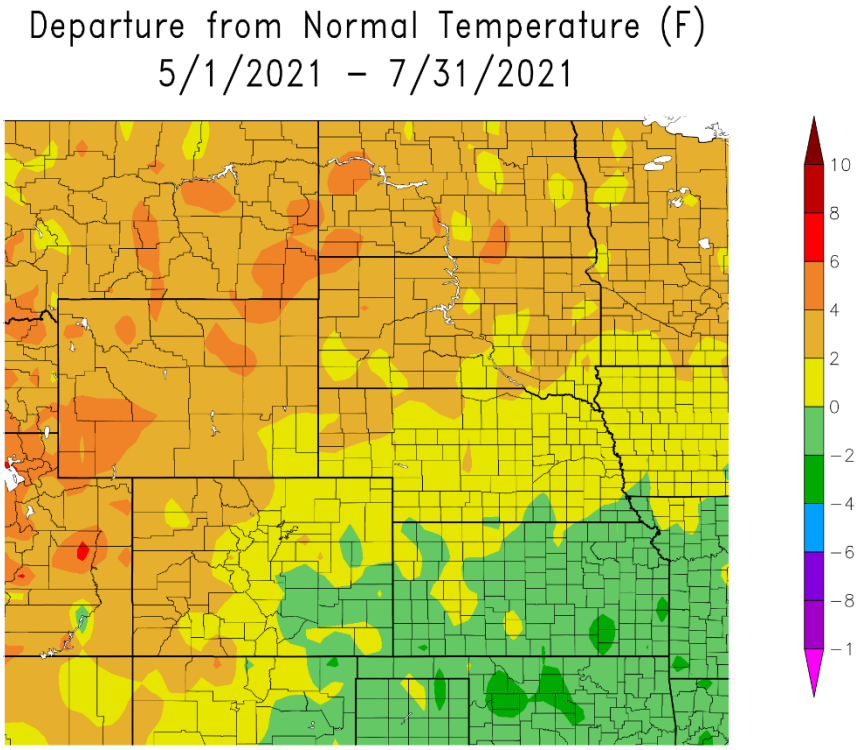


Figure 6. HPRCC May-June-July 2021 Departure from Normal Temperature.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of August 2021 is drier than normal across most of the Basin except for Missouri and parts of Kansas. Soil moisture ranks in the lowest to 5th lowest percentile for almost all of Montana and North Dakota. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**.

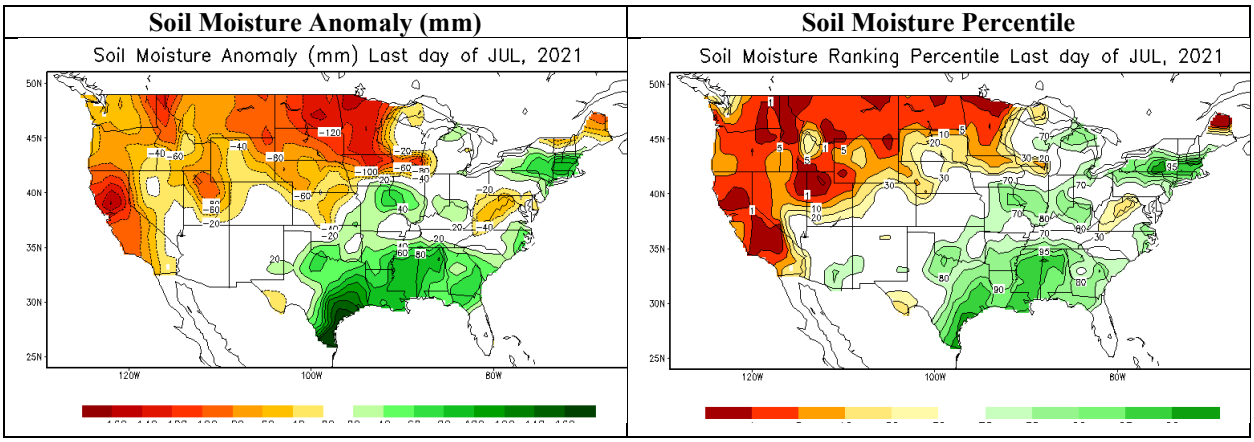


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which primarily includes long-term precipitation outlooks. As the plains snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack in the Basin has been nonexistent since before April 1, so was not factored into the April 1 forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the June 1 snowpack. The snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain snow water equivalent (SWE) beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current year's average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

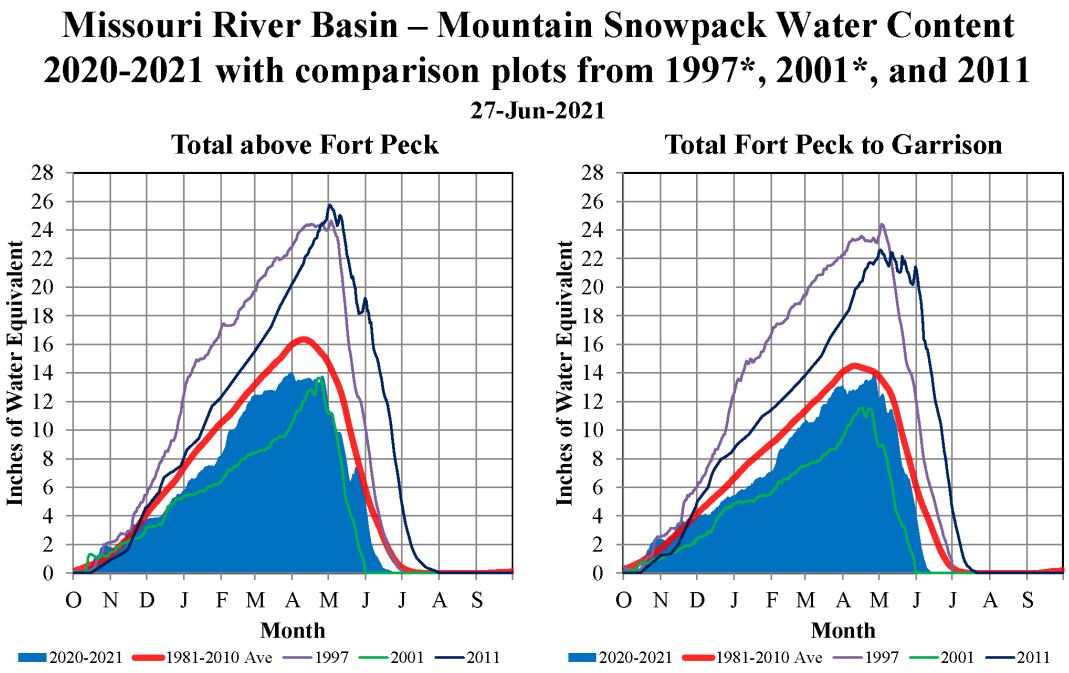


Figure 8. Mountain snowpack water content on June 27, 2021 compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of June 27, 2021, the mountain snowpack in the Fort Peck reach and the Garrison reach had both completely melted. Mountain snowpack in the Fort Peck reach peaked on March 31 at 14.1", which is 86% of the normal peak. Mountain snowpack in the Garrison reach peaked on April 26 at 14.0", which is 96% of the normal peak. Mountain snowpack melted out several weeks earlier than normal, and runoff from that snowmelt had already been realized into Fort Peck and Garrison reservoirs before July 1.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates that ENSO-neutral conditions are present with a La Niña watch in effect. There is a 51% chance that ENSO-neutral conditions will continue through the August-October season. La Niña conditions could emerge during the September-November season and last through the 2021-2022 winter with a 66% chance of La Niña conditions during November through January.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The August CPC outlooks in **Figure 9** indicate increased chances for above-normal temperatures over most of the basin and equal chances of above-normal, normal, or below-normal temperatures in Kansas and Missouri. Precipitation outlooks indicate increased chances for below-normal precipitation over the Dakotas, eastern Montana and Wyoming, and into Nebraska and Iowa. Equal chances of above-normal, normal, or below-normal precipitation are possible in the rest of the Basin.

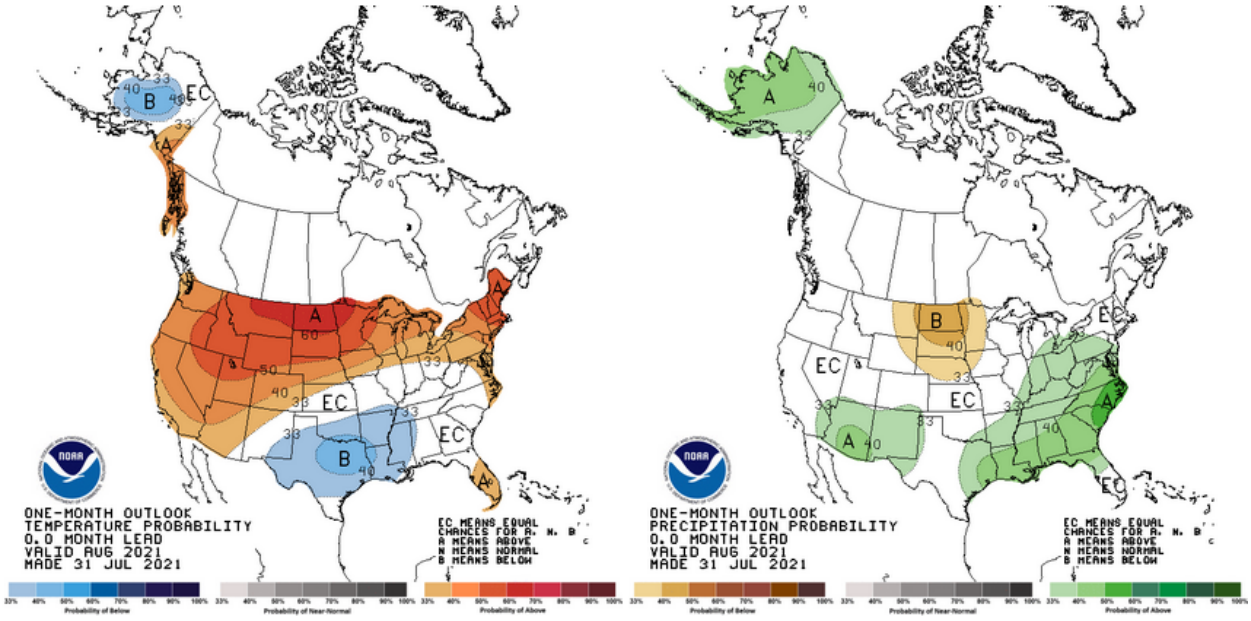


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (August).

Three-month temperature and precipitation outlooks for August-September-October 2021 and November-December-January 2021-2022 are shown below in **Figure 10** and **Figure 11**. During the August-September-October period (**Figure 10**), the CPC indicates increased chances for above-normal temperatures and below-normal precipitation over most of the Basin.

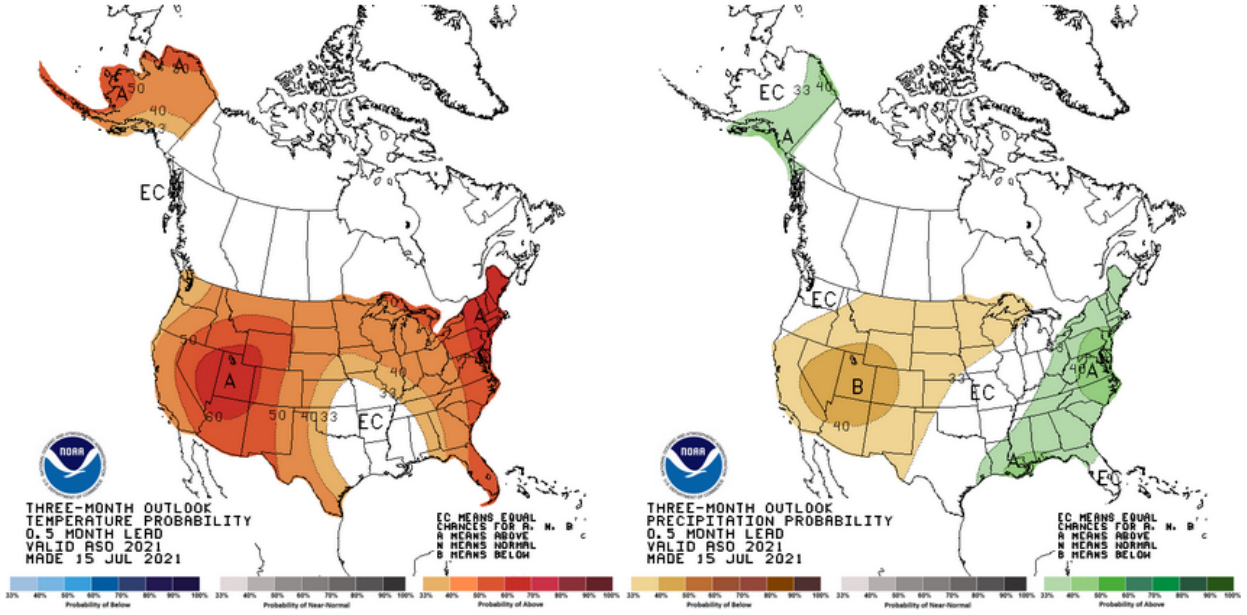


Figure 8. NOAA CPC Three-Month Temperature and Precipitation Outlooks (August-September-October).

For the remainder of the 2021 calendar year into January 2022, CPC outlooks show equal chances for above-normal, normal, or below-normal temperatures in much of the Basin. Wyoming, Colorado, western Nebraska, and Kansas indicate increased chances for above-normal temperatures. Equal chances for above-normal, normal, or below-normal precipitation are indicated throughout the Basin (**Figure 11**).

As previously noted, there is limited confidence in long-term climate outlooks; therefore, the climate outlooks will likely change as the calendar progresses.

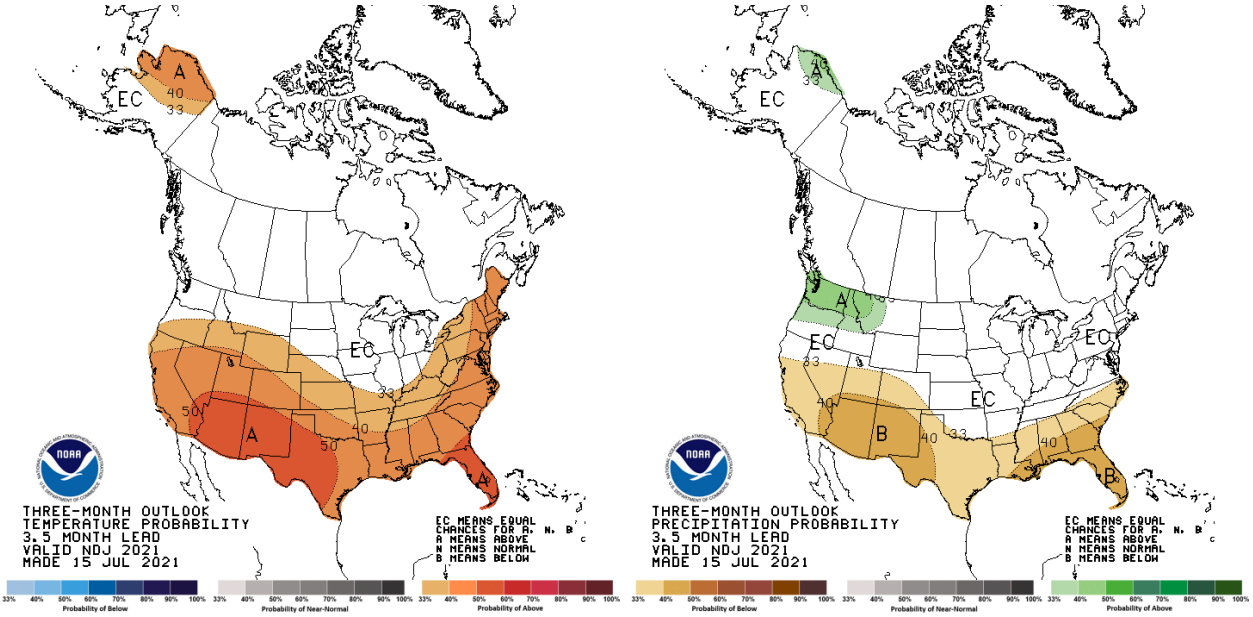


Figure 9. NOAA CPC Three-Month Temperature and Precipitation Outlooks (November-December-January).

Summary

Given the current and forecasted dry soil conditions and dry climate conditions, we expect runoff to remain below average during the remainder of the calendar year. In summary, the 2021 calendar year runoff forecast is **14.6 MAF, 57% of average**.

Upper Missouri River Basin
September 2021 Calendar Year Runoff Forecast
September 8, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

August runoff was 750,000 acre-feet, 54% of average for the upper Basin. Runoff was well-below average in the upper three reaches (Fort Peck, Garrison, and Oahe).

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Basin (above Sioux City, IA) is **14.7 MAF, 57% of average**. If realized, this runoff amount would be the 10th lowest runoff in 123 years of record-keeping. The 2021 calendar year runoff forecast for the area above Gavins Point is **13.2 MAF**, **56% of average**.

Due to the variability in precipitation and other hydrologic factors that can occur over the next 4 months, expected inflow could range from the 15.4 MAF upper basic forecast to the 14.1 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for August 31, 2021 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 81% of the Basin, with Extreme (D3) or Exceptional (D4) Drought present in 30% of the Basin, mostly in Montana and into the Dakotas. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of November, indicates drought conditions are likely to persist or expand throughout most of the upper Basin. Some improvement is possible in eastern South Dakota and eastern North Dakota.

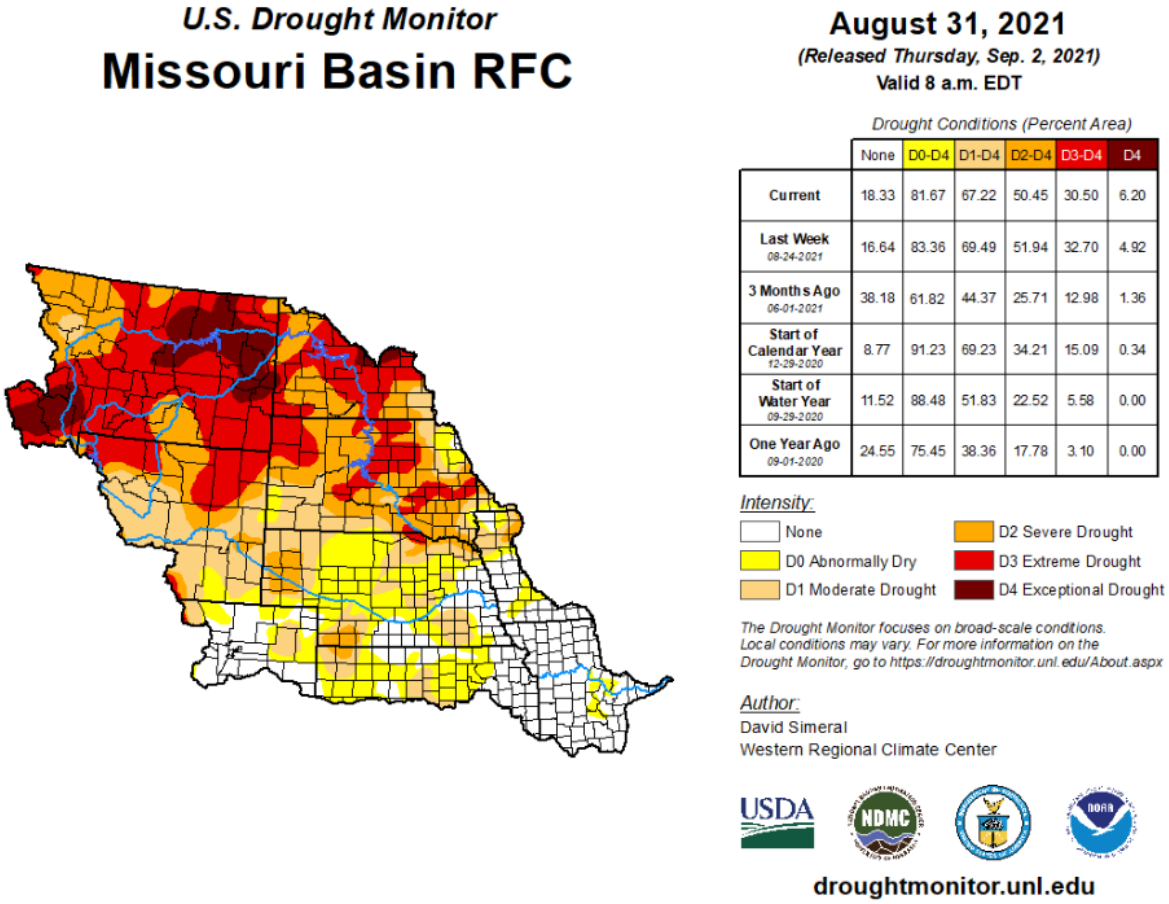


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

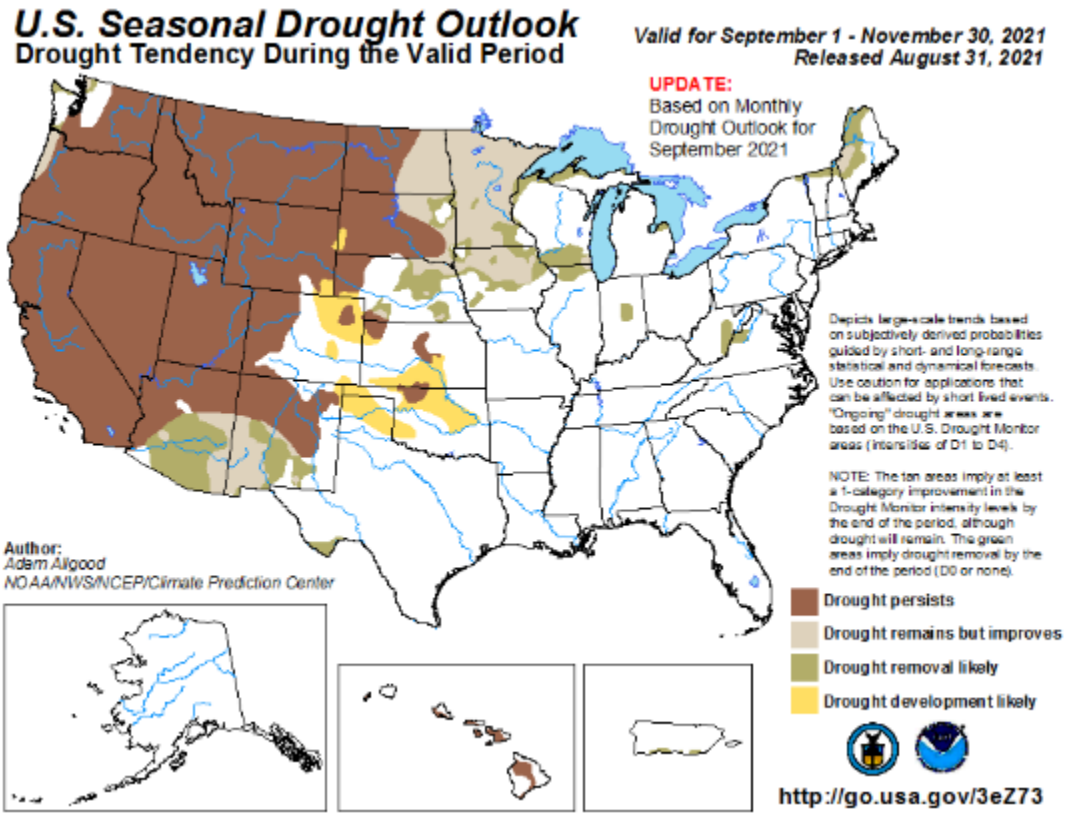


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The August precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. August precipitation was generally below normal in the lower Basin and above normal in the upper Basin. Areas of Wyoming and Montana had over 300 percent of normal precipitation, whereas areas of Kansas and eastern Colorado had below 5 percent of normal precipitation.

Precipitation as a percent of normal for the June-July-August 2021 period was below normal for most of the Basin except for Missouri and central Wyoming (**Figure 4**). Much of the Basin experienced less than 70% of its normal precipitation accumulation over the latest 3-month period; large areas of Montana, eastern Wyoming, eastern Colorado, western Nebraska, and western Kansas experienced less than 50% of their normal precipitation accumulation.

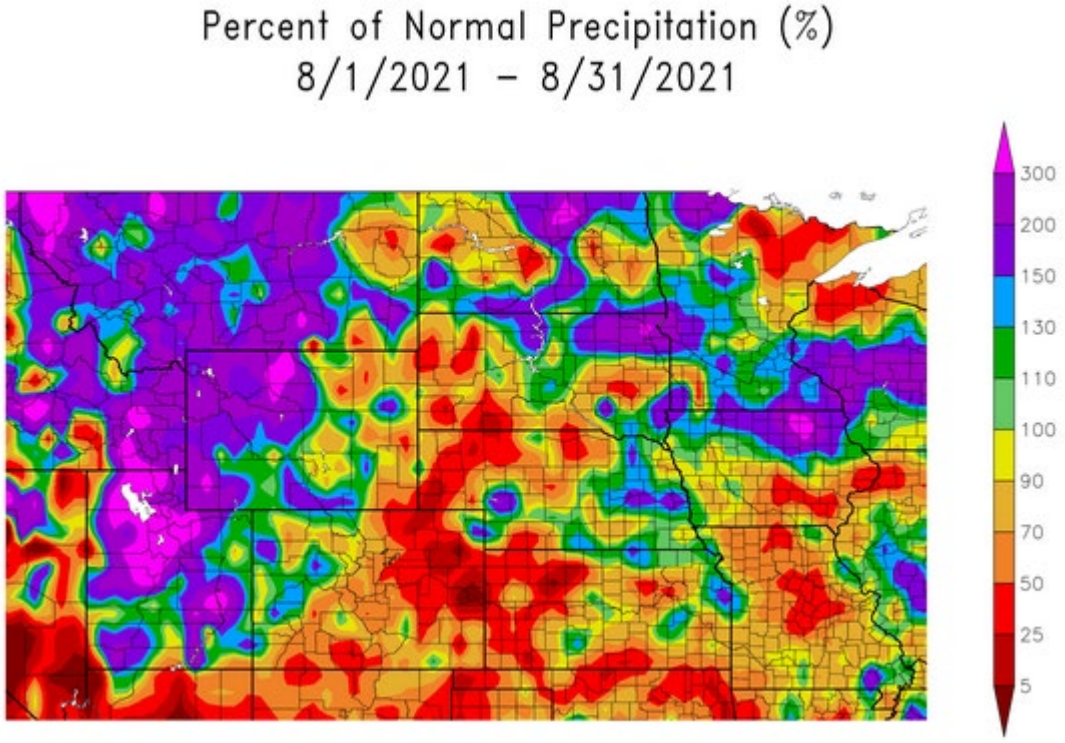


Figure 3. HPRCC August 2021 Percent of Normal Precipitation.

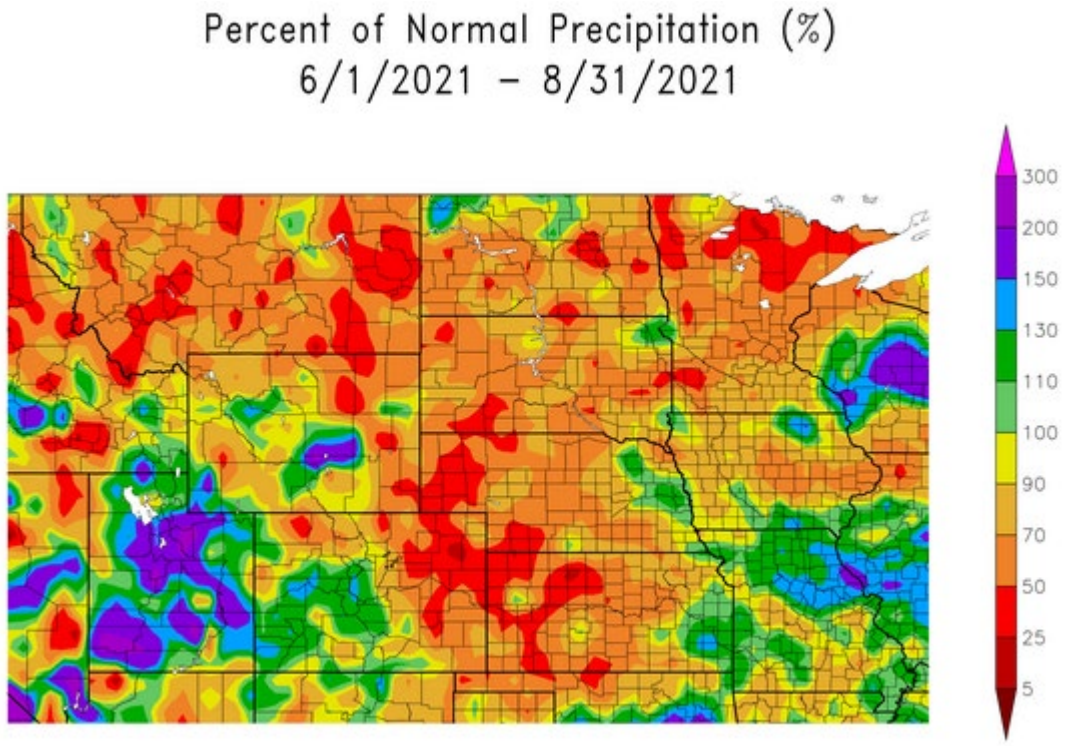


Figure 4. HPRCC June-July-August 2021 Percent of Normal Precipitation.

Temperature

August temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate that temperatures were 0 to 4 degrees warmer than normal over the eastern Basin and 0 to 2 degrees cooler than normal in the western Basin. June-July-August 2021 temperature departures are shown in **Figure 6**. The three-month average departures were above normal for most of the Basin, with slightly below normal areas along southern Kansas and Missouri.

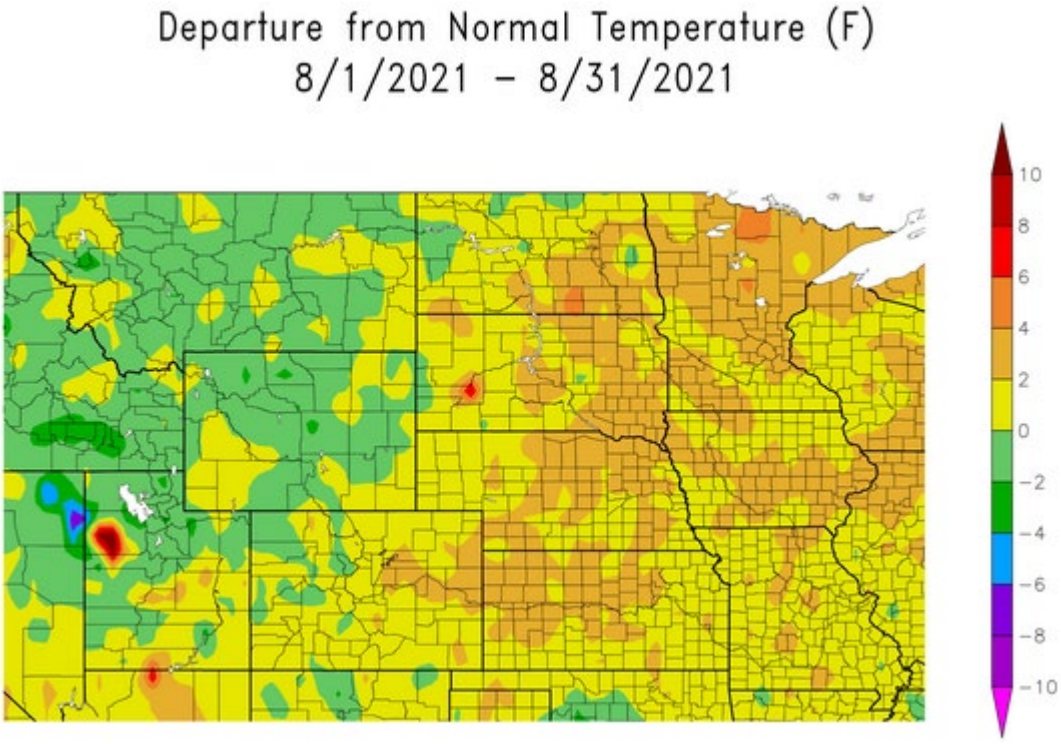


Figure 5. HPRCC August 2021 Departure from Normal Temperature.

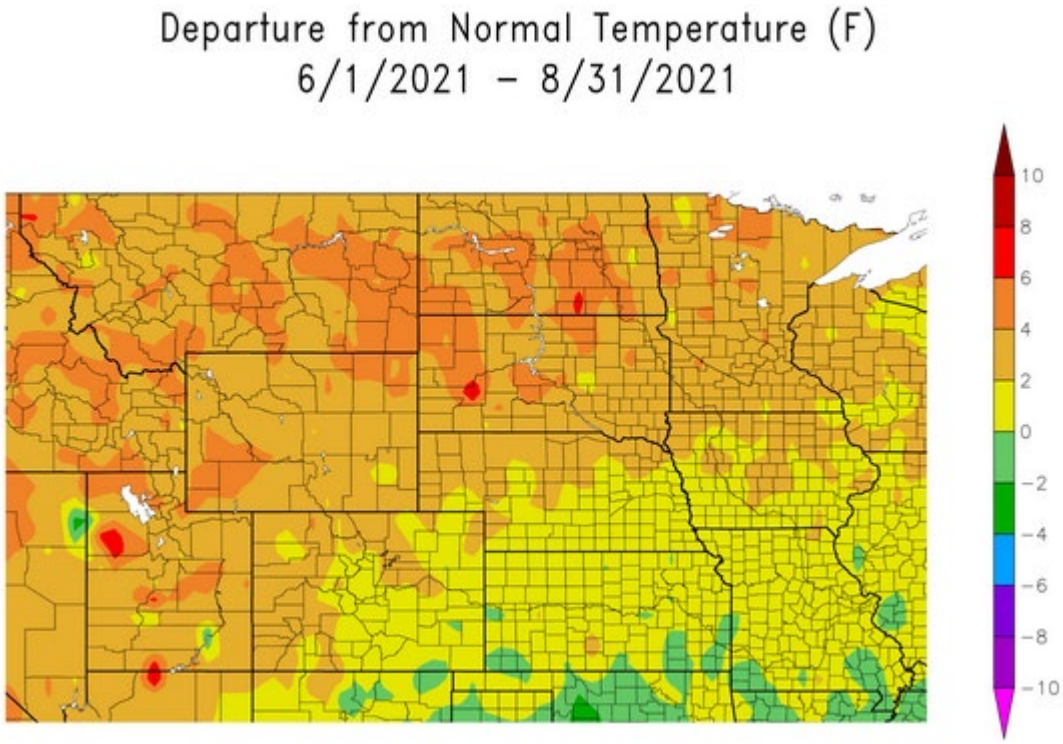


Figure 6. HPRCC June-July-August 2021 Departure from Normal Temperature.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the beginning of September 2021 is drier than normal across the upper Basin, and about average in the lower Basin, with pockets of slightly drier or wetter than normal areas. Soil moisture ranks in the lowest to 5th lowest percentile for a large portion of the upper Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**.

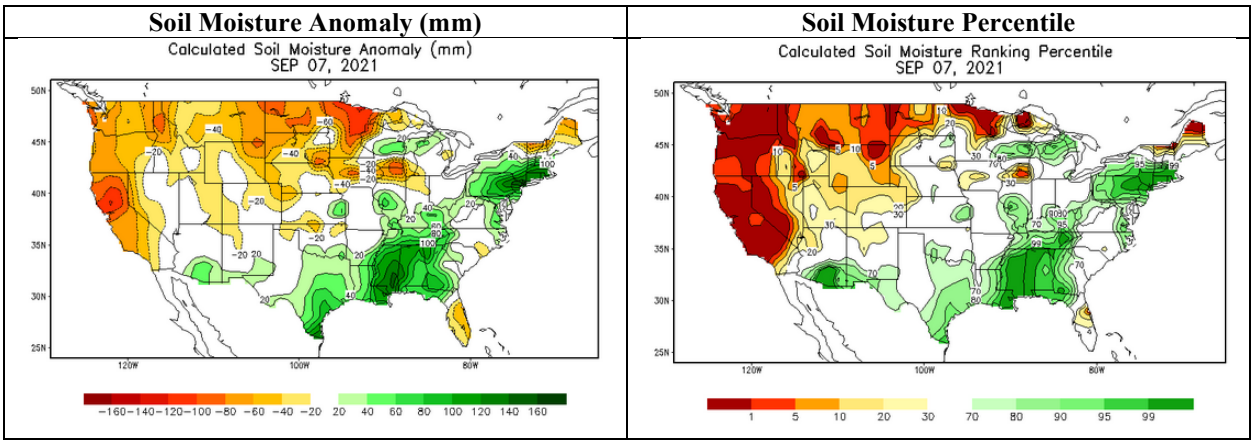


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which primarily includes long-term precipitation outlooks. As the plains snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made. Plains snowpack in the Basin melted out before April 1 and thus was not factored into this forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the June 1 snowpack. The snowpack typically peaks in mid-April. Mountain snowpack in the Basin melted out in late June and thus was not factored into this forecast.

Figure 8 includes time series plots of the average mountain snow water equivalent (SWE) beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current year's average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

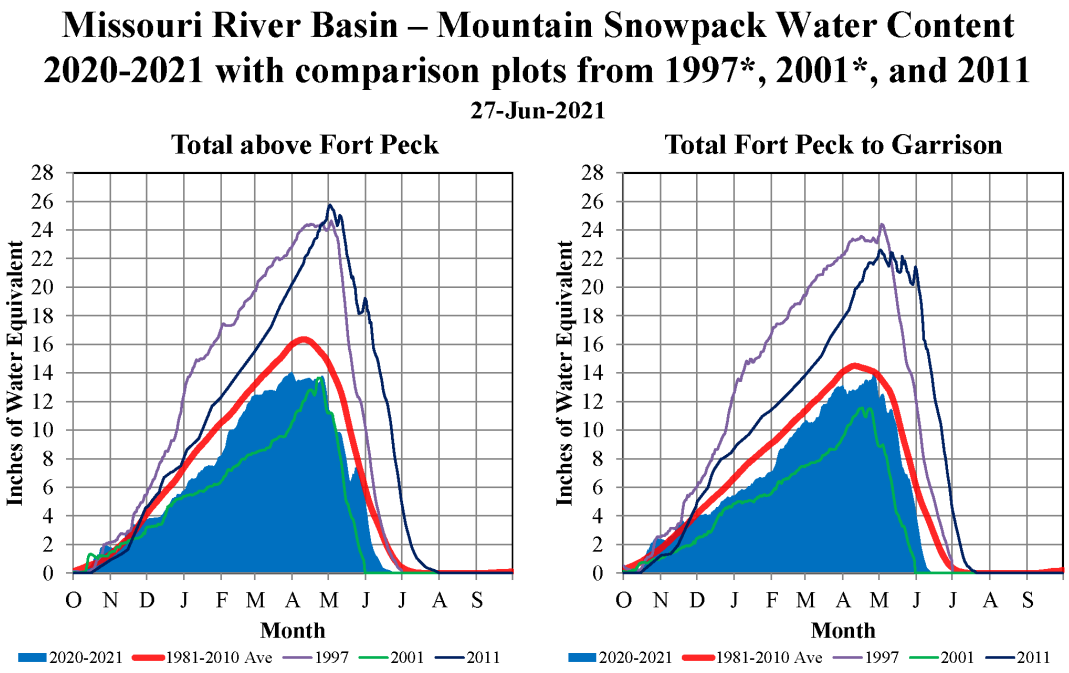


Figure 8. Mountain snowpack water content on June 27, 2021 compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of June 27, 2021, the mountain snowpack in the Fort Peck reach and the Garrison reach had both completely melted. Mountain snowpack in the Fort Peck reach peaked on March 31 at 14.1", which is 86% of the normal peak. Mountain snowpack in the Garrison reach peaked on April 26 at 14.0", which is 96% of the normal peak. Mountain snowpack melted out several weeks earlier than normal, and runoff from that snowmelt had already been realized into Fort Peck and Garrison reservoirs before July 1.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates that ENSO-neutral conditions are present with a La Niña watch in effect. There is a 60% chance that ENSO-neutral conditions will continue through September. La Niña conditions could emerge during the fall and last through the 2021-2022 winter with a 70% chance of La Niña conditions during November through January.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The September CPC outlooks in **Figure 9** indicate equal chances of above-normal, normal, or below-normal temperatures across the entire Basin. Precipitation outlooks indicate equal chances of above-normal, normal, or below-normal precipitation over most of the Basin.

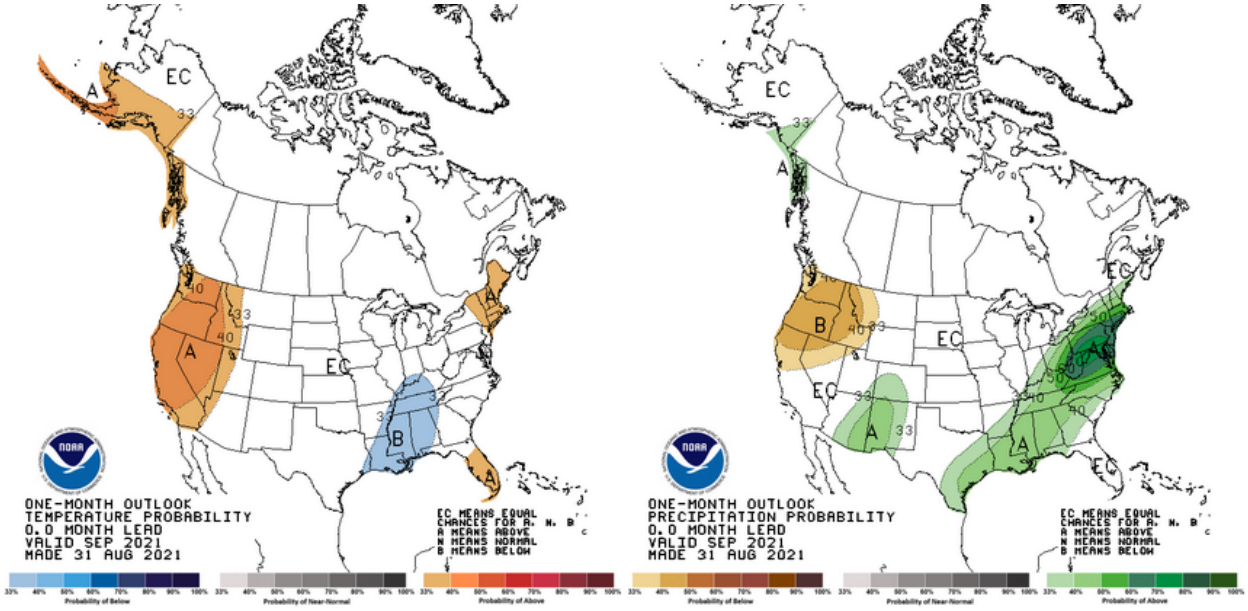


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (September).

Three-month temperature and precipitation outlooks for October-November-December 2021 are shown below in **Figure 10**. During the October-November-December period (**Figure 10**), the CPC indicates increased chances for above-normal temperatures over the lower Basin and below-normal precipitation over most of the Basin, except Montana and North Dakota, which have equal chances for above-normal, normal, and below-normal precipitation.

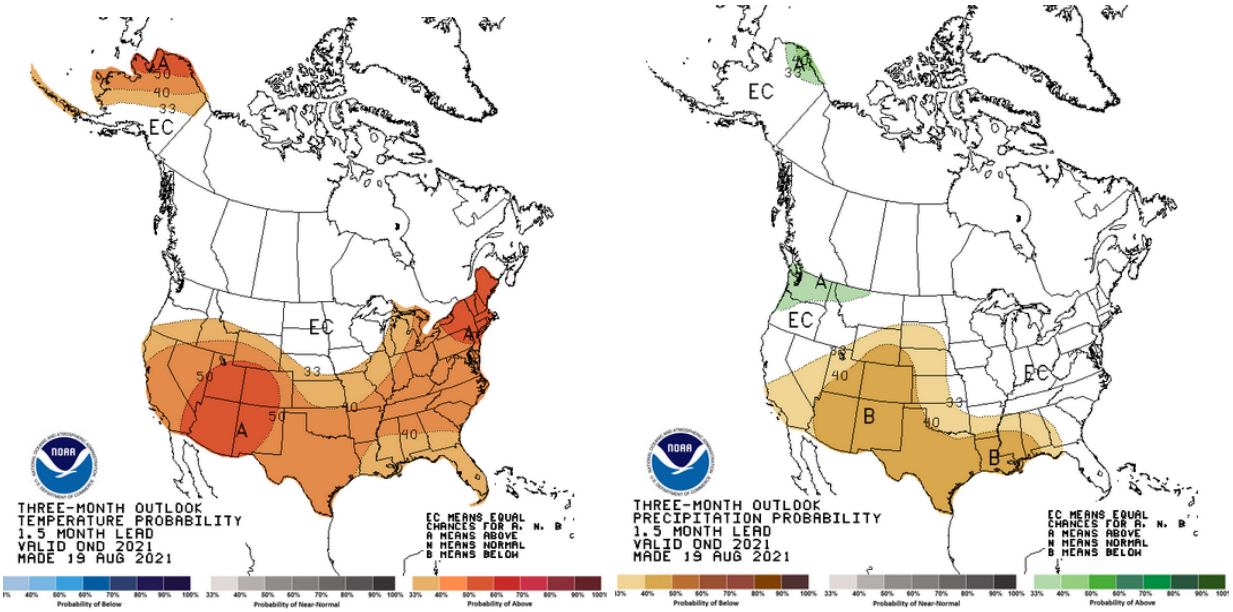


Figure 8. NOAA CPC Three-Month Temperature and Precipitation Outlooks (October-November-December).

Summary

Given the current dry soil conditions and dry climate conditions, we expect runoff to remain below average during the remainder of the calendar year. In summary, the 2021 calendar year runoff forecast is **14.7 MAF, 57% of average**.

Upper Missouri River Basin
October 2021 Calendar Year Runoff Forecast
October 5, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

September runoff was 800,000 acre-feet, 67% of average for the upper Basin. Runoff was well-below average in the upper three reaches (Fort Peck, Garrison, and Oahe), above average in the Fort Randall and Gavins Point reaches, and slightly below average in the Sioux City reach.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Basin (above Sioux City, IA) is **14.8 MAF, 57% of average**. If realized, this runoff amount would be the 10th lowest runoff in 123 years of record-keeping. The 2021 calendar year runoff forecast for the area above Gavins Point is **13.3 MAF**, **57% of average**.

Due to the variability in precipitation and other hydrologic factors that can occur over the next 3 months, expected inflow could range from the 15.3 MAF upper basic forecast to the 14.4 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for September 28, 2021 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 88% of the Basin, with Extreme (D3) or Exceptional (D4) Drought present in 29% of the Basin, mostly in Montana and into the Dakotas. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of December, indicates drought conditions are likely to persist throughout most of the upper Basin, with additional areas of drought likely to develop in Nebraska, Kansas, and Colorado. Some improvement is possible in eastern South Dakota.

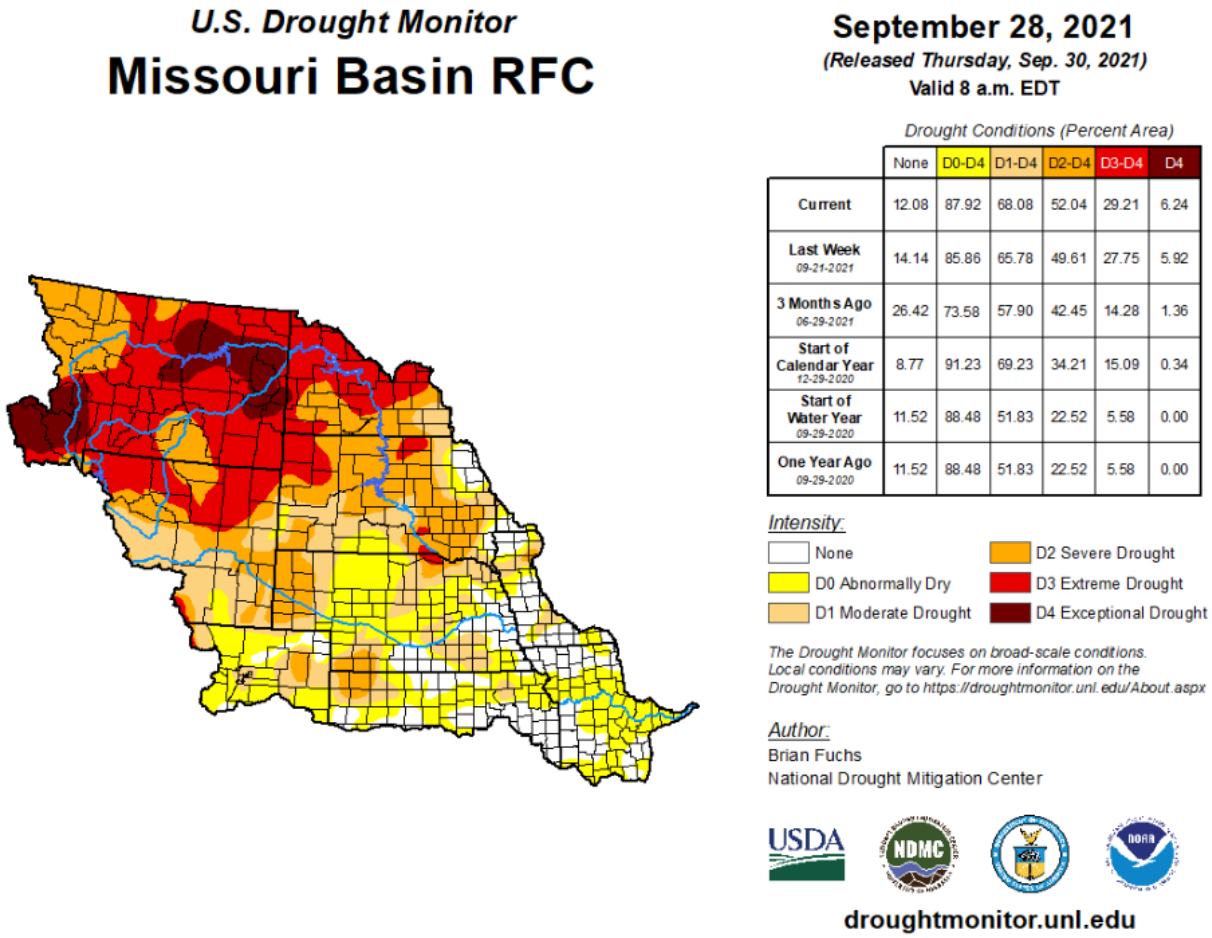


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

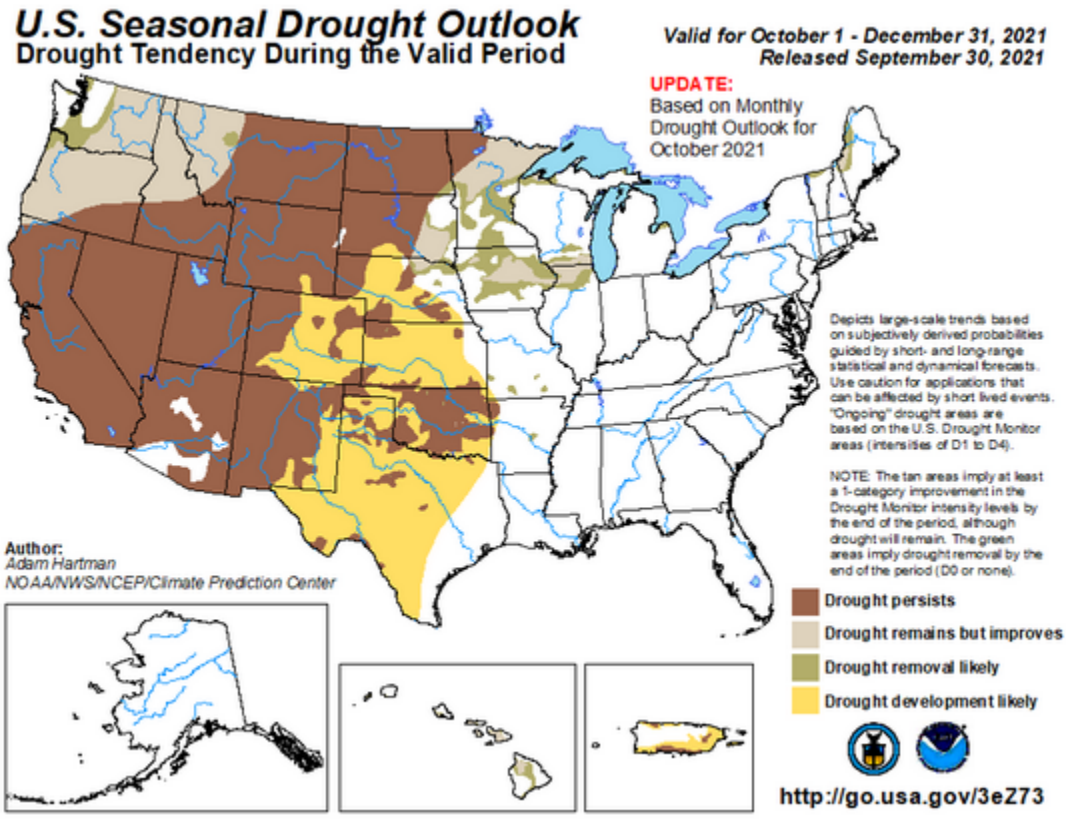


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The September precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. September precipitation was generally below normal over most of the Basin, with areas of above-normal precipitation in central South Dakota, central Nebraska, Kansas, central Wyoming, and eastern Colorado. An area in central Wyoming had over 300 percent of normal precipitation, whereas areas of Montana had below 5 percent of normal precipitation.

Precipitation as a percent of normal for the July-August-September 2021 period was below normal for most of the Basin except for central Wyoming, central and eastern South Dakota, and small areas of Nebraska, Iowa, Kansas and Missouri (**Figure 4**). Much of the Basin experienced less than 70% of its normal precipitation accumulation over the latest 3-month period.

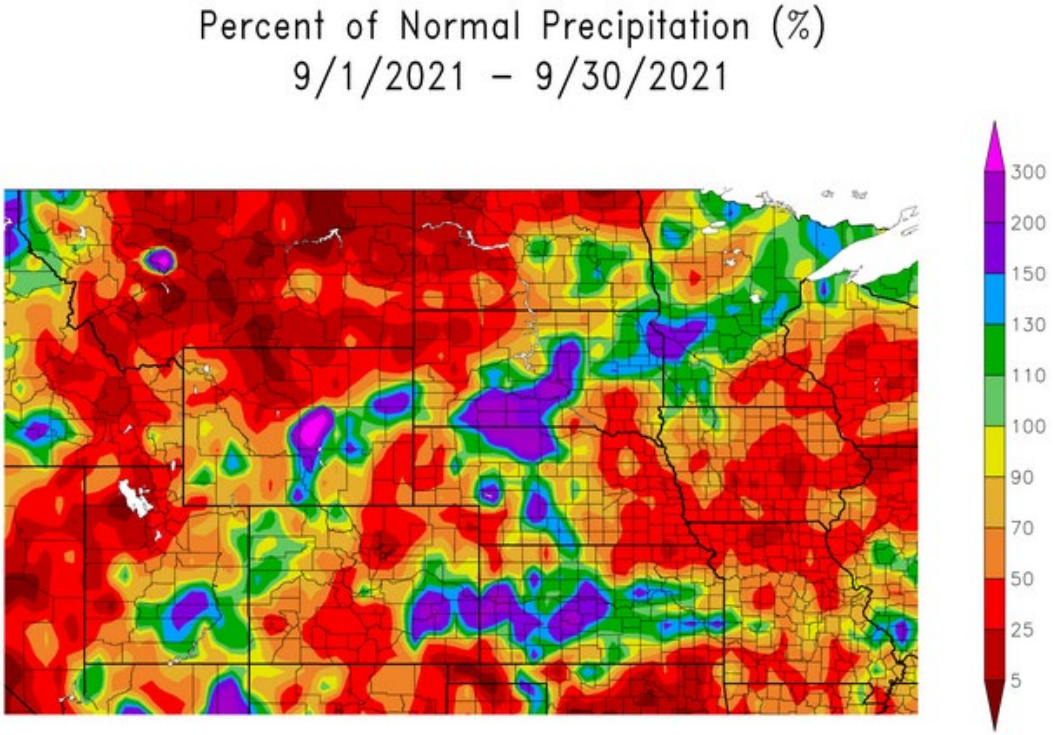


Figure 3. HPRCC September 2021 Percent of Normal Precipitation.

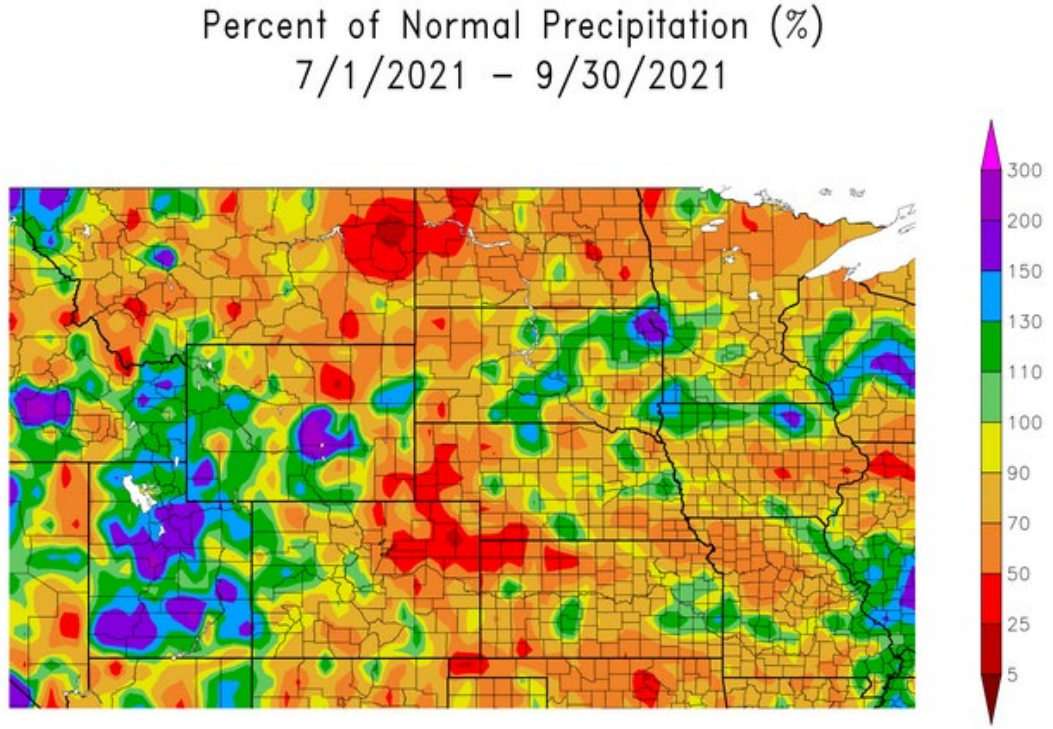


Figure 4. HPRCC July-August-September 2021 Percent of Normal Precipitation.

Temperature

September temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate that temperatures were 1 to greater than 5 degrees above normal over the entire Basin. July-August-September 2021 temperature departures are shown in **Figure 6**. The three-month average departures were above normal for the entire Basin, with areas of 4 to 10 degrees above normal temperatures in Montana, North Dakota, and South Dakota.

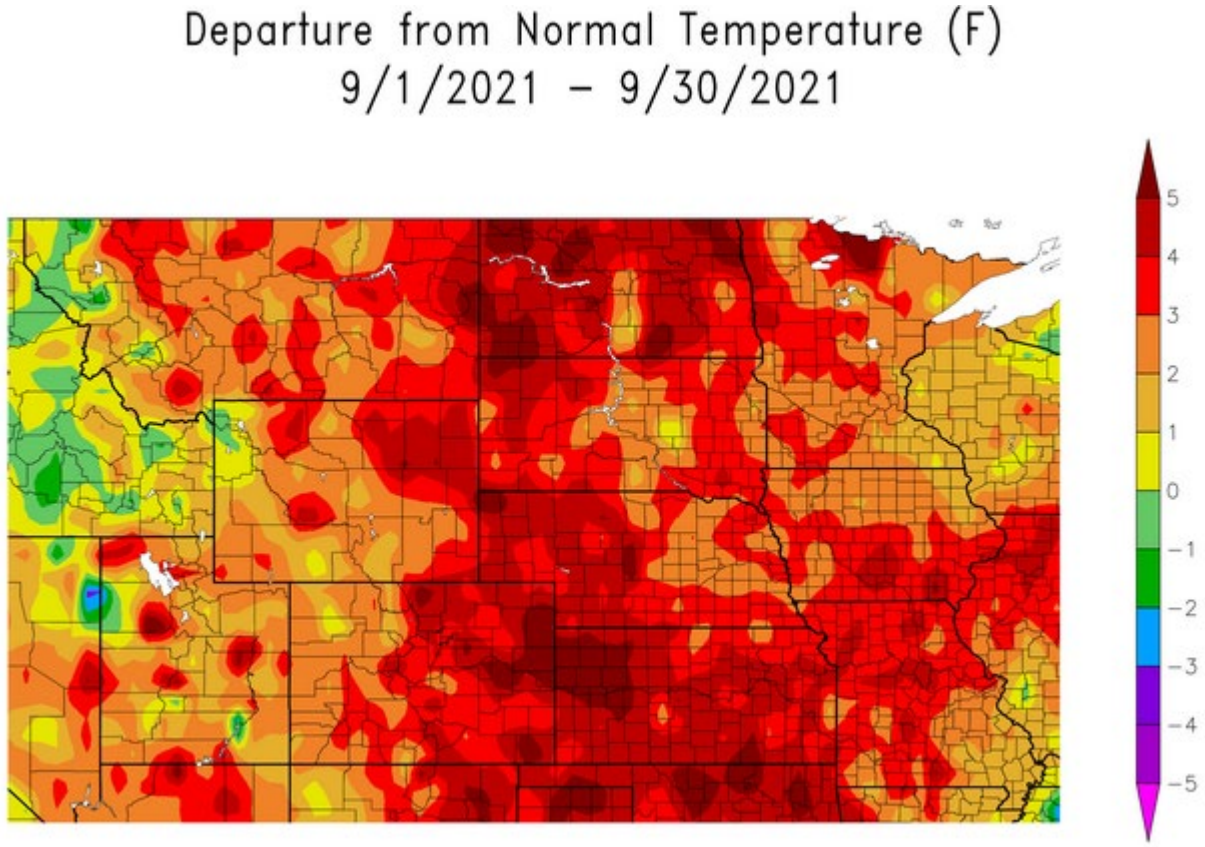


Figure 5. HPRCC September 2021 Departure from Normal Temperature.

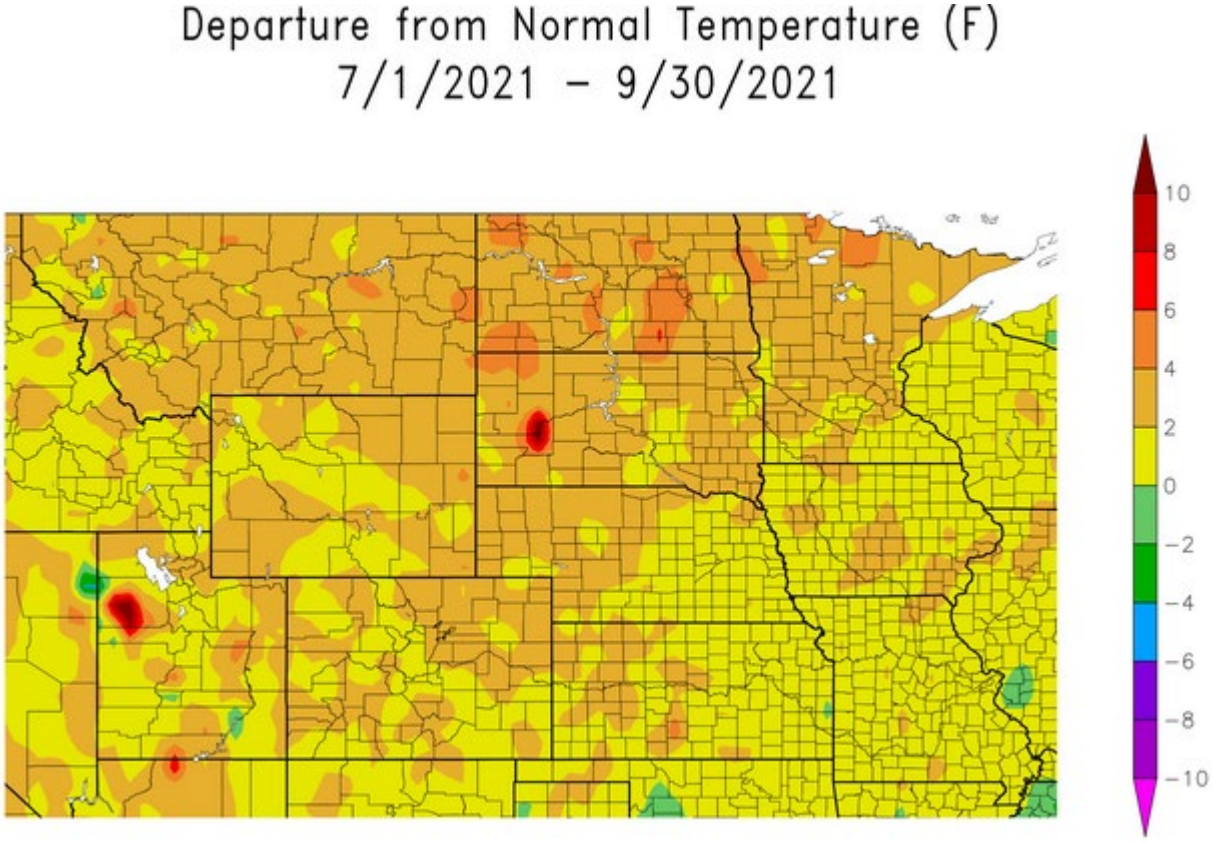


Figure 6. HPRCC July-August-September 2021 Departure from Normal Temperature.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the end of September 2021 is drier than normal across the upper Basin and much of the lower Basin, with some areas of about normal soil moisture in the lower Basin. Soil moisture ranks in the lowest to 5th lowest percentile for a large portion of the upper Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**.

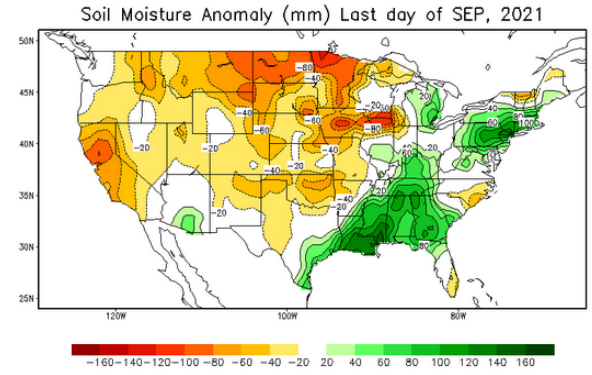
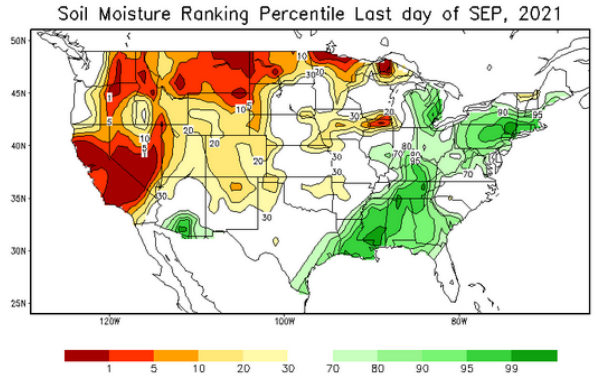
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
	

Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which primarily includes long-term precipitation outlooks. As the plains snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack in the Basin melted out before April 1 and thus was not factored into this forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the June 1 snowpack. The snowpack typically peaks in mid-April. Mountain snowpack in the Basin melted out in late June and thus was not factored into this forecast.

Figure 8 includes time series plots of the average mountain snow water equivalent (SWE) beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current year's average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

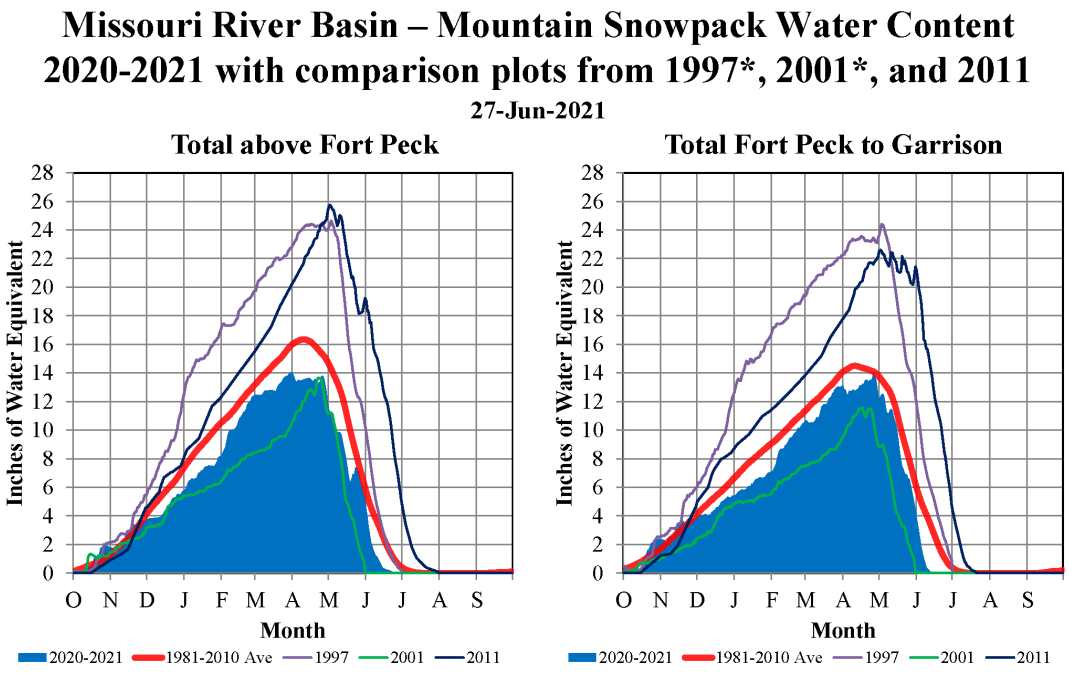


Figure 8. Mountain snowpack water content on June 27, 2021 compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of June 27, 2021, the mountain snowpack in the Fort Peck reach and the Garrison reach had both completely melted. Mountain snowpack in the Fort Peck reach peaked on March 31 at 14.1", which is 86% of the normal peak. Mountain snowpack in the Garrison reach peaked on April 26 at 14.0", which is 96% of the normal peak. Mountain snowpack melted out several weeks earlier than normal, and runoff from that snowmelt had already been realized into Fort Peck and Garrison reservoirs before July 1.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates that ENSO-neutral conditions are present, with La Niña conditions expected to develop in the next couple months. There is a 70-80% chance of La Niña conditions during the 2021-2022 winter.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The October CPC outlooks in **Figure 9** indicate increased chances of above-normal temperatures across the entire Basin. The precipitation outlook indicates equal chances of above-normal, normal, or below-normal precipitation in Montana, Wyoming, and western Colorado, with increased chances of above-normal precipitation across the rest of the Basin.

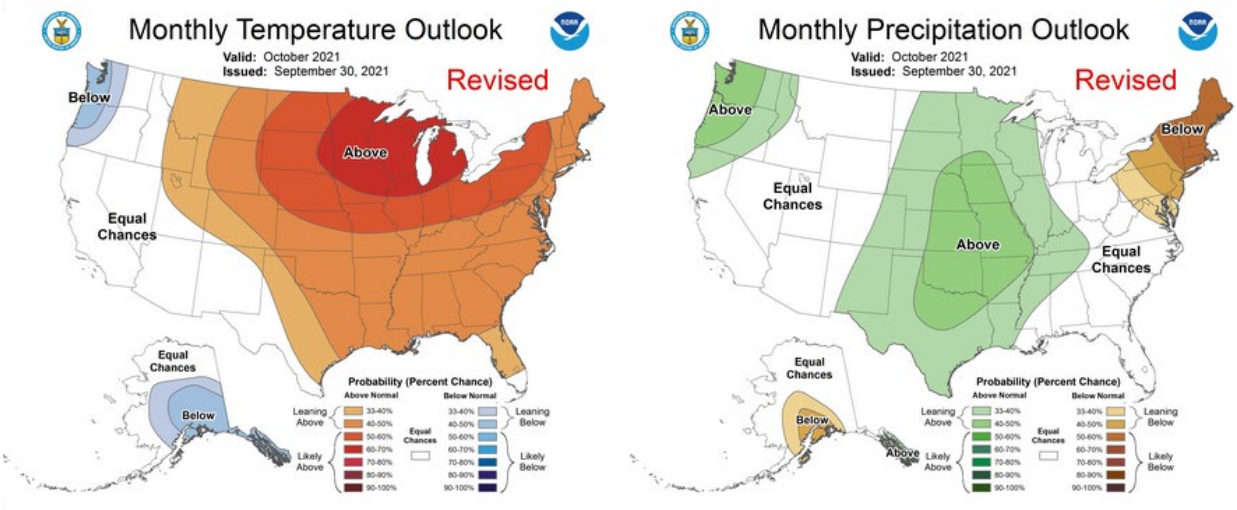


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (October).

Three-month temperature and precipitation outlooks for October-November-December 2021 are shown in **Figure 10**. During the October-November-December period (**Figure 10**), the CPC indicates increased chances for above-normal temperatures over Wyoming, Colorado, Kansas, and Missouri, with equal chances in Montana, North Dakota, South Dakota, Nebraska, and Iowa. The three-month precipitation outlook indicates increased chances for below-normal precipitation over most of the Basin, except Montana, North Dakota, Iowa, and Missouri, which have equal chances for above-normal, normal, and below-normal precipitation.

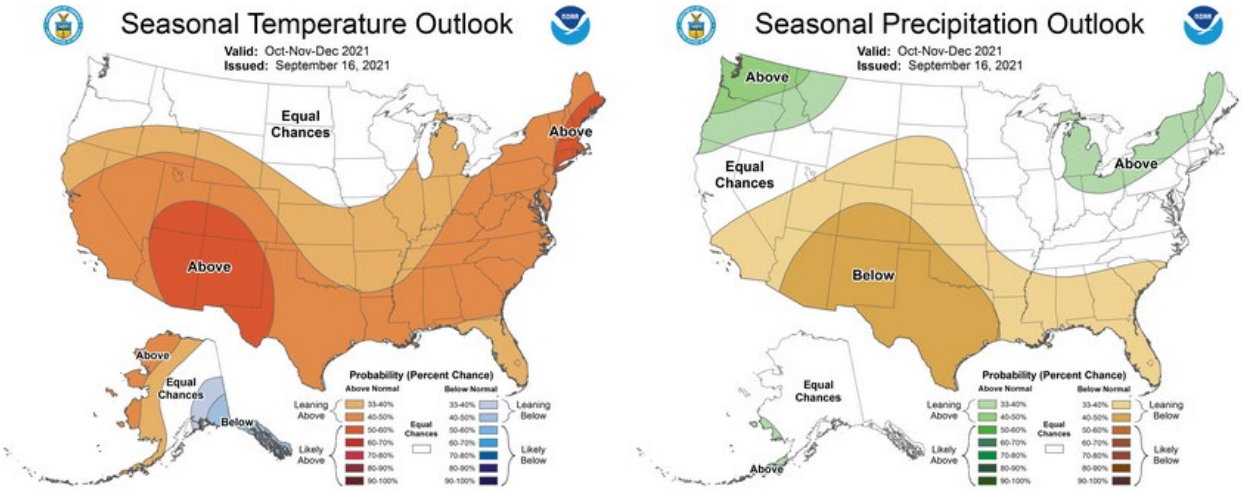


Figure 8. NOAA CPC Three-Month Temperature and Precipitation Outlooks (October-November-December).

Summary

Given the current dry soil conditions and climate conditions, we expect runoff to remain below average during the remainder of the calendar year. In summary, the 2021 calendar year runoff forecast is **14.8 MAF, 57% of average**.

Upper Missouri River Basin
November 2021 Calendar Year Runoff Forecast
November 3, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

Observed October runoff was 900,000 acre-feet, which is 75% of average and 150,000 acre-feet more than forecasted for October. Runoff was below average in all reaches except Oahe and Gavins Point.

2021 Calendar Year Forecast Synopsis

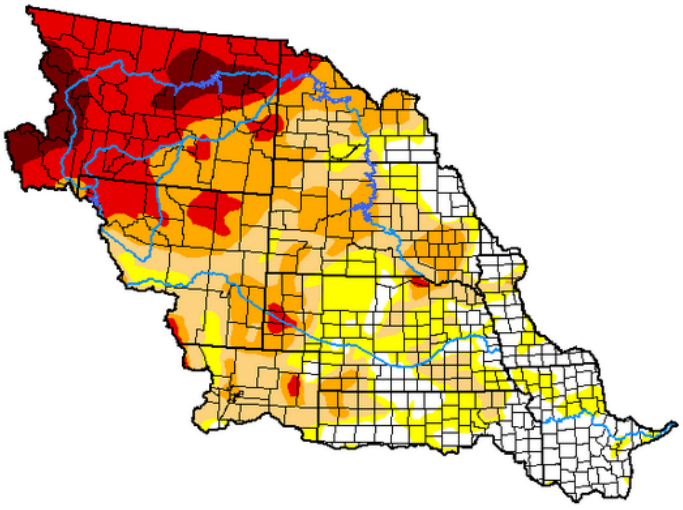
The 2021 calendar year runoff forecast for the upper Basin (above Sioux City, IA) is **15.0 MAF, 58% of average**. If realized, this runoff amount would be the 10th lowest runoff in 123 years of record-keeping. The 2021 calendar year runoff forecast for the area above Gavins Point is **13.6 MAF**, **58% of average**.

Due to the variability in precipitation and other hydrologic factors that can occur over the next 2 months, expected inflow could range from the 15.4 MAF upper basic forecast to the 14.8 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for October 26, 2021 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 82% of the Basin, with Extreme (D3) or Exceptional (D4) Drought present in 23% of the Basin, mostly in Montana and the Dakotas. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of January, indicates drought conditions are likely to persist throughout most of the upper Basin, with additional areas of drought likely to develop in Kansas and Colorado. Some improvement is possible in Montana.



U.S. Drought Monitor

Missouri Basin RFC

October 26, 2021

(Released Thursday, Oct. 28, 2021)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	18.24	81.76	65.63	44.72	23.19	5.44
Last Week 10-19-2021	16.69	83.31	65.84	44.11	26.44	5.07
3 Months Ago 07-27-2021	23.85	76.15	63.20	47.19	24.46	2.12
Start of Calendar Year 12-29-2020	8.77	91.23	69.23	34.21	15.09	0.34
Start of Water Year 09-28-2021	12.08	87.92	68.08	52.04	29.21	6.24
One Year Ago 10-27-2020	4.19	95.81	61.51	32.48	11.06	0.25

Intensity:

None
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:
Richard Heim
NCEI/NOAA

droughtmonitor.unl.edu

Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

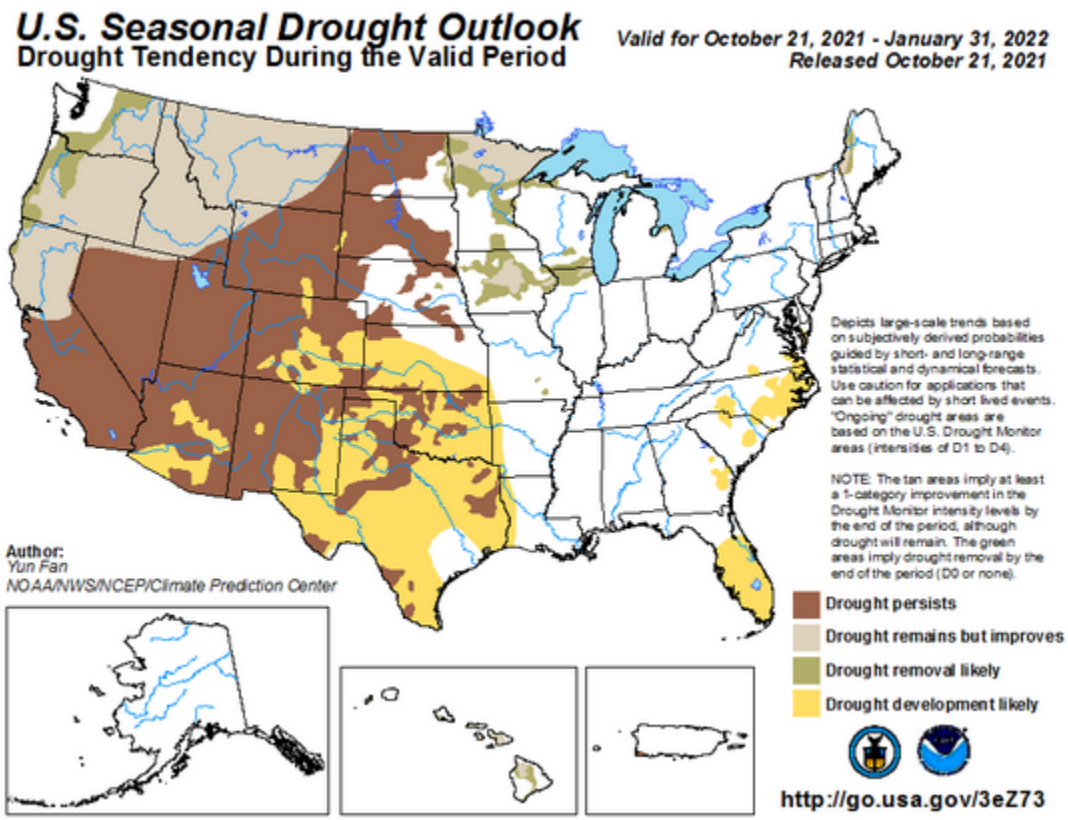


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The October precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. October precipitation was varied across the basin. Areas in Wyoming, North Dakota, South Dakota, Iowa, and Missouri received well-above-normal precipitation, while areas in Montana, Colorado, western Nebraska, and western Kansas received well-below-normal precipitation.

Precipitation as a percent of normal for the August-September-October 2021 period followed a similar pattern to October (**Figure 4**), but not as extreme, with most of the basin falling in the 50% to 150% of normal range. Exceptions were northeastern Colorado, which was 25-50% of normal, and areas of the Dakota, which were 150-300% of normal.

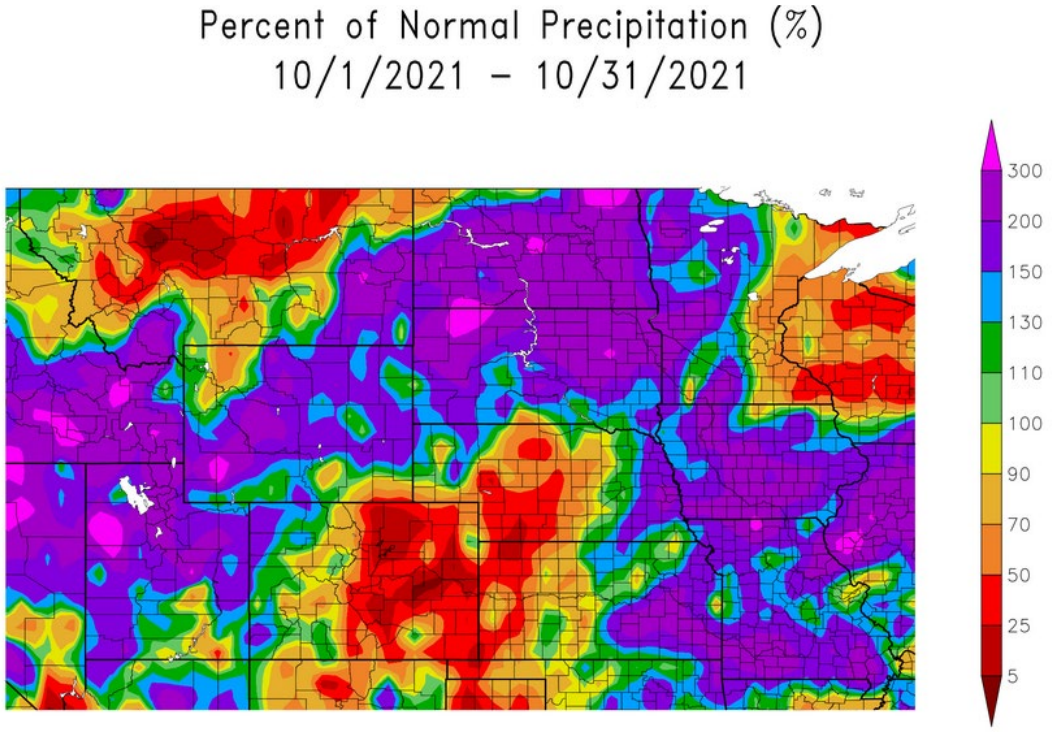


Figure 3. HPRCC October 2021 Percent of Normal Precipitation.

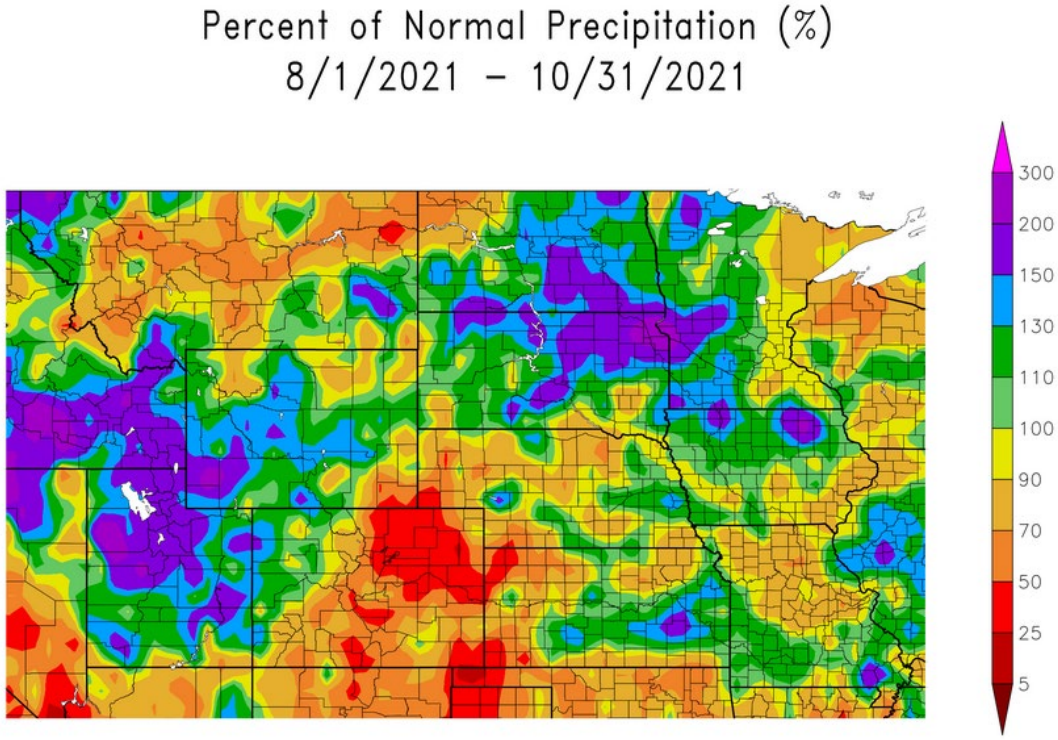


Figure 4. HPRCC August-September-October 2021 Percent of Normal Precipitation.

Temperature

October temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate that temperatures were normal to 8 degrees above normal over the entire Basin. August-September-October 2021 temperature departures are shown in **Figure 6**. The three-month average departures were above normal for the entire Basin, with large areas of 4 to 6 degrees above normal temperatures in North Dakota and South Dakota.

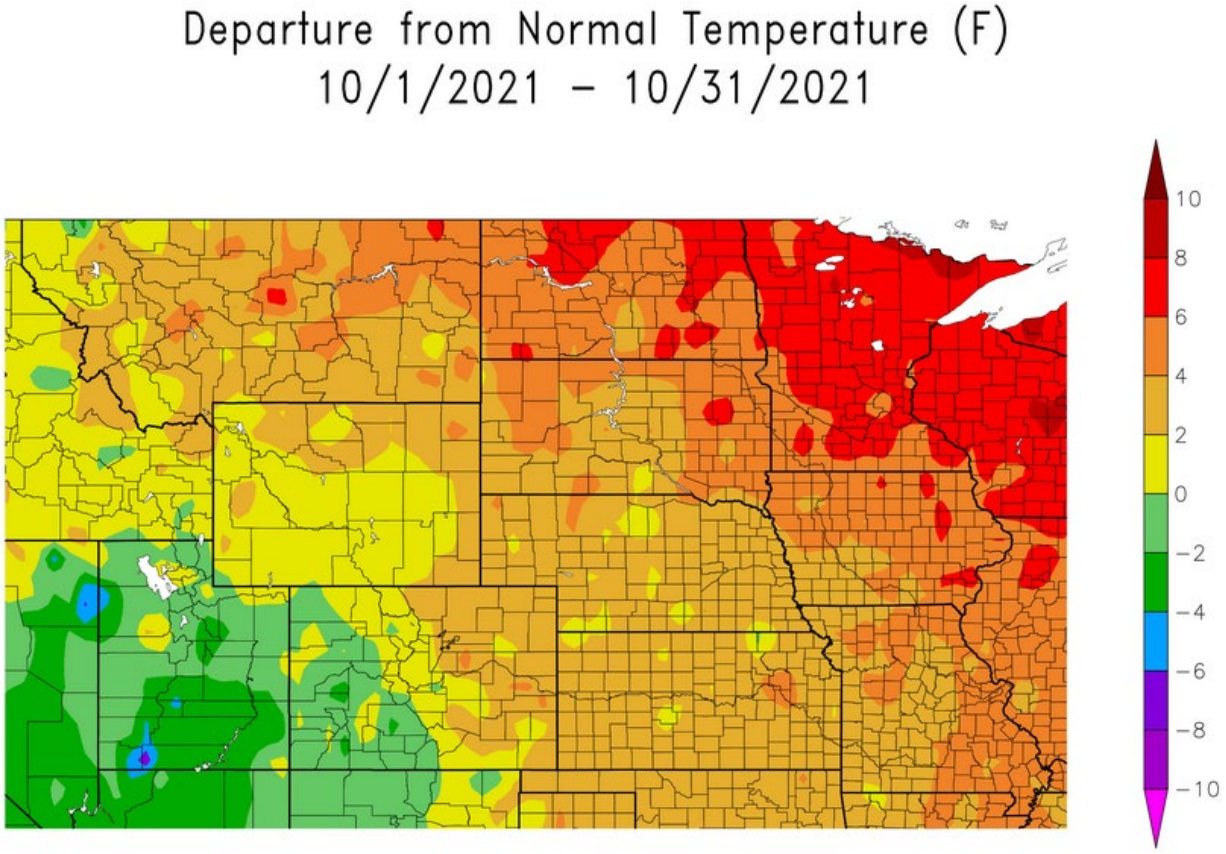


Figure 5. HPRCC October 2021 Departure from Normal Temperature.

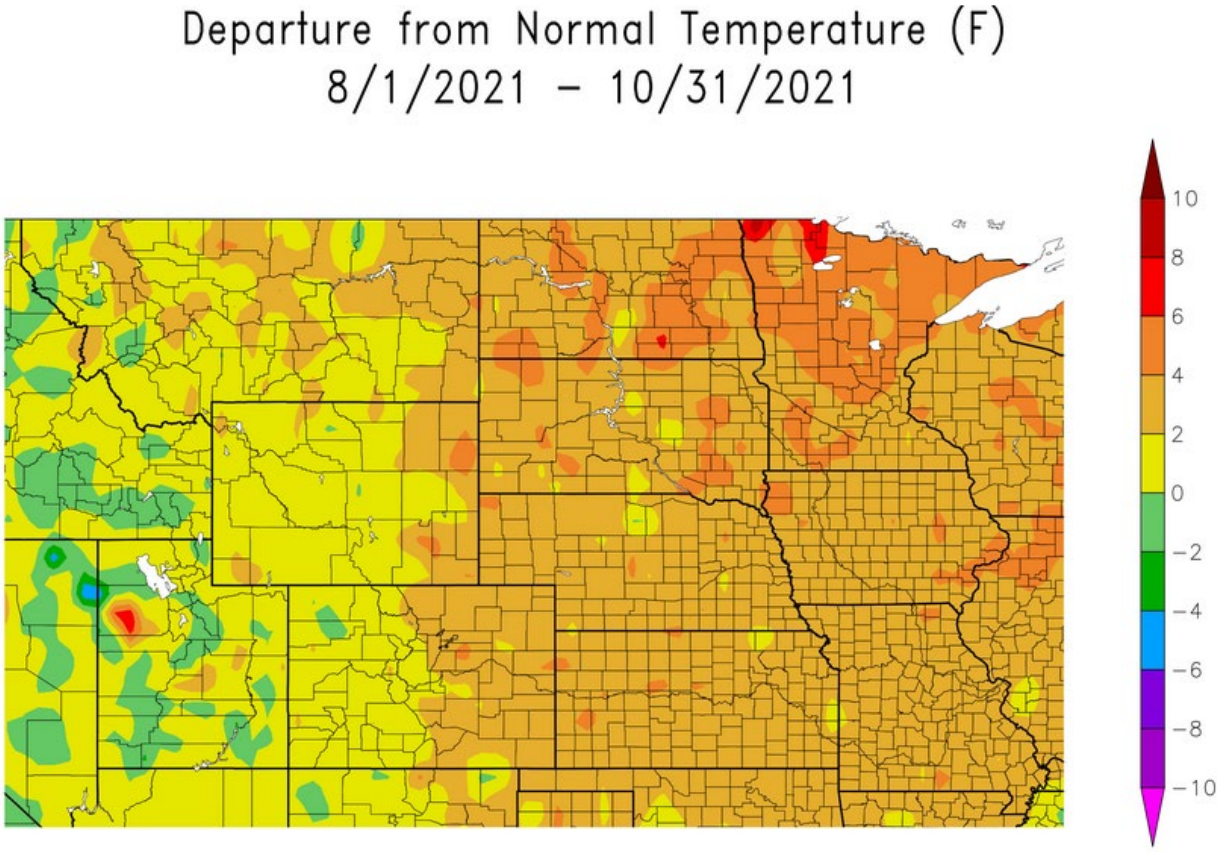


Figure 6. HPRCC August-September-October 2021 Departure from Normal Temperature.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the end of October 2021 is drier than normal across Montana, North Dakota, Wyoming, and Colorado. Soil moisture ranks in the lowest to 5th lowest percentile for most of Montana. Soil moisture is above normal for most of South Dakota, and near normal for the rest of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**.

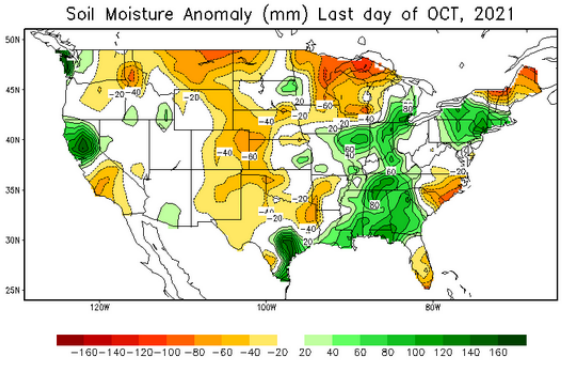
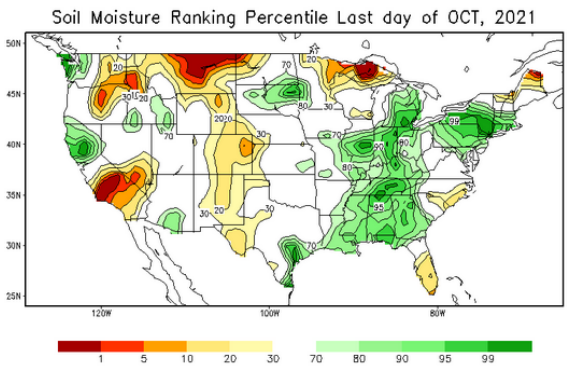
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
	

Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which primarily includes long-term precipitation outlooks. As the plains snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack in the Basin melted out before April 1 and thus was not factored into this forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the June 1 snowpack. The snowpack typically peaks in mid-April. Mountain snowpack in the Basin melted out in late June and thus was not factored into this forecast.

Figure 8 includes time series plots of the average mountain snow water equivalent (SWE) beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current year's average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

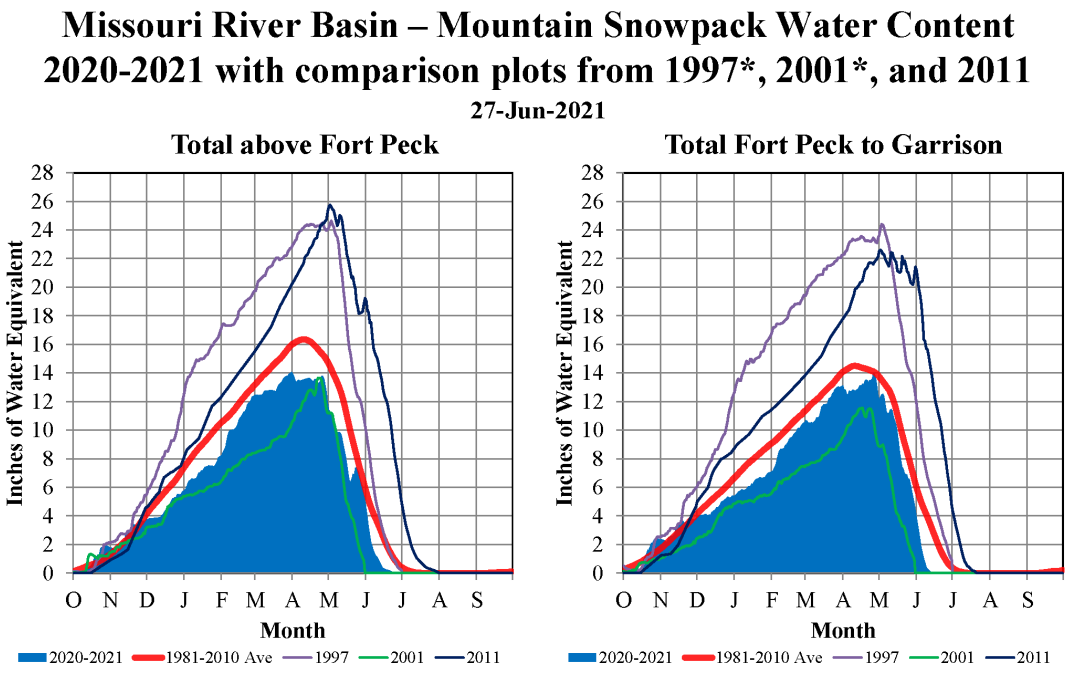


Figure 8. Mountain snowpack water content on June 27, 2021 compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of June 27, 2021, the mountain snowpack in the Fort Peck reach and the Garrison reach had both completely melted. Mountain snowpack in the Fort Peck reach peaked on March 31 at 14.1", which is 86% of the normal peak. Mountain snowpack in the Garrison reach peaked on April 26 at 14.0", which is 96% of the normal peak. Mountain snowpack melted out several weeks earlier than normal, and runoff from that snowmelt had already been realized into Fort Peck and Garrison reservoirs before July 1.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates that La Niña conditions have developed and have an 87% chance of continuing into February 2022.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The November CPC outlooks in **Figure 9** indicate increased chances of above-normal temperatures across the southwestern portion of the Basin, with equal chances elsewhere. The precipitation outlook indicates increased chances for above-normal precipitation in Montana and Wyoming, with equal chances of above-normal, normal, or below-normal precipitation across the rest of the Basin.

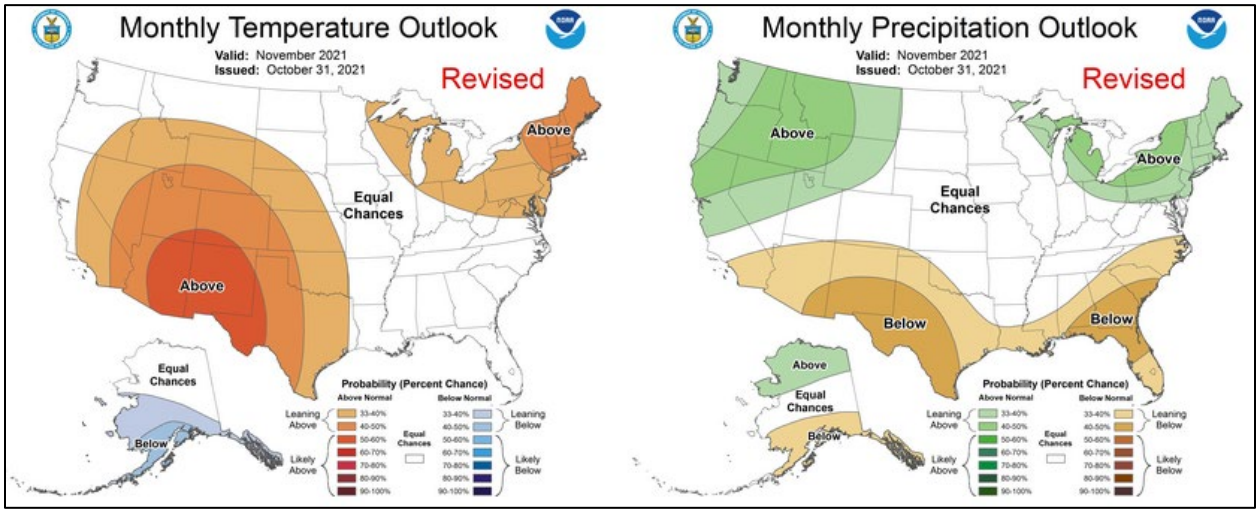


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (November).

Three-month temperature and precipitation outlooks for November-December 2021-January 2022 are shown in **Figure 10**. The CPC indicates increased chances for above-normal temperatures over Wyoming, Colorado, Nebraska, Kansas, Missouri, and Iowa, with equal chances in Montana, North Dakota, and South Dakota. The three-month precipitation outlook indicates equal chances over most of the Basin, except for Montana and northwestern Wyoming, which have increased chances for above-normal precipitation.

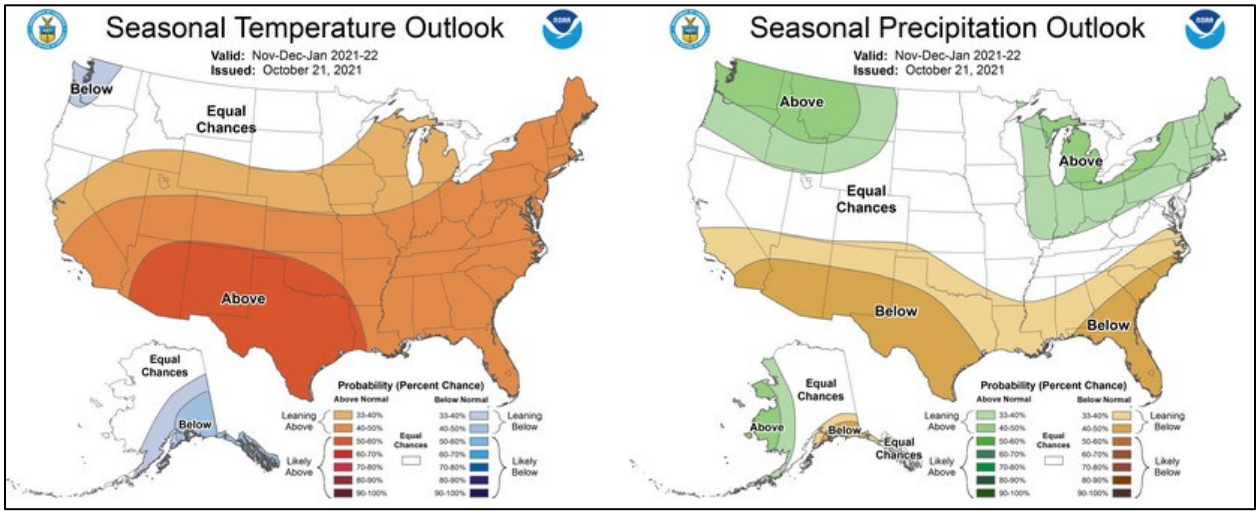


Figure 8. NOAA CPC Three-Month Temperature and Precipitation Outlooks (November-December 2021-January 2022).

Summary

Given the current dry soil conditions and climate conditions, we expect runoff to remain below average during the remainder of the calendar year. In summary, the 2021 calendar year runoff forecast is **15.0 MAF, 58% of average**.

Upper Missouri River Basin
December 2021 Calendar Year Runoff Forecast
December 3, 2021

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri Basin above Sioux City (upper Basin). The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

Observed November runoff was 700,000 acre-feet, which is 66% of average and 50,000 acre-feet less than forecasted for November. Runoff was below average in all reaches except Gavins Point and Sioux City.

2021 Calendar Year Forecast Synopsis

The 2021 calendar year runoff forecast for the upper Basin (above Sioux City, IA) is **15.0 MAF, 58% of average**. If realized, this runoff amount would be the 10th lowest runoff in 123 years of record-keeping. The 2021 calendar year runoff forecast for the area above Gavins Point is **13.5 MAF**, **58% of average**.

Due to the variability in precipitation and other hydrologic factors that can occur over the next month, expected inflow could range from the 15.2 MAF upper basic forecast to the 14.9 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for October 26, 2021 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 80% of the Basin, with Extreme (D3) or Exceptional (D4) Drought present in 24% of the Basin, mostly in Montana. The Monthly Drought Outlook in **Figure 2**, which extends through the end of the year, indicates drought conditions are likely to persist throughout most of the Upper Basin, with some improvement possible in western Montana and western Wyoming.

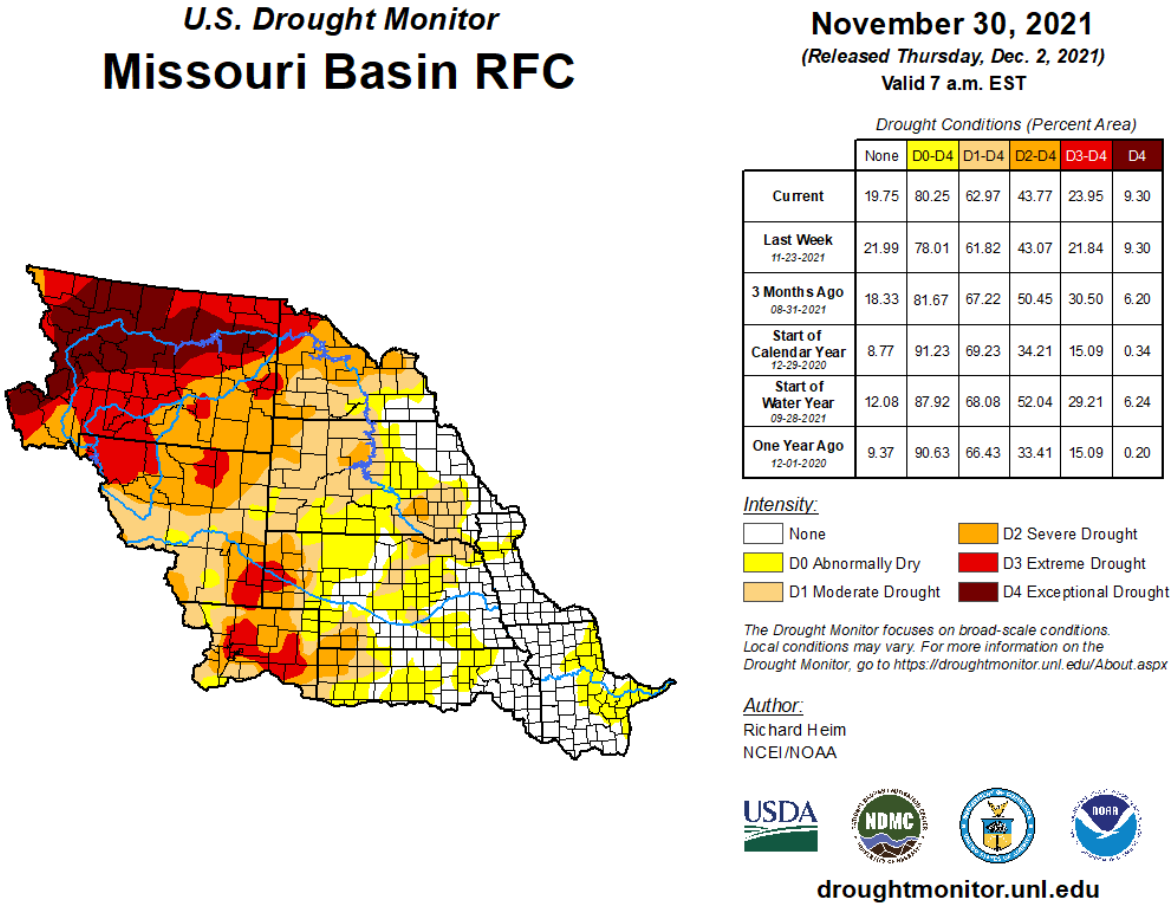


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

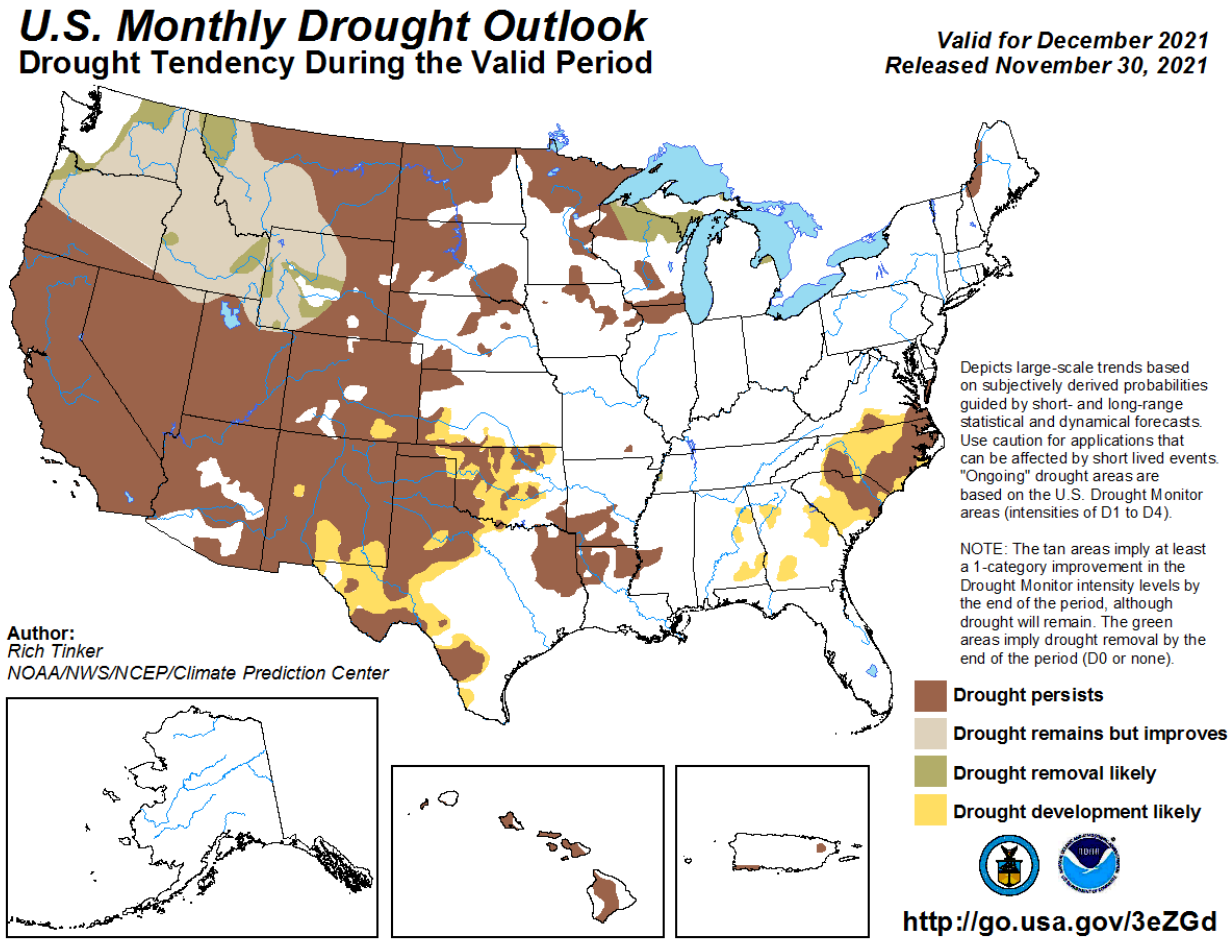


Figure 2. National Drought Mitigation Center U.S. Drought Monthly Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The November precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. November precipitation was 5% to 50% of normal over most of the Basin, except for a small area of slightly above average precipitation in central North Dakota.

Precipitation as a percent of normal for the September-October-November 2021 period was varied (**Figure 4**). Most of the Dakotas, parts of Wyoming, and parts of Kansas saw above average precipitation, while the rest of the basin saw below average precipitation.

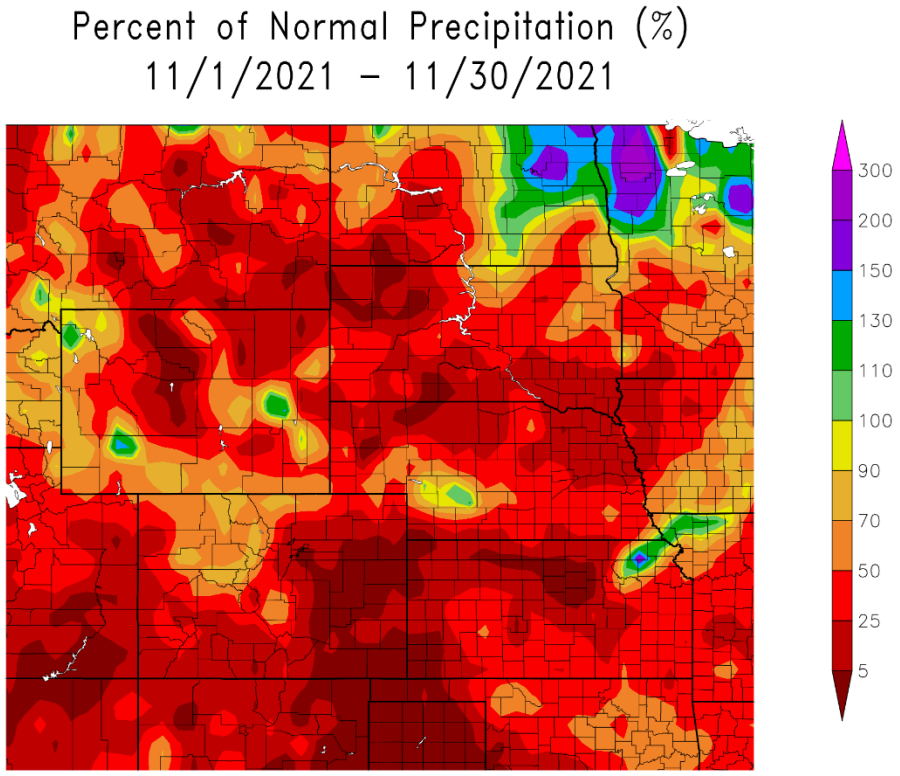


Figure 3. HPRCC November 2021 Percent of Normal Precipitation.

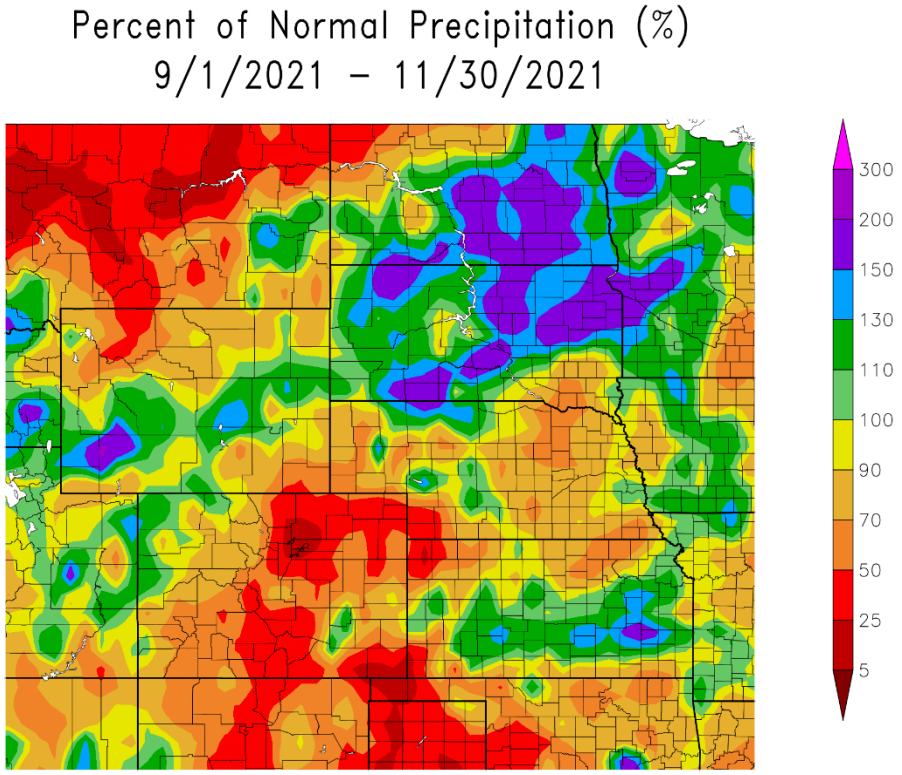


Figure 4. HPRCC September-October-November 2021 Percent of Normal Precipitation.

Temperature

November temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate that temperatures were 2 to 8 deg F above normal throughout the entire basin. September-October-November 2021 temperature departures are shown in **Figure 6**. The three-month average departures were 2 to 6 deg F above normal for the entire Basin.

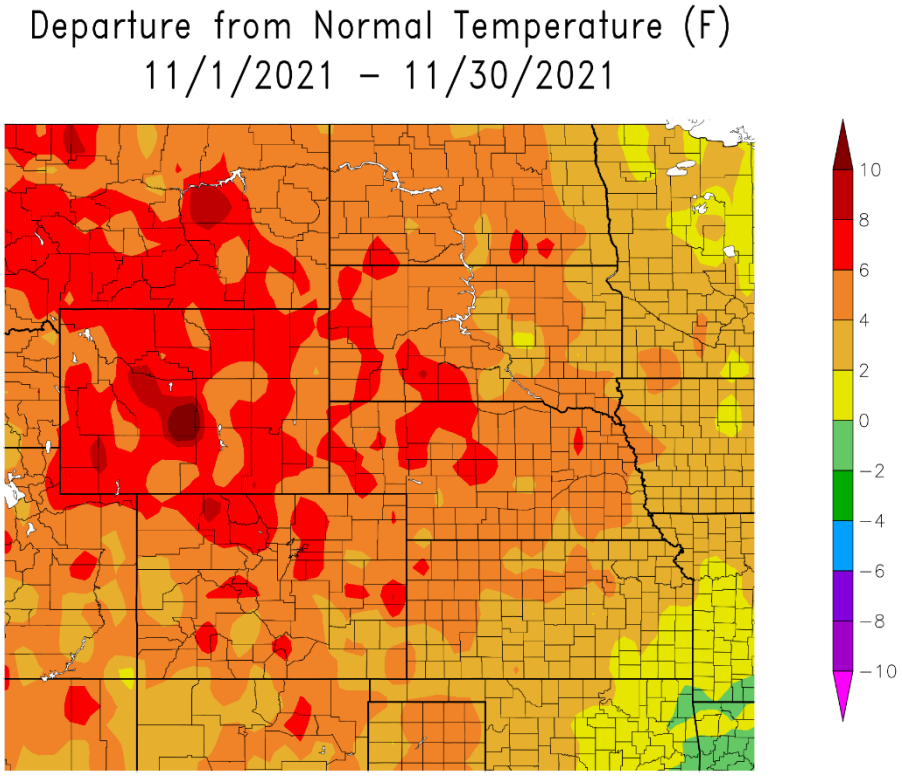


Figure 5. HPRCC November 2021 Departure from Normal Temperature.

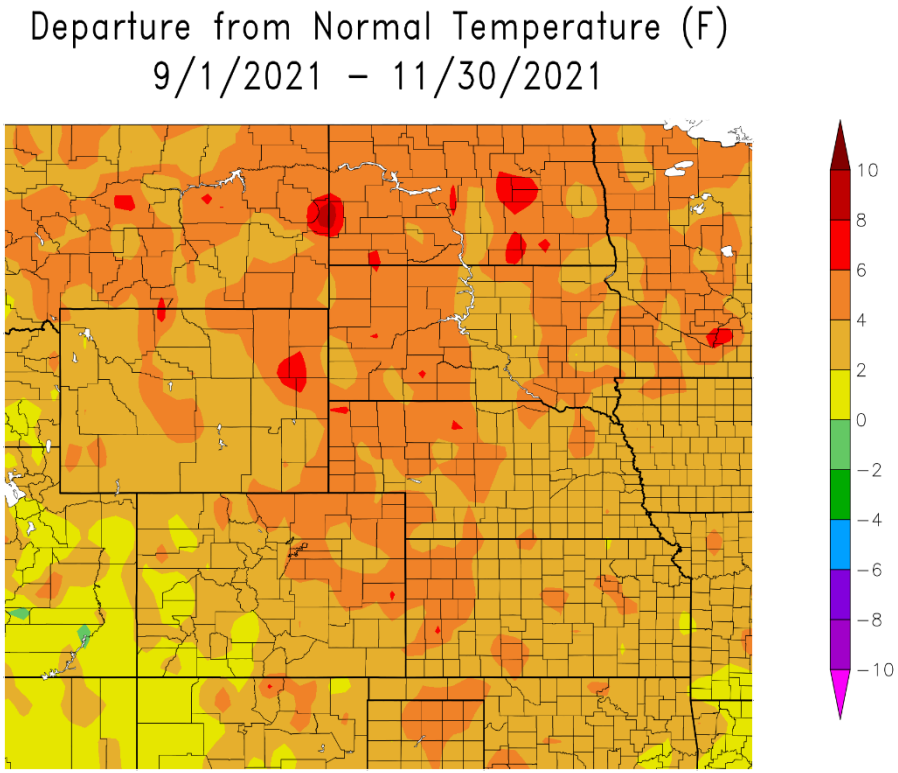


Figure 6. HPRCC September-October-November 2021 Departure from Normal Temperature.

Soil Moisture

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically, when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture at the end of November 2021 is drier than normal across Montana, Wyoming, Colorado, and western Nebraska and Kansas. Soil moisture ranks in the lowest to 5th lowest percentile for a large area in eastern Montana. Soil moisture is above normal for a small portion of northeast South Dakota, and near normal for the rest of the Basin. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**.

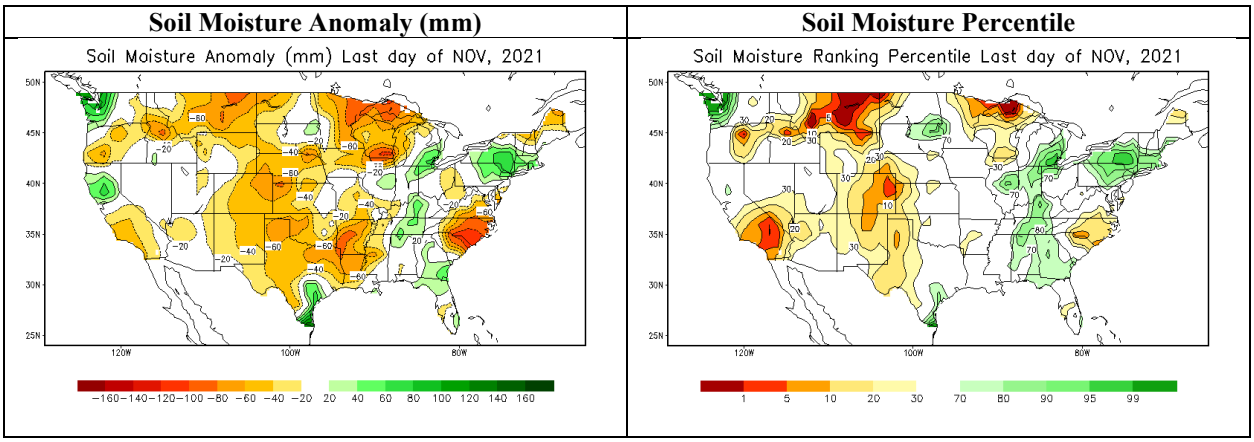


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the Basin during the months of March and April. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which primarily includes long-term precipitation outlooks. As the plains snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack in the Basin melted out before April 1 and thus was not factored into this forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has good correlation to the June 1 snowpack. The snowpack typically peaks in mid-April. Mountain snowpack in the Basin melted out in late June and thus was not factored into this forecast.

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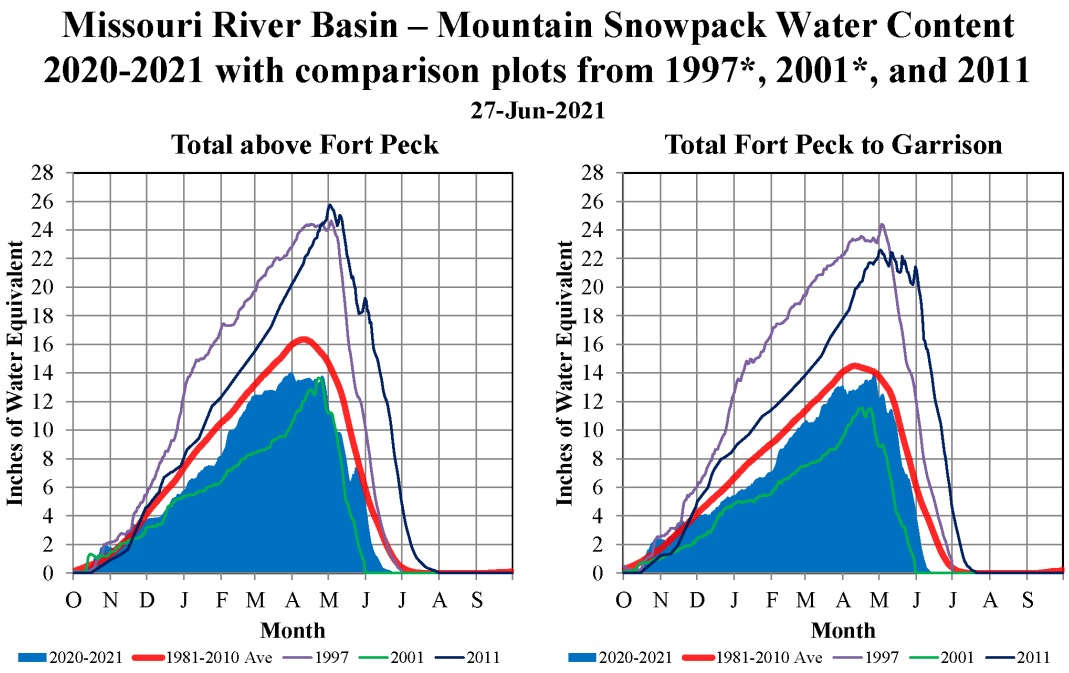

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The latest ENSO Outlook indicates that La Niña conditions are present and have a 90% chance of continuing through February 2022. There is a 50% chance of La Niña conditions continuing through May 2022.

Temperature and Precipitation Outlooks

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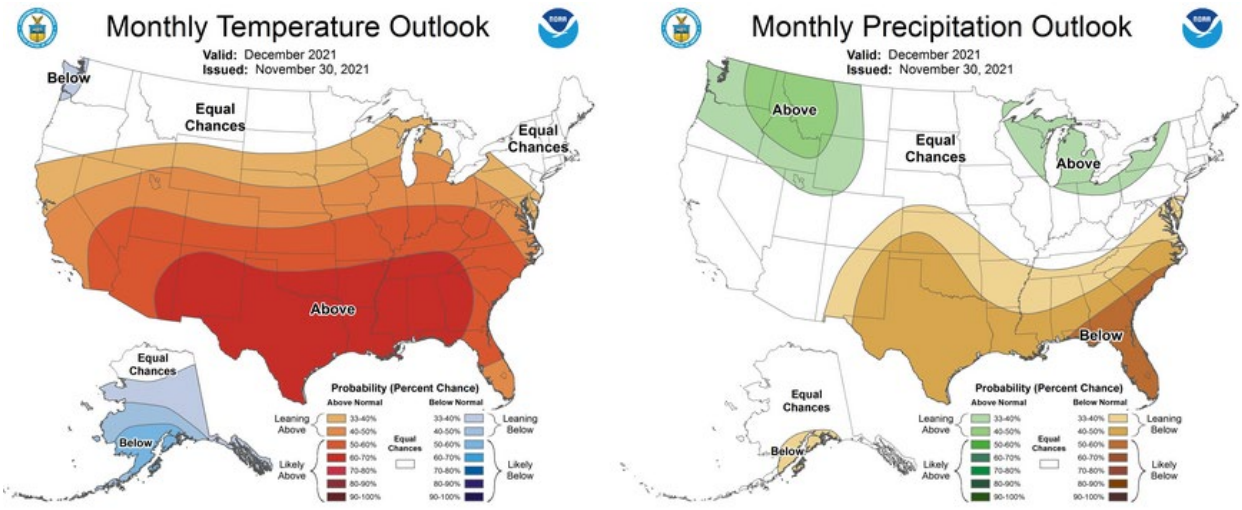
The December CPC precipitation outlook in **Figure 9** show increased chances for above-normal precipitation in Montana and Wyoming and increased chances for below-normal precipitation in Kansas. Equal chances for above-normal, normal, or below-normal precipitation are possible in the remainder of the Basin. The December temperature outlook shows equal chances for above-normal, normal, or below-normal temperatures in Montana, North Dakota, and northern South Dakota, with increased chances for above-normal temperatures elsewhere.



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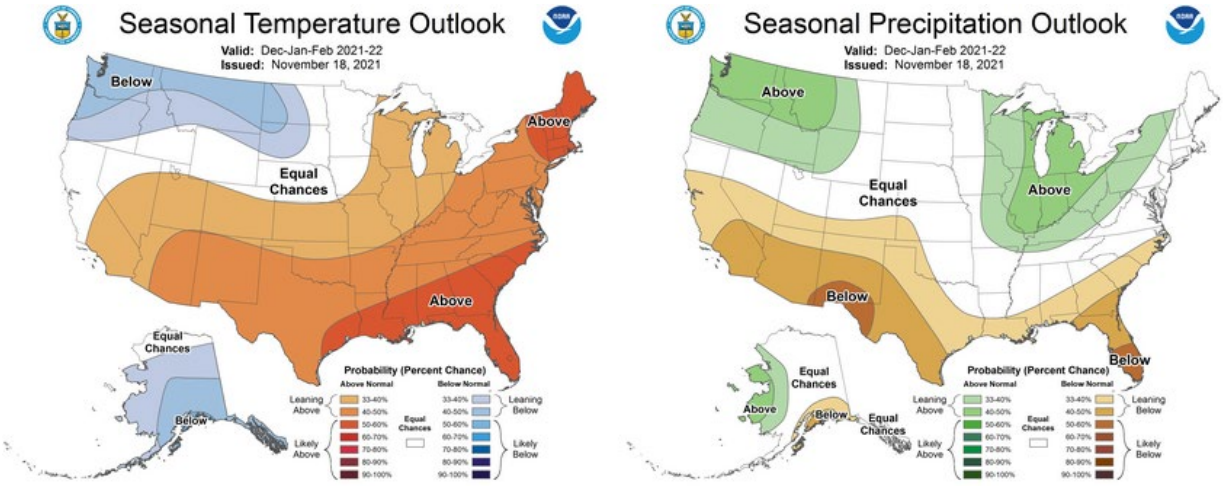

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