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.

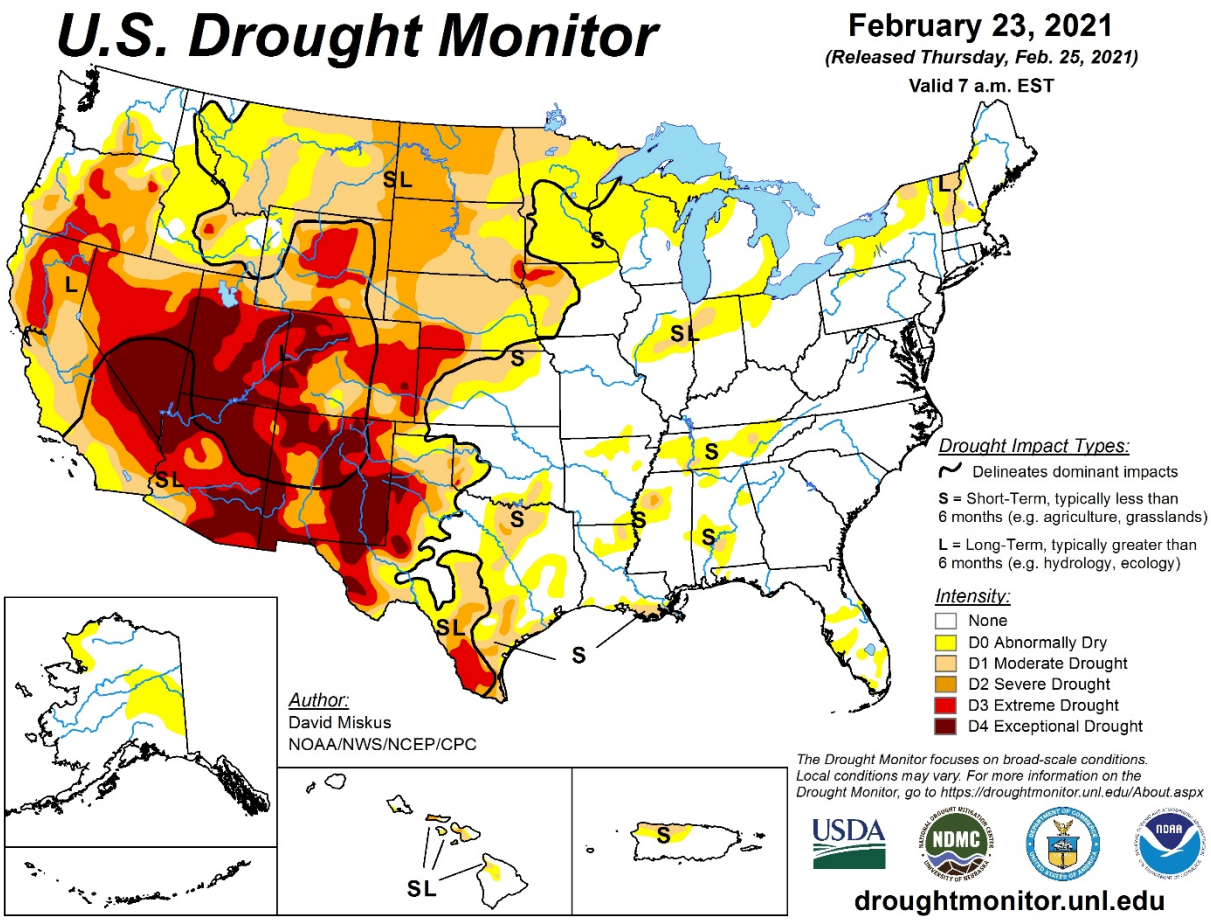

Figure 1. National Drought Mitigation Center U.S. Drought Monitor for February 23, 2021.

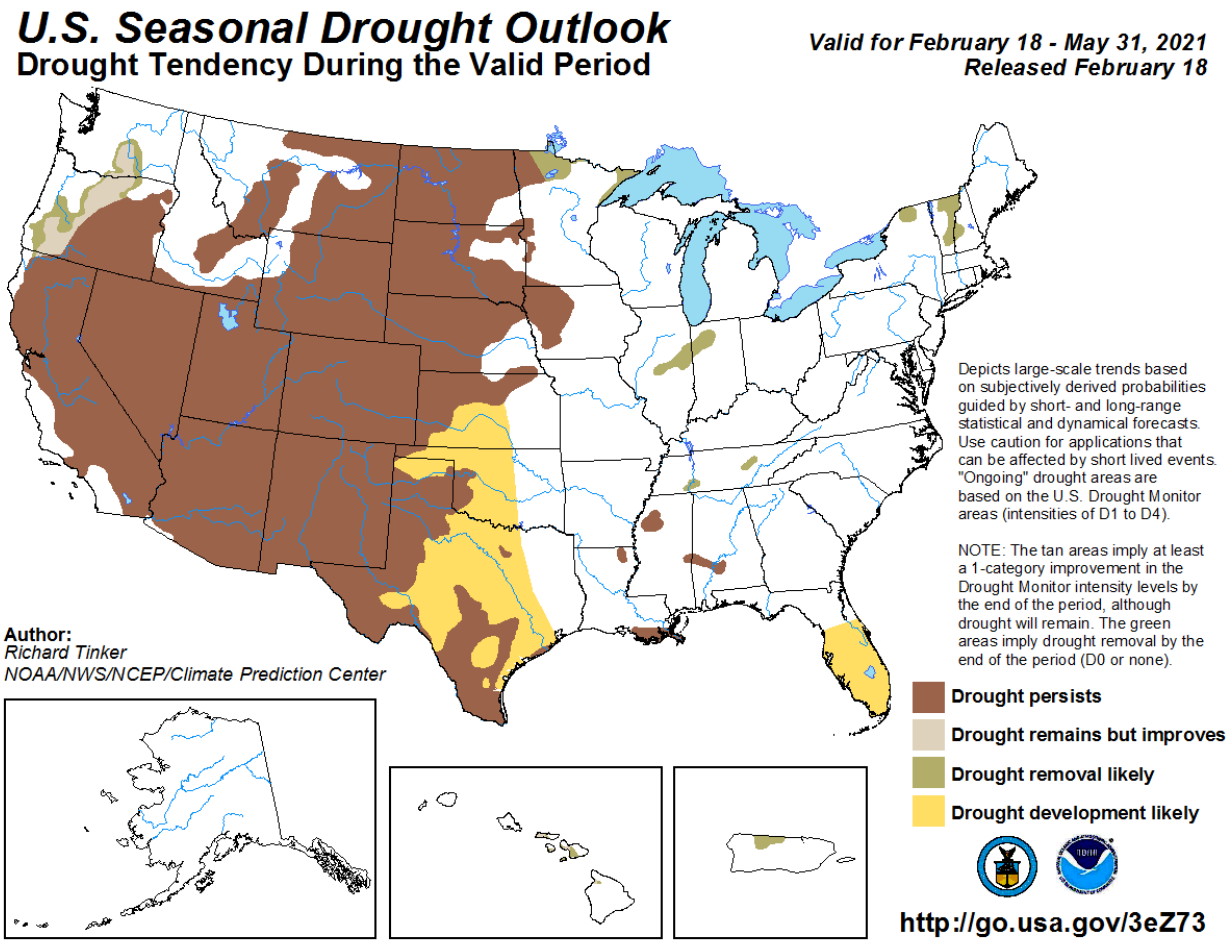

Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

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**).

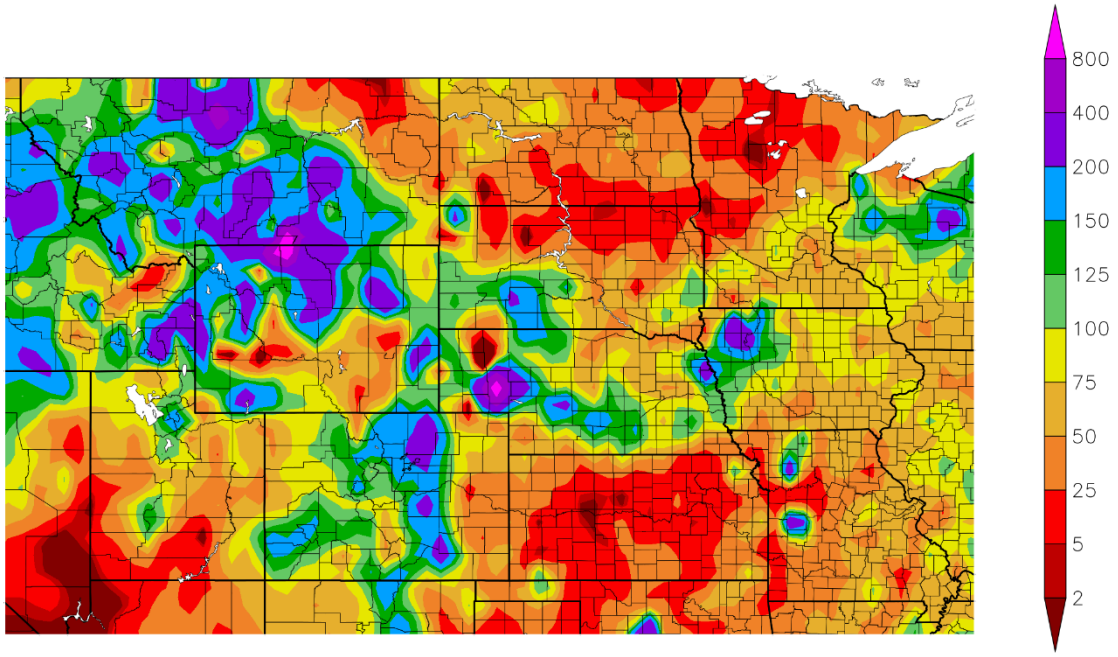

Figure 3. February 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

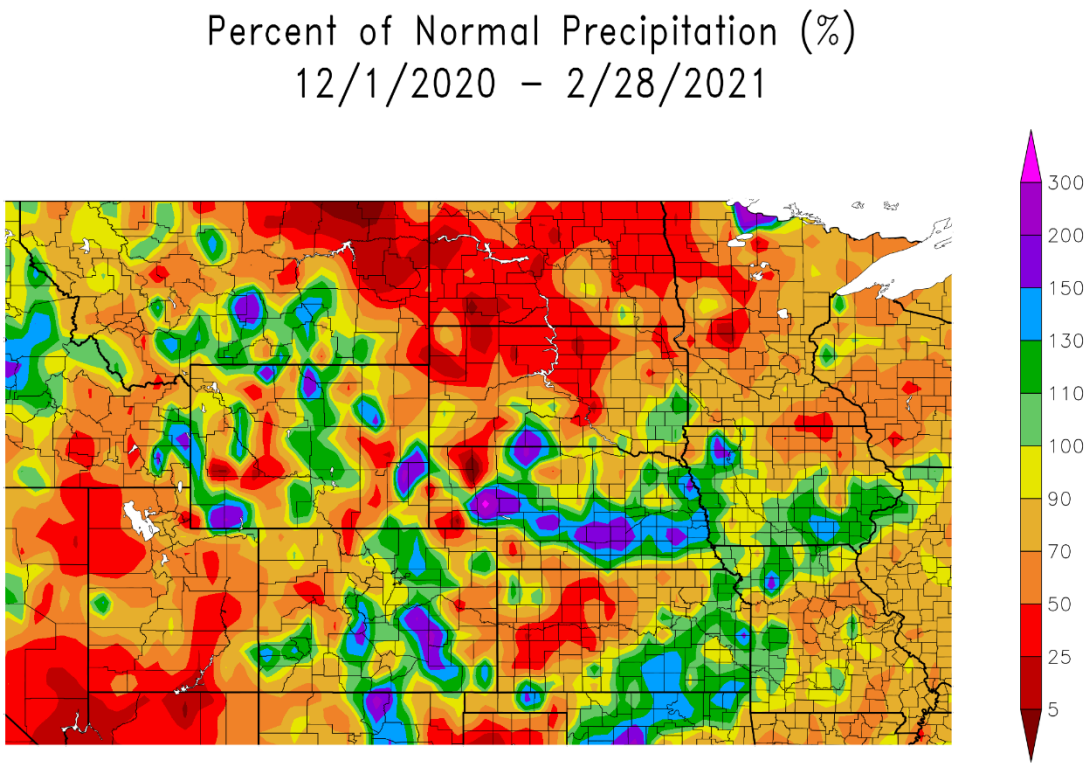

Figure 4. December 2020-February 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

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.

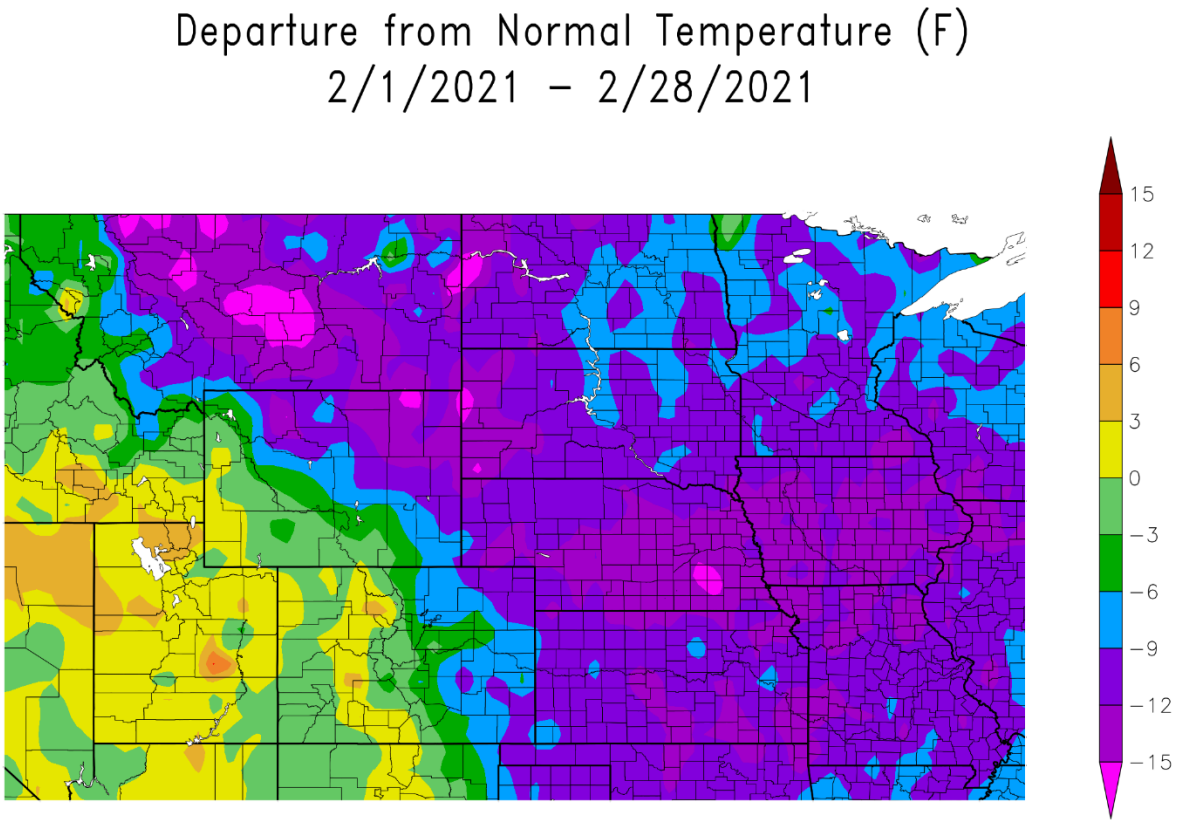

Figure 5. February 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

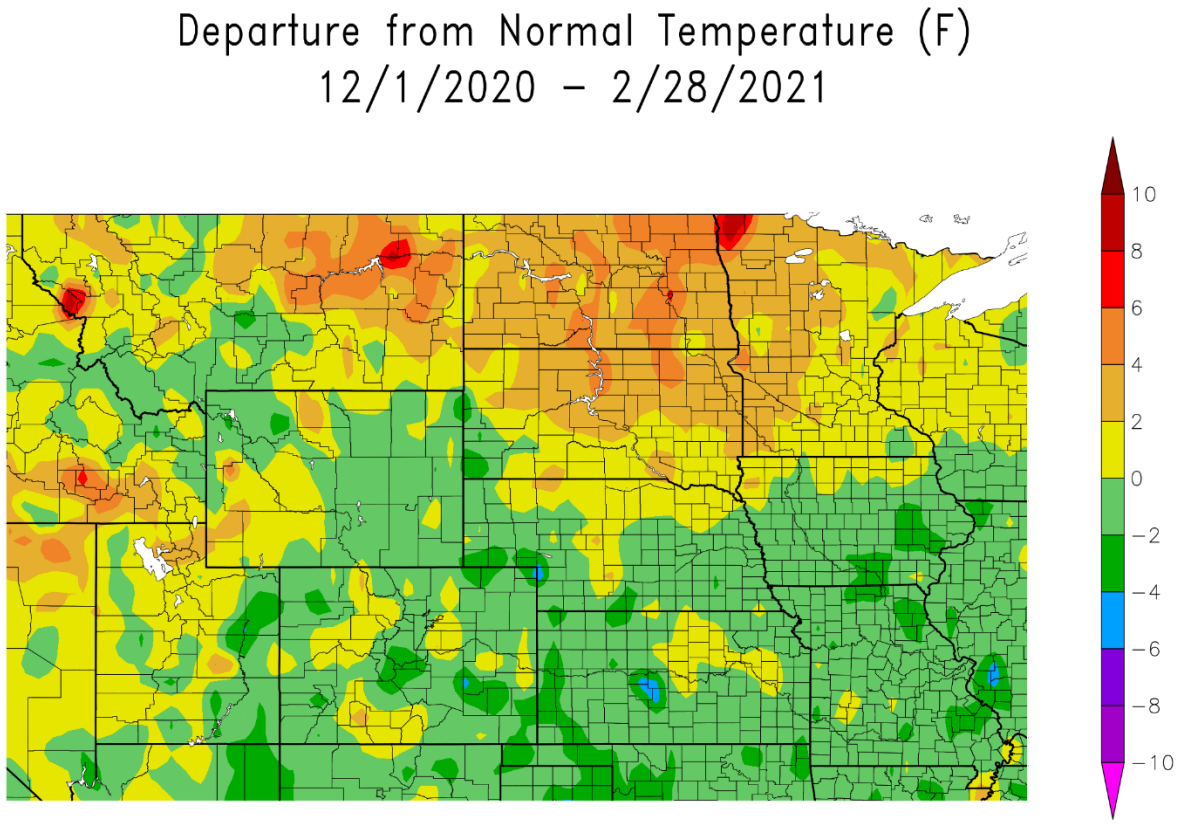

Figure 6. December 2020-February 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

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.

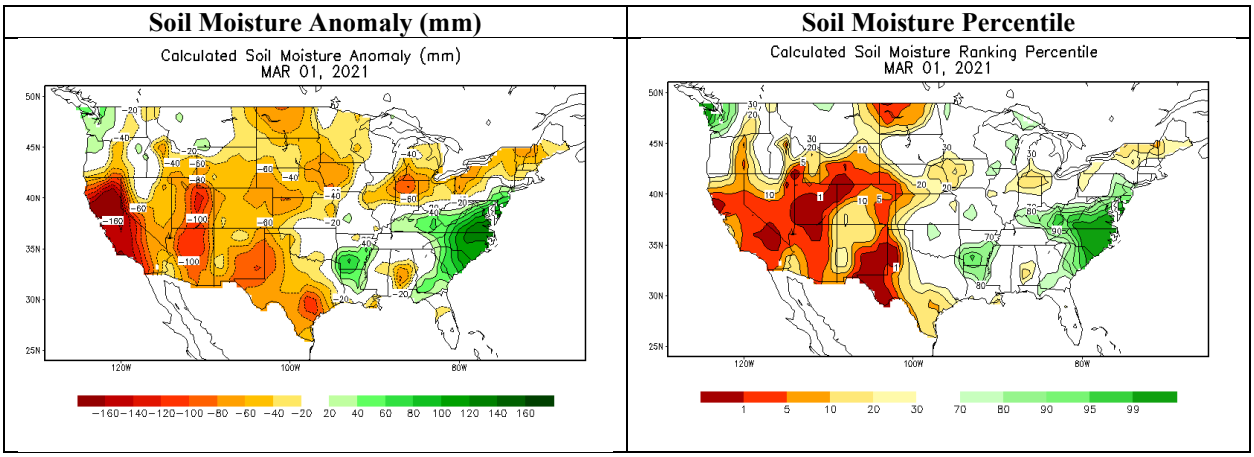

Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

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.

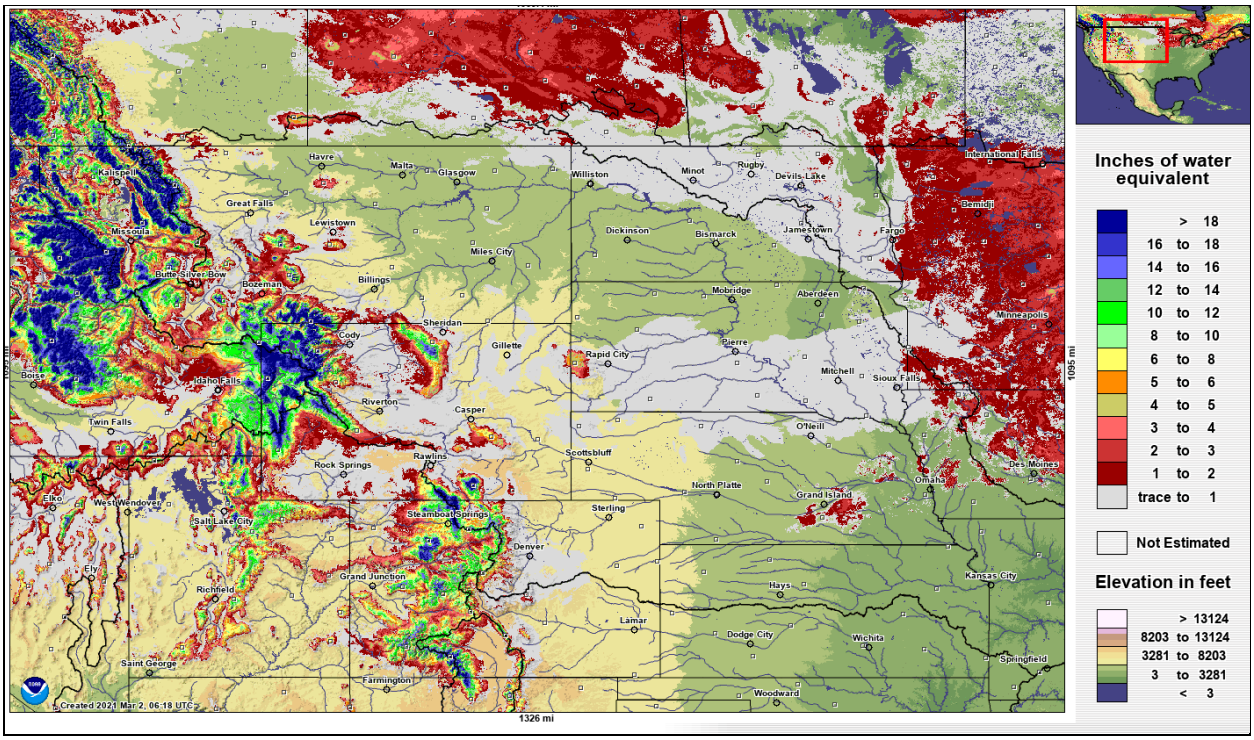

Figure 8. March 1, 2021 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

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).

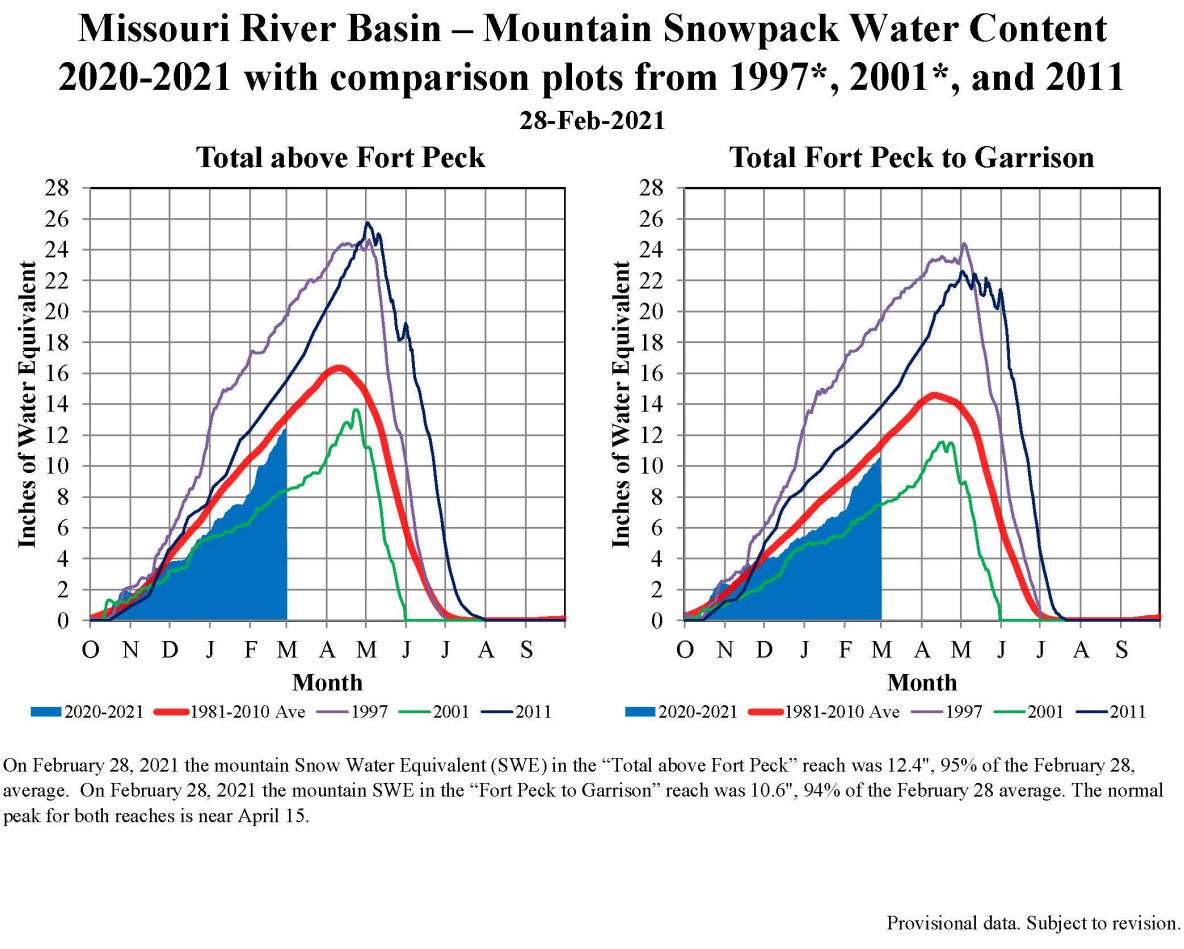

Figure 9. Mountain snowpack water content on February 28, 2021 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

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.

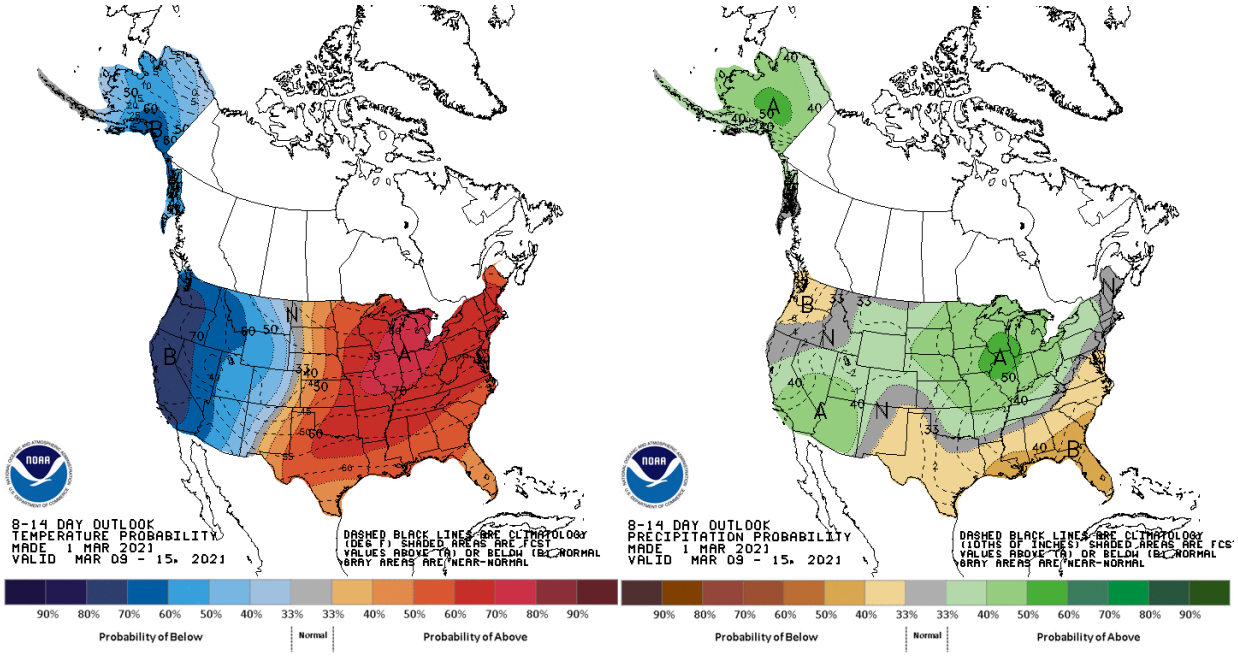

Figure 10. CPC 8-14 Day temperature and precipitation outlooks through March 15, 2021.

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.

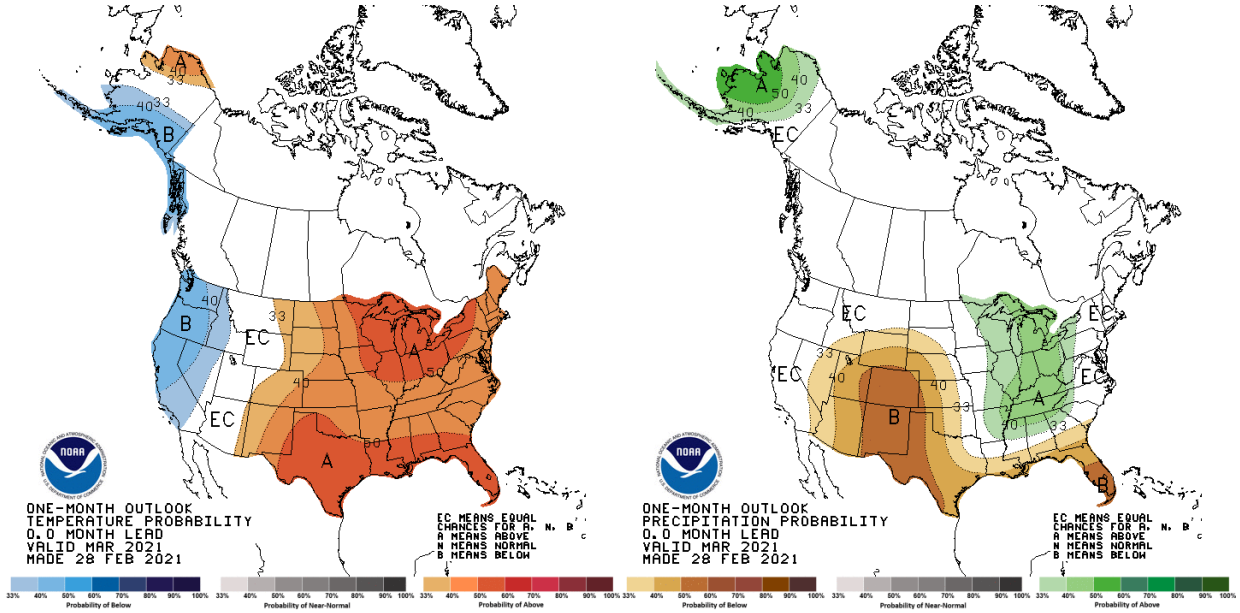

Figure 11. CPC March 2021 temperature and precipitation outlooks.

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.

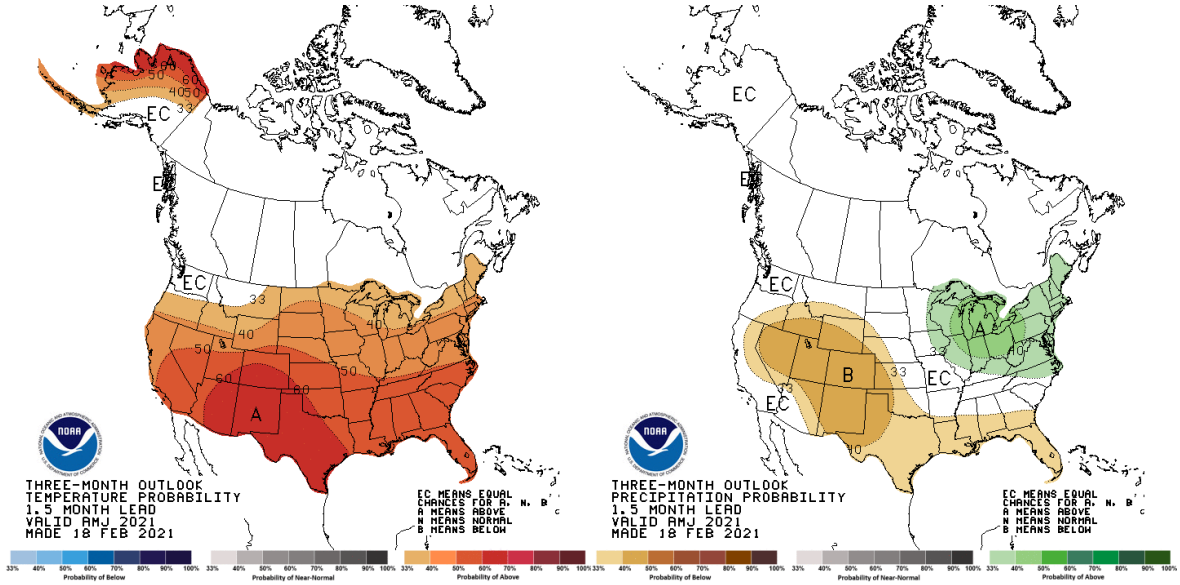

Figure 12. CPC April-May-June temperature and precipitation outlooks.

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.

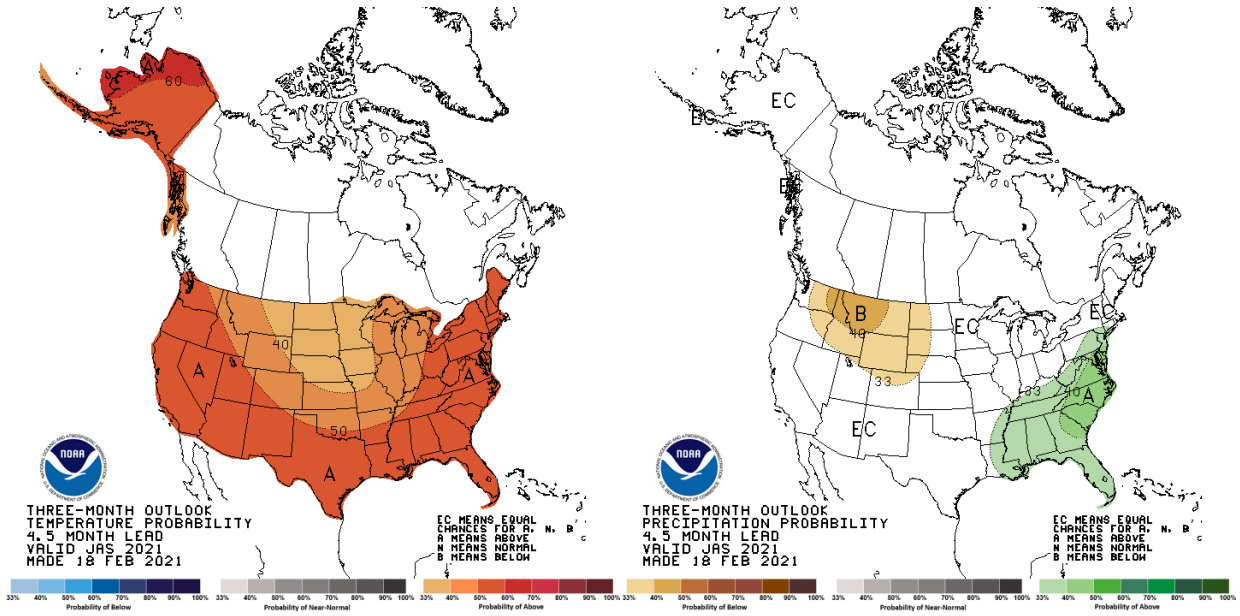

Figure 13. CPC July-August-September temperature and precipitation outlooks.

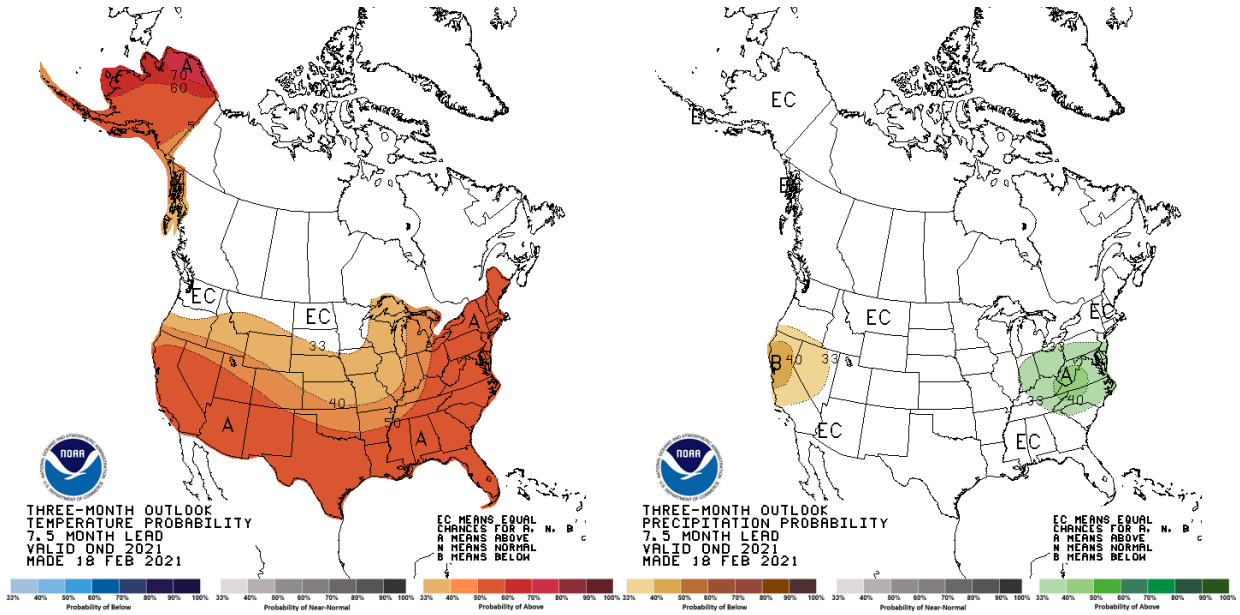

Figure 14. October-November-December temperature and precipitation outlooks.

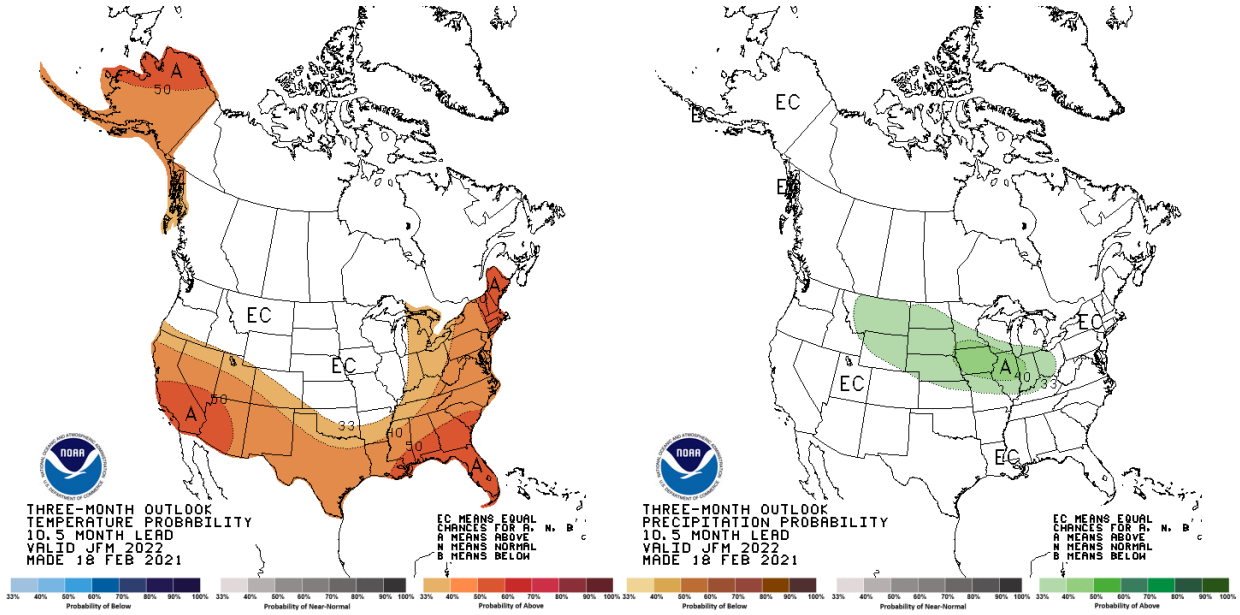

Figure 15. January-February-March 2022 temperature and precipitation outlooks.

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