

**Upper Missouri River Basin  
January 2018 Calendar Year Runoff Forecast  
January 3, 2018**

**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 December runoff summation for the upper Basin above Sioux City was 130% of average. The December runoff summation for the upper Basin above Gavins Point was 116% of average. Runoff was well above average in every reach except Fort Randall and Gavins Point. The first three weeks of December experienced warmer-than-normal temperatures, but gave way to much colder temperatures the last week.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on January 2, is **26.6 MAF (105% of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **24.3 MAF (105% 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 36.9 MAF upper basic forecast to the 17.5 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 twelve months are being forecast for this January 1 forecast

(0 months observed/12 months forecast), the range of wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is attributed to all 6 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 January 2, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows drought conditions in all states of the Missouri Basin and over a majority of the upper Basin. Extreme Drought (D3) conditions are present in northeastern Montana and western South Dakota, while there are Moderate (D1) and Severe (D2) Drought conditions over a broader area of the upper Basin. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of March, indicates that drought conditions could improve in central and western Montana, but will likely persist in eastern Montana, western North Dakota, and western South Dakota.

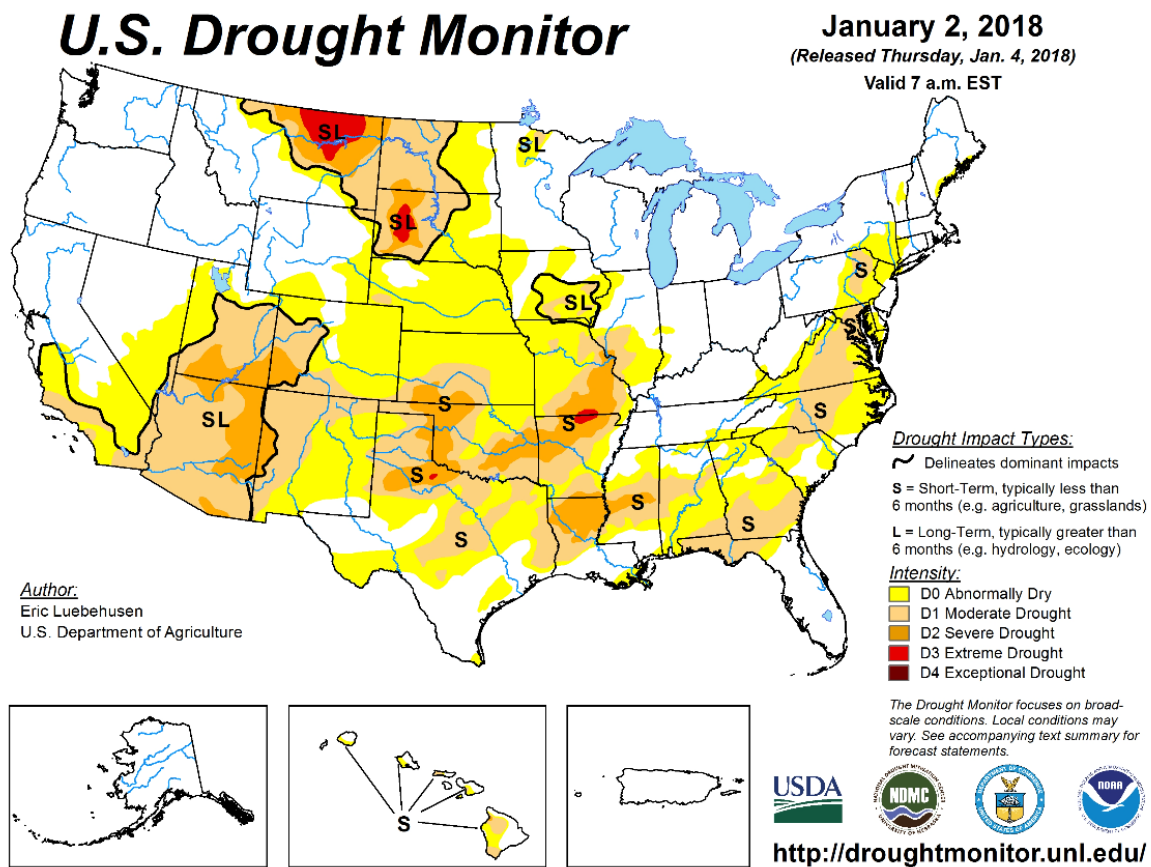


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for January 2, 2018.

**U.S. Seasonal Drought Outlook**  
**Drought Tendency During the Valid Period**

Valid for December 21 - March 31, 2018  
 Released December 21, 2017

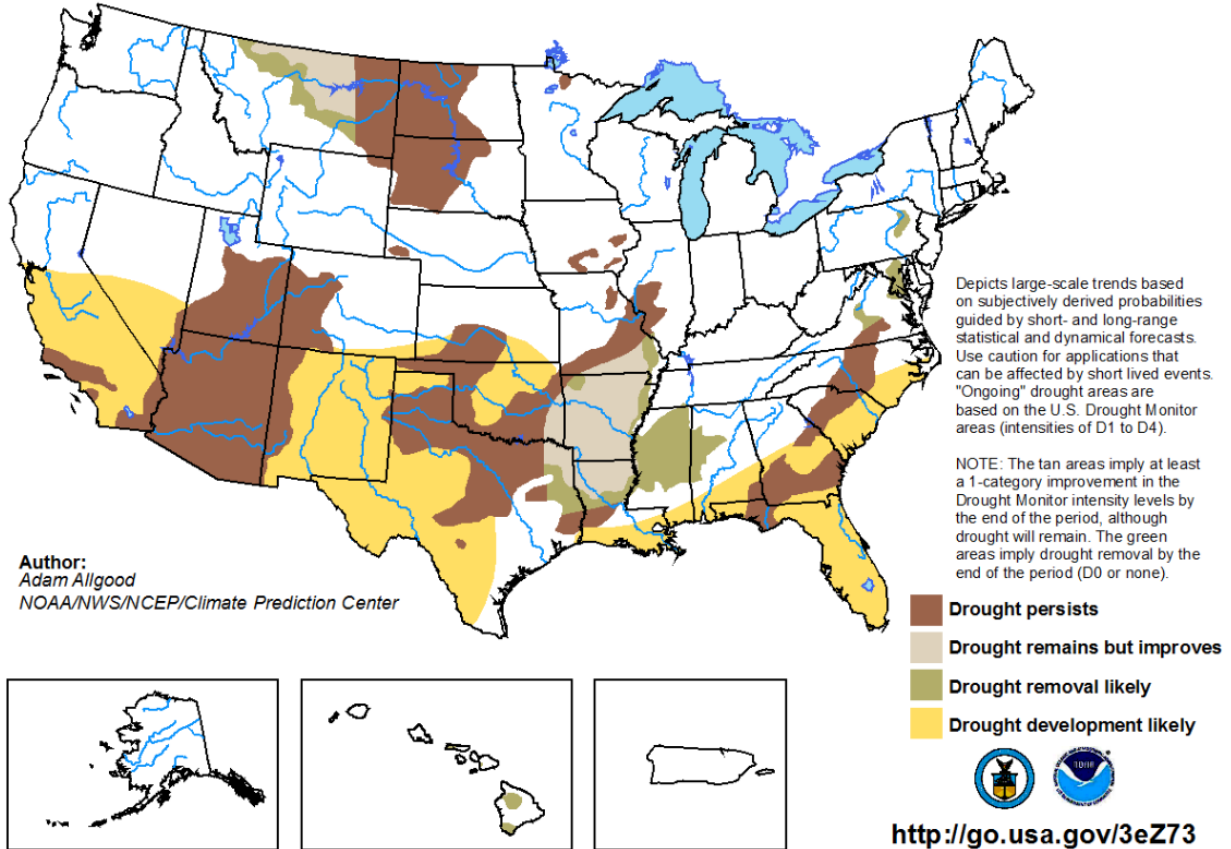


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

**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 inches of precipitation (left) and percent of normal precipitation (right). December precipitation was more than 300% of average in areas of Montana, Wyoming, western Nebraska, and the western Dakotas. In contrast, December precipitation was less than 5% of average in portions of Colorado and Kansas.

October-November-December precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the ongoing above-normal precipitation pattern in the Rocky Mountains of Montana and Wyoming. Precipitation accumulations greater than 150% of normal have led to above-average mountain snowpack in the Fort Peck and Garrison reaches this year. An above-normal precipitation pattern has also covered much of Montana, Nebraska and Iowa.

In contrast, North Dakota, South Dakota, Colorado, and Kansas have experienced below-normal precipitation.

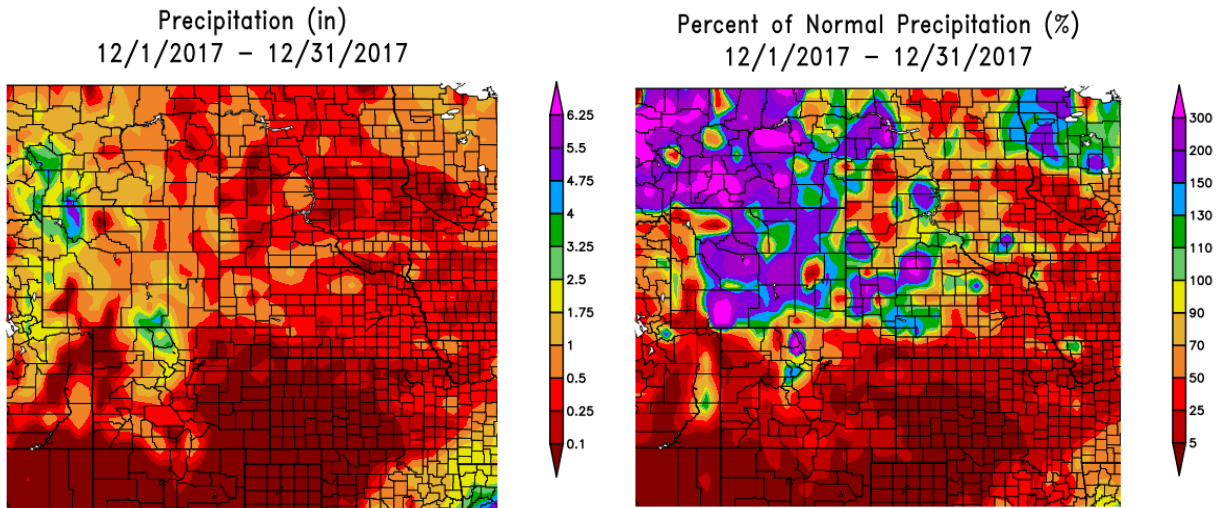


Figure 3. December 2017 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

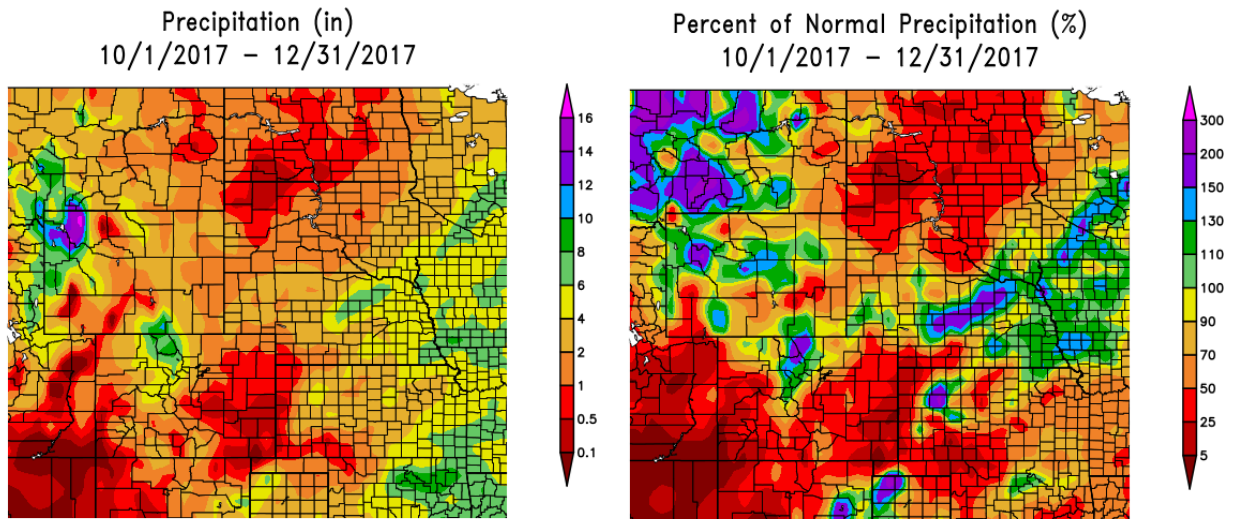
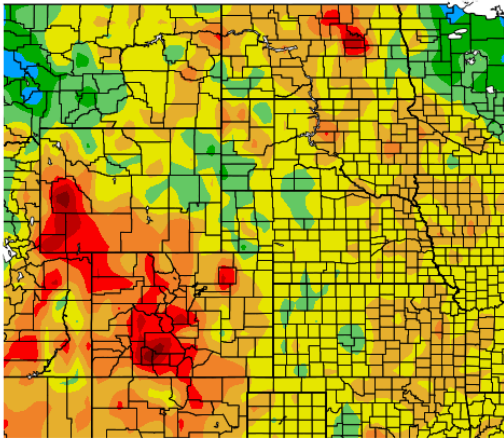


Figure 4. October-November-December 2017 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

December temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** indicate normal temperatures over most of the Basin, with a few areas of above-normal temperatures in western Wyoming, Colorado, and northern North Dakota, and a few areas of below-normal temperatures in Montana, Wyoming, the western Dakotas, and Nebraska. October-November-December temperature departures, in the right image of **Figure 5**, were near normal in the Basin.

Departure from Normal Temperature (F)  
12/1/2017 – 12/31/2017



Departure from Normal Temperature (F)  
10/1/2017 – 12/31/2017

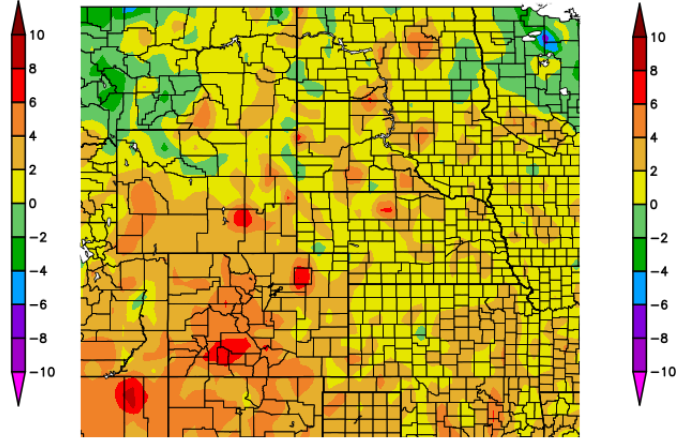


Figure 5. December 2017 and October-November-December 2017 Departure from Normal Temperature (deg F).  
Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

### 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.

The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on January 1, 2018. Soil moisture conditions have been a reflection of the precipitation patterns over the past three months. Soil moisture anomalies and percentiles are above normal in western and central Montana, Wyoming, Colorado, eastern South Dakota and central Nebraska. Spring runoff could potentially be above normal under normal winter precipitation and snowfall accumulations due to the above-normal soil moisture conditions in western Montana and Wyoming. In contrast, soil moisture anomalies and percentiles are below normal in North and South Dakota, Kansas, Iowa, and much of Missouri. As a result, spring runoff could potentially be below normal under normal winter precipitation and snowfall accumulations in the Dakotas and the lower Basin.

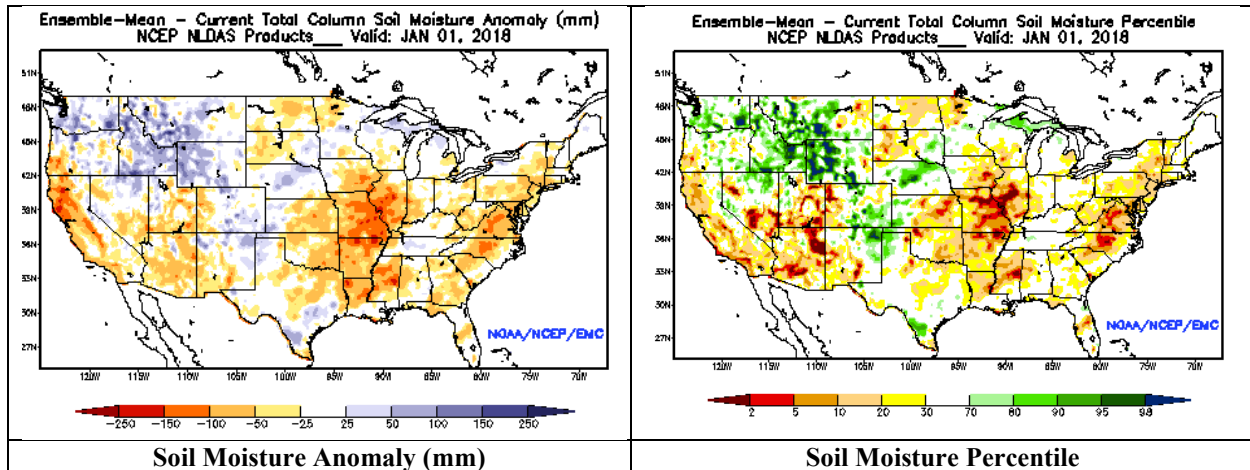


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

## 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. Some areas of North Dakota have received a significant amount of snowfall so far this winter. The NWS at Bismarck, which normally receives about 29 inches of snowfall by the end of January, has received 58.7 inches of snow as of February 1.

The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from January 1, shown in **Figure 7**, indicates 1 to 3 inches of snow water equivalent (SWE) have accumulated in the plains of eastern and central Montana. Only trace amounts of SWE are present across the remainder of the Basin.

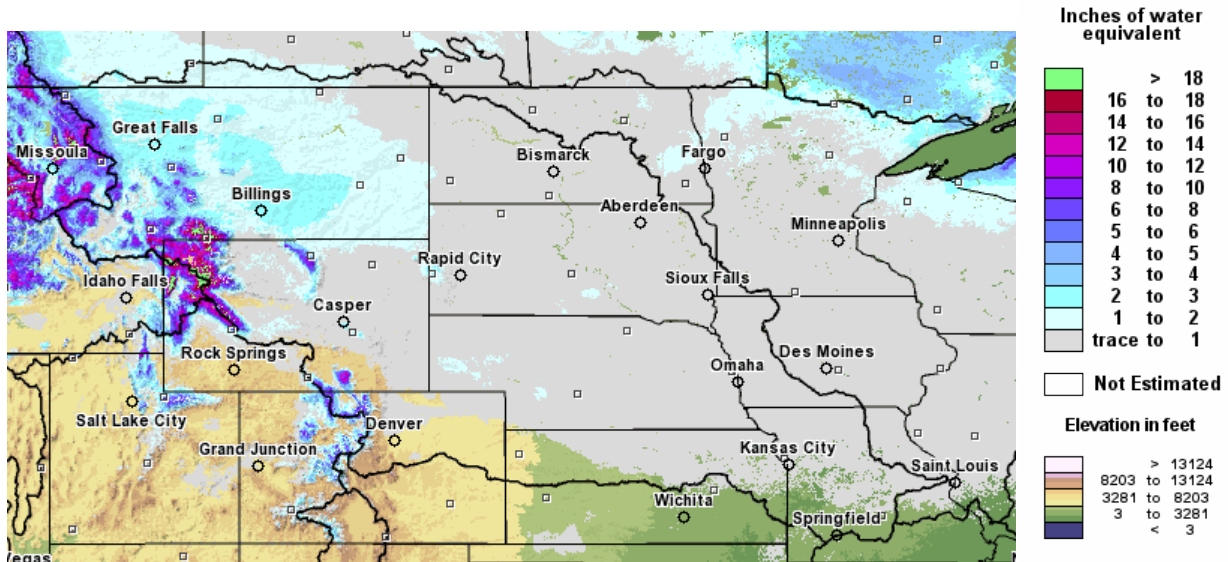


Figure 7. January 1, 2018 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. <http://www.nohrsc.nws.gov/interactive/html/map.html>

### Mountain Snowpack

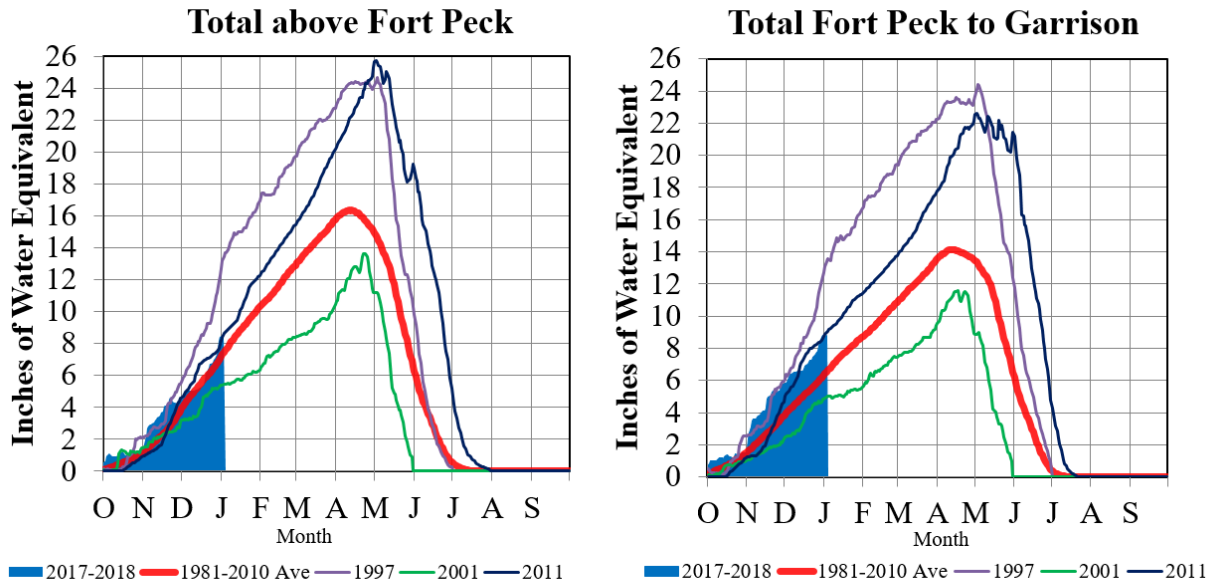
Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. It is typically NOT a factor influencing runoff at the beginning of a calendar year.

**Figure 8** includes time series plots of the average mountain SWE beginning on October 1, 2017 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).

As of January 1, 2018, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 8.5 inches, which is 118% 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 8.7 inches, which is 134% of average based on the 1981-2010 average SWE for the Garrison reach. Typically by January 1, 44% of the total accumulation has occurred.

# Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

January 1, 2018



The Missouri River Basin mountain snowpack normally peaks near April 15. On January 1, 2018 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 8.5”, 118% of the average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 8.7”, 134% of the average. Normally by January 1, about 44% of the peak mountain SWE has occurred in both reaches.

\*Generally considered the high and low year of the last 20-year period, respectively.

Provisional data. Subject to revision.

**Figure 8. Mountain snowpack water content on January 1, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.**

## 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 Niña conditions are present. During a La Niña phase of ENSO, there are increased probabilities for above-normal precipitation and below-normal temperatures in the upper Missouri Basin during the winter season.

## 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 9**) indicates increased chances for above-normal temperatures over most of the Basin, potentially inhibiting formation of mountain and plains snowpack. The precipitation outlook indicates increased chances for below-normal precipitation over most of the Basin.

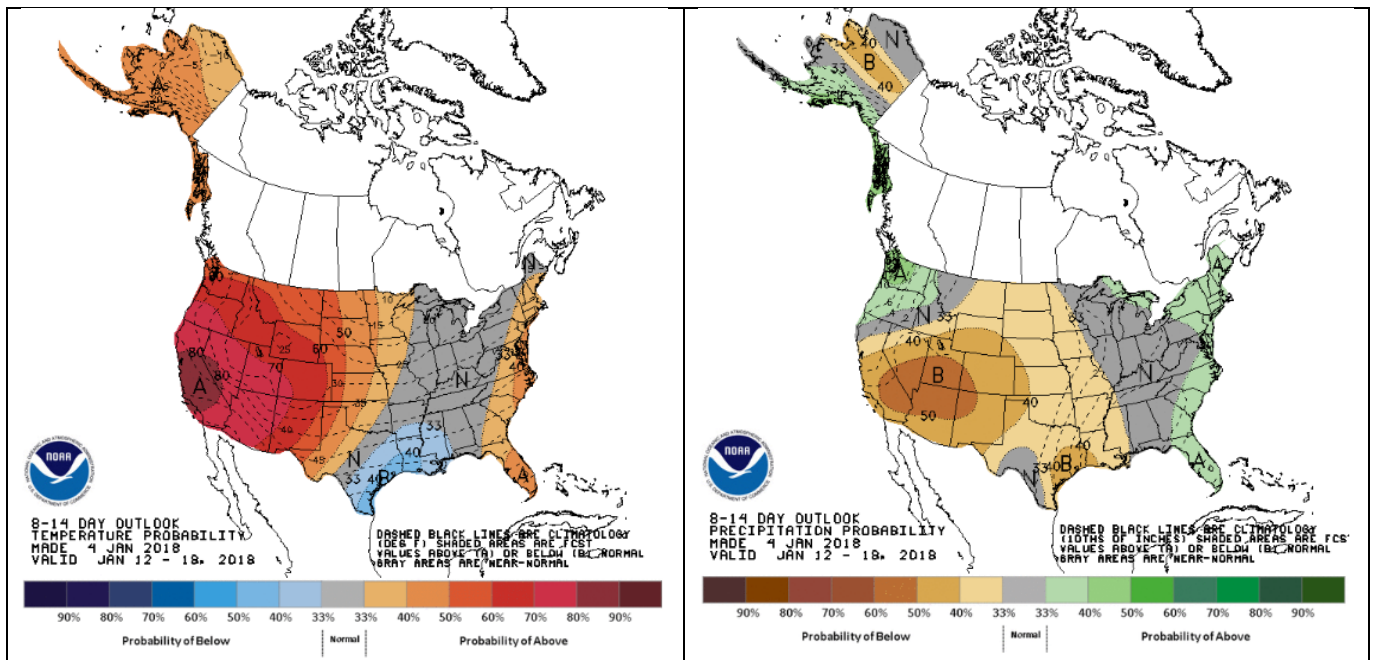


Figure 9. CPC 8-14 Day temperature and precipitation outlooks through January 18, 2018.

The January CPC outlooks in **Figure 10** indicate equal chances for above-normal, normal or below-normal temperatures over most of the Rockies, with increased chances for below-normal temperatures over most of the plains. With regard to precipitation, there are mostly equal chances for above-normal, normal or below-normal precipitation in the Basin; however, there is a slight increase in the chance for below-normal precipitation in the eastern Dakotas. There are also increased chances for above-normal precipitation in Kansas and Missouri.

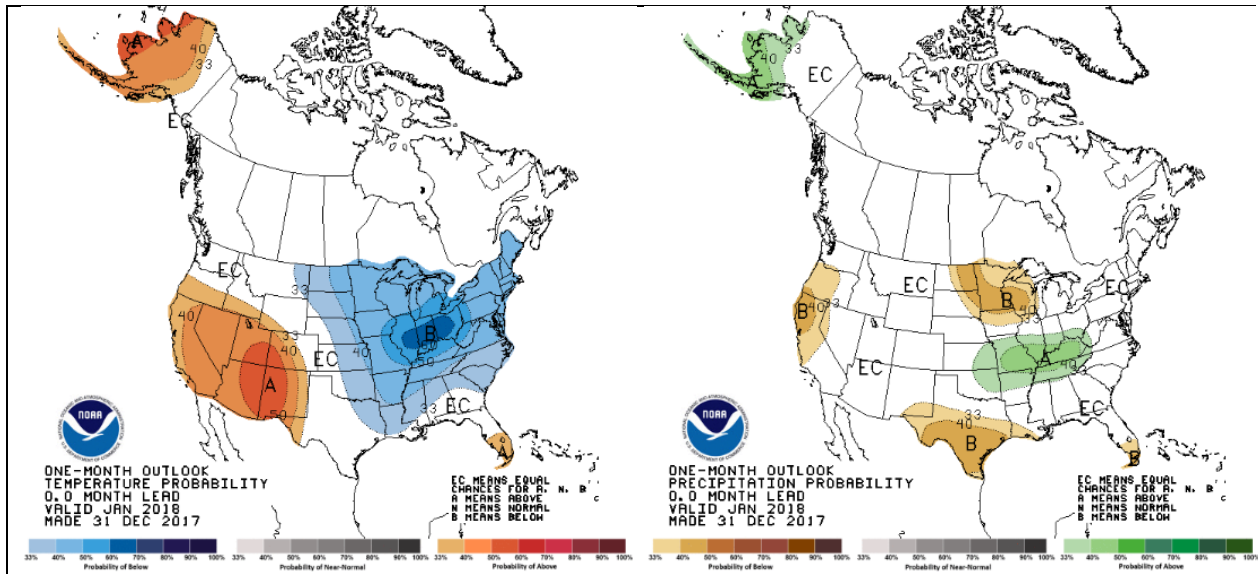


Figure 10. CPC January 2018 temperature and precipitation outlooks.

During the February-March-April 2018 period, the CPC outlooks in **Figure 11** indicate increased chances for below-normal temperatures in northern Montana, North Dakota, much of South Dakota and Iowa based on the projected weak La Niña. With regard to the precipitation outlook, the weak La Niña could increase chances for above-normal precipitation in the upper Basin, particularly in Montana, Wyoming, and North Dakota. There are equal chances for precipitation in eastern South Dakota and portions of Nebraska and Kansas.

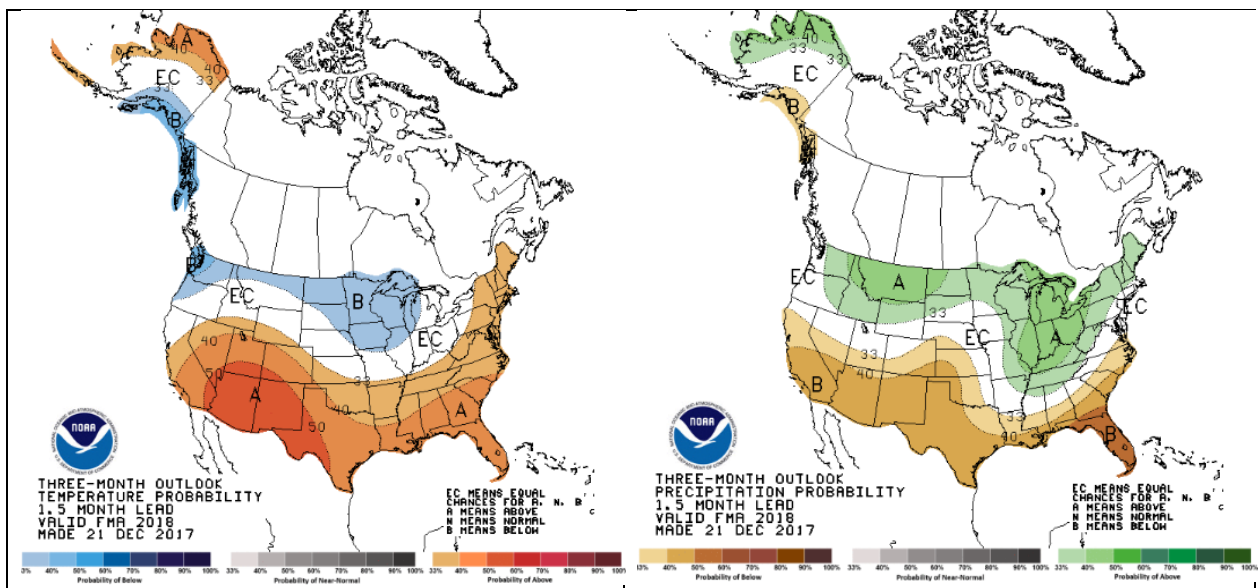


Figure 7. CPC February-March-April 2018 temperature and precipitation outlooks.

During the May-June—July 2018 period, CPC outlooks in Figure 12 indicate equal chances for above-normal, below-normal, and normal temperatures in the upper Basin, and a slight increase in the chances for above-normal temperatures in the lower Basin. The precipitation outlook

indicates a slight increase for below-normal precipitation over the mountains, and equal chances elsewhere in the Basin.

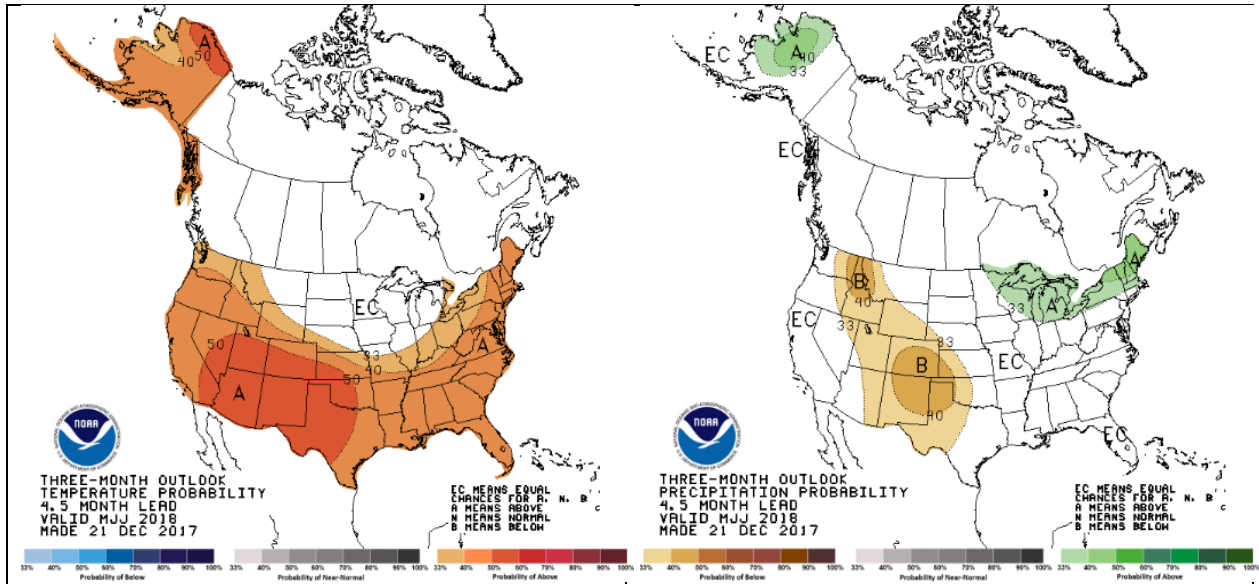


Figure 12. CPC May-June-July 2018 temperature and precipitation outlooks.

During the August-September-October 2018 period, CPC outlooks in Figure 13 indicate slight increases for above-normal temperatures, and equal chances for precipitation. The precipitation outlook is reflected in the average runoff forecast for August, September, and October of 2018.

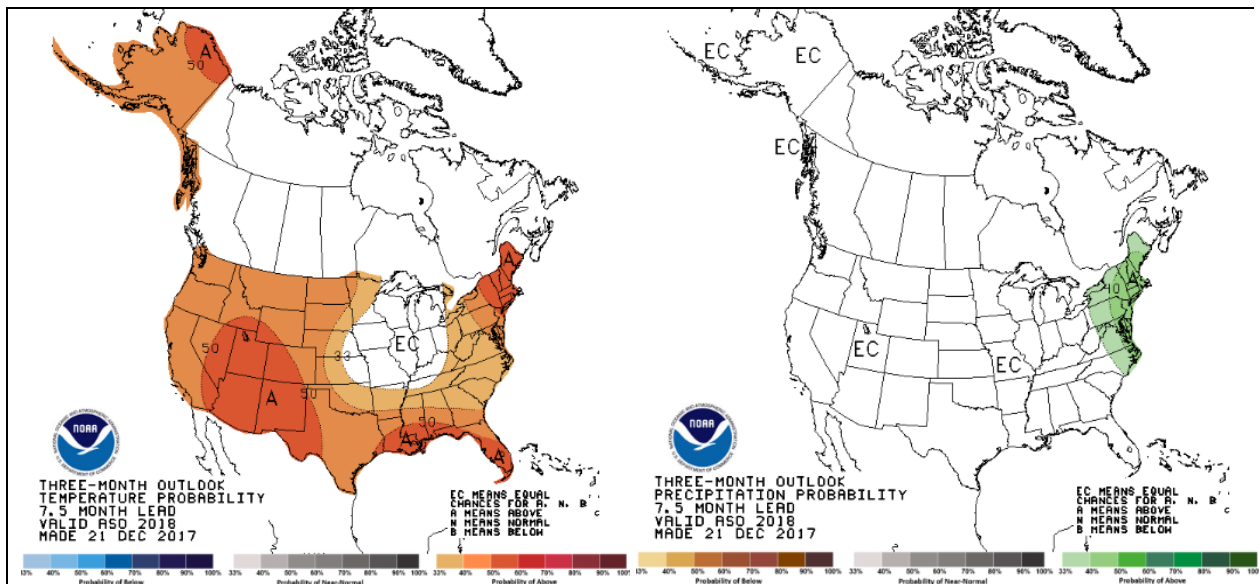


Figure 13. CPC August-September-October 2018 temperature and precipitation outlooks.

During the November 2018-December 2018-January 2019 period, CPC outlooks in Figure 14 also indicate slight increases for above-normal temperatures, and equal chances for precipitation. The precipitation outlook is reflected in the average runoff forecast for the end of 2018.

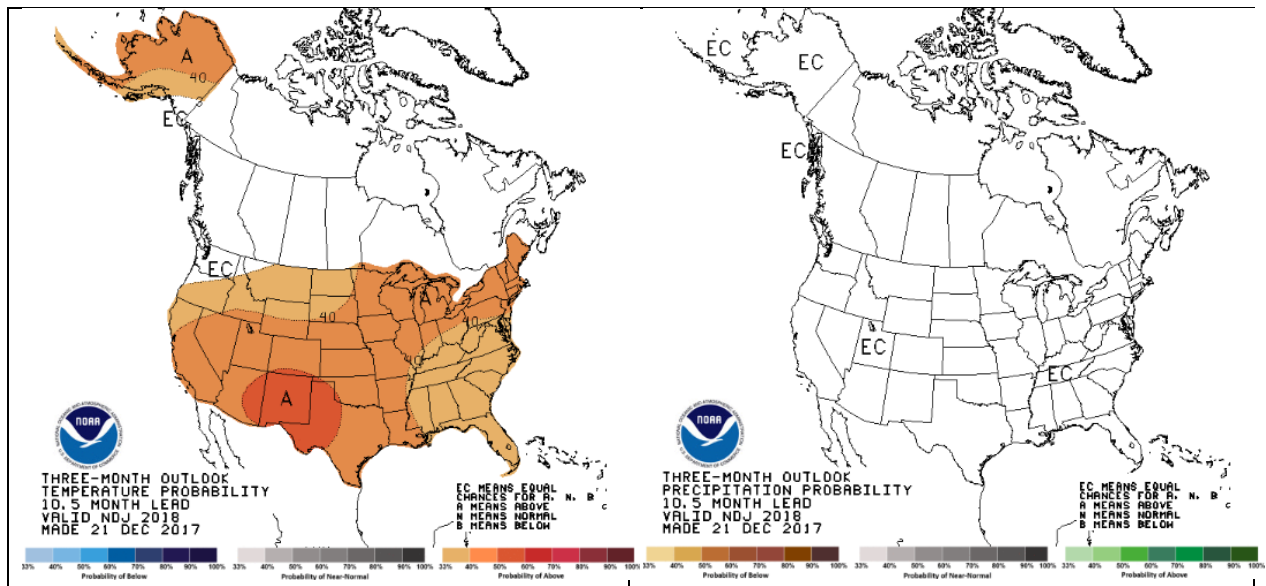
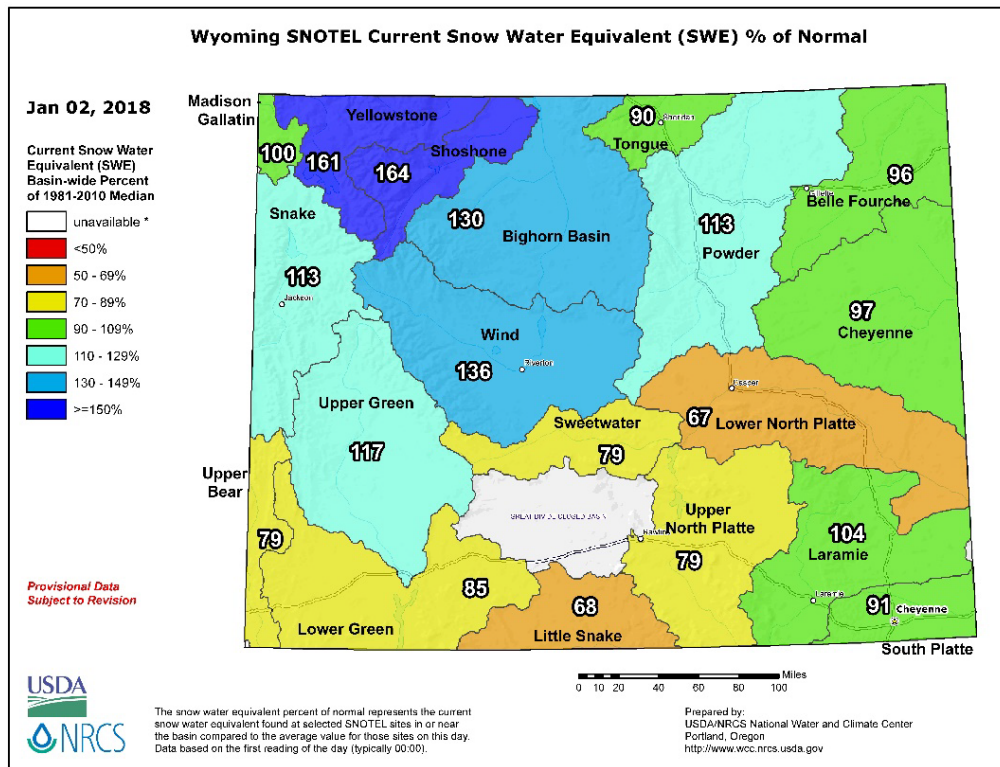
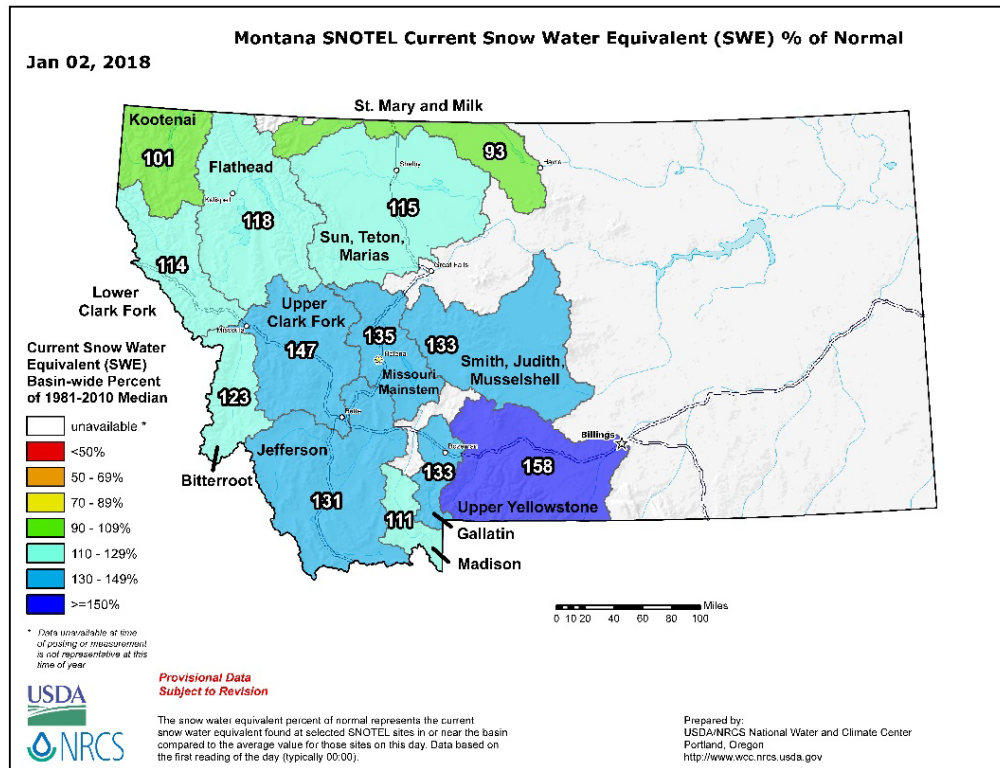


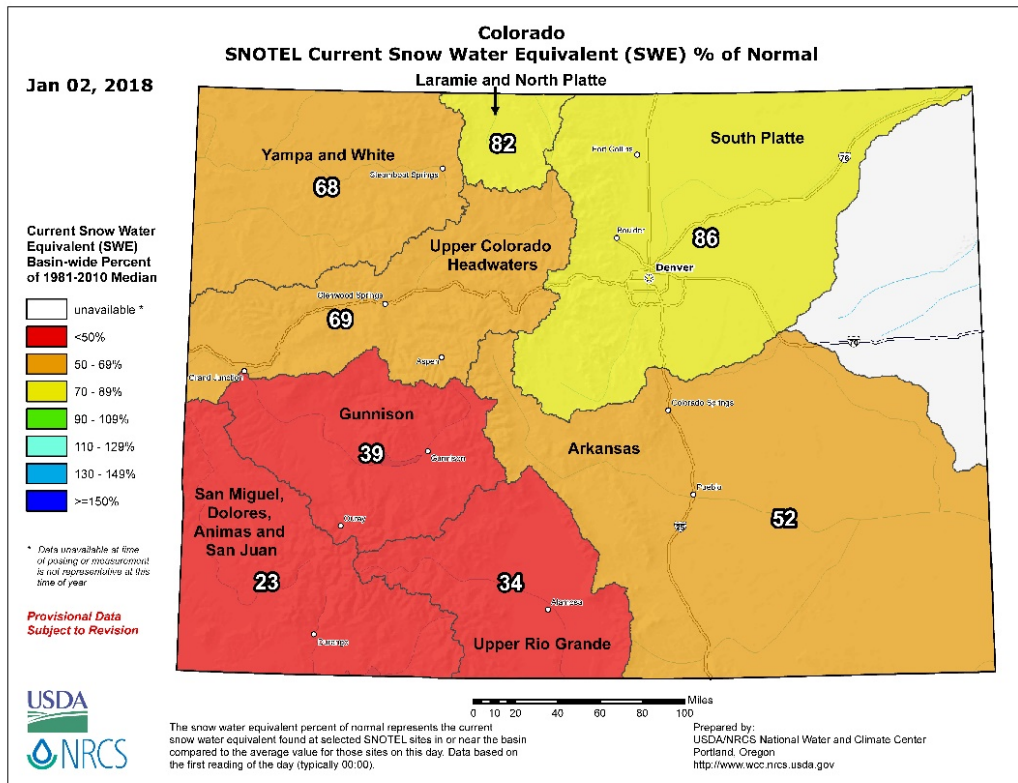
Figure 14. CPC November 2018-December 2018-January 2019 temperature and precipitation outlooks.

## Summary

In summary, the 2018 calendar year runoff forecast is 26.6 MAF, 105% of average. For the beginning of the year, below-normal runoff is forecast for all reaches except Sioux City due to the continuing cold temperatures. Above normal runoff is then forecasted for the Fort Peck and Garrison reaches from February through July due to the plains and mountain snowpack. Below-normal to normal runoff conditions are forecasted for the remainder of the Basin due to the lack of plains snow.

# Additional Figures





USDA NRCS National Water & Climate Center

\* - DATA CURRENT AS OF: January 04, 2018 05:36:38 PM

- Based on January 01, 2018 forecast values

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

max	30%	70%	min	30-yr		50%	% of
Forecast Point	(KAF)	(KAF)	(KAF)	avg	period	(KAF)	avg
-----	-----	-----	-----	-----	-----	-----	-----
Wind R ab Bull Lake Ck					APR-JUL	715	157
880	780	645	545	455			
					APR-SEP	785	160
965	860	710	600	490			
Bull Lake Ck nr Lenore (2)					APR-JUL	167	120
200	181	152	131	139			
					APR-SEP	200	118
245	220	185	160	169			
Boysen Reservoir Inflow (2)					APR-JUL	890	146
1240	1030	745	540	610			
					APR-SEP	965	145
1340	1120	815	595	665			
Greybull R at Meeteetse					APR-JUL	162	124
215	184	139	106	131			
					APR-SEP	220	124
285	245	192	153	177			
Shell Ck nr Shell					APR-JUL	63	115
79	69	56	46	55			
					APR-SEP	75	114
93	82	68	57	66			
Bighorn R at Kane (2)					APR-JUL	1240	148
1730	1430	1040	745	840			
					APR-SEP	1340	148
1870	1550	1120	805	905			
NF Shoshone R at Wapiti					APR-JUL	695	151
820	745	640	565	460			
					APR-SEP	775	150
910	830	715	635	515			

SF Shoshone R nr Valley					APR-JUL	330	153
390	355	305	270	215			
					APR-SEP	385	157
455	410	355	315	245			
Buffalo Bill Reservoir Inflow					APR-JUL	1070	159
1290	1160	980	850	675			
					APR-SEP	1190	160
1420	1280	1090	950	745			
Bighorn R nr St. Xavier (2)					APR-JUL	2170	157
2790	2420	1910	1540	1380			
					APR-SEP	2340	160
3030	2620	2060	1650	1460			
Tongue R nr Dayton (2)					APR-JUL	70	81
103	83	57	38	86			
					APR-SEP	81	83
115	95	67	46	98			
Tongue River Reservoir Inflow (2)					APR-JUL	148	77
255	192	103	38	193			
					APR-SEP	168	78
285	215	121	52	215			
NF Powder R nr Hazelton					APR-JUL	11.1	122
14.9	12.7	9.6	7.3	9.1			
					APR-SEP	12.0	121
15.9	13.5	10.4	8.1	9.9			
Powder R at Moorhead					APR-JUL	235	133
380	295	179	95	177			
					APR-SEP	260	133
405	320	200	114	196			

PRELIMINARY RAPID VALLEY UNIT FORECASTS

max	30%	70%	min	30-yr		50%	% of
Forecast Point				avg	period	(KAF)	avg
(KAF)	(KAF)	(KAF)	(KAF)				
-----					-----	-----	-----
-----							
Deerfield Reservoir Inflow (2)					MAR-JUL	6.4	103
10.5	8.0	4.7	2.3	6.2			
					APR-JUL	5.2	100
8.8	6.7	3.7	1.55	5.2			

Pactola Reservoir Inflow (2)					MAR-JUL	23	92
41	30	16.0	5.4	25			
					APR-JUL	20	91
37	27	13.3	3.2	22			

PRELIMINARY PLATTE RIVER BASIN FORECASTS

max	30%	70%	min	30-yr		50%	% of
Forecast Point				avg	period	(KAF)	avg
(KAF)	(KAF)	(KAF)	(KAF)				
-----					-----	-----	-----
North Platte R nr Northgate (2)					APR-JUL	190	84
325	245	136	56	225			
					APR-SEP	210	84
355	270	151	65	250			
Encampment R nr Encampment (2)					APR-JUL	88	68
159	117	61	18.6	129			
					APR-SEP	92	67
165	122	62	19.0	138			
Rock Ck ab King Canyon Cnl nr Arlington					APR-JUL	50	102
71	58	42	29	49			
					APR-SEP	53	102
74	61	44	31	52			
Seminole Reservoir Inflow (2)					APR-JUL	585	82
1020	765	410	148	715			
					APR-SEP	630	82
1090	815	445	171	770			
Sweetwater R nr Alcova					APR-JUL	43	73
77	57	29	9.0	59			
					APR-SEP	47	73
83	61	32	10.2	64			
La Prele Ck nr Douglas					APR-JUL	7.5	38
24	13.0	3.5	0.35	19.9			
					APR-SEP	7.9	40
25	13.6	3.7	0.41	19.9			
North Platte R bl Glendo Reservoir (2)					APR-JUL	640	78
1220	875	400	56	820			
					APR-SEP	655	77
1260	900	415	57	850			

North Platte R bl Guernsey Reservoir (2)	APR-JUL	635	77
1230      875      395      37      820			
	APR-SEP	650	76
1260      900      400      33      850			
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	124	108
180      147      101      68      115			
	APR-SEP	136	108
196      160      111      75      126			
Little Laramie R nr Filmore	APR-JUL	57	112
82      67      47      32      51			
	APR-SEP	62	113
88      72      51      35      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  
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February 6, 2018**

**U.S. Army Corps of Engineers, Northwestern Division  
Missouri River Basin Water Management  
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**Observed Runoff**

January runoff was 1.2 MAF, which is 153% of average. Runoff during January was above average in all reaches except the Oahe reach. The above-average runoff was caused by periodic warmer-than-normal temperatures that led to some plains snowmelt and river ice melt.

**2018 Calendar Year Forecast Synopsis**

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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 36.3 MAF upper basic forecast to the 17.8 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 much wetter or drier conditions, respectively. Given that eleven months are being forecast for this February 1 forecast (1 months observed/11 months forecast), the range of wetter-than-expected (upper basic) and

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## Current Conditions

### Drought Analysis

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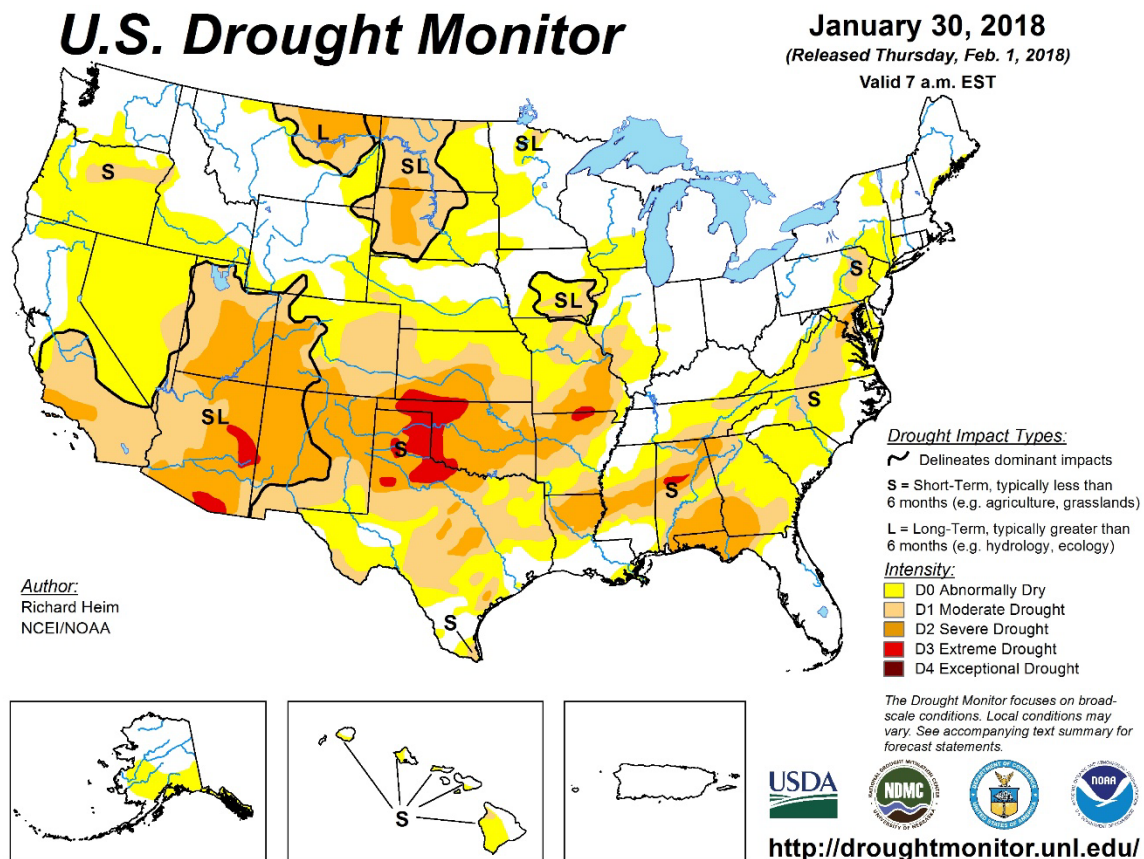


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for January 30, 2018.

# U.S. Seasonal Drought Outlook

## Drought Tendency During the Valid Period

Valid for January 18 - April 30, 2018  
Released January 18, 2018

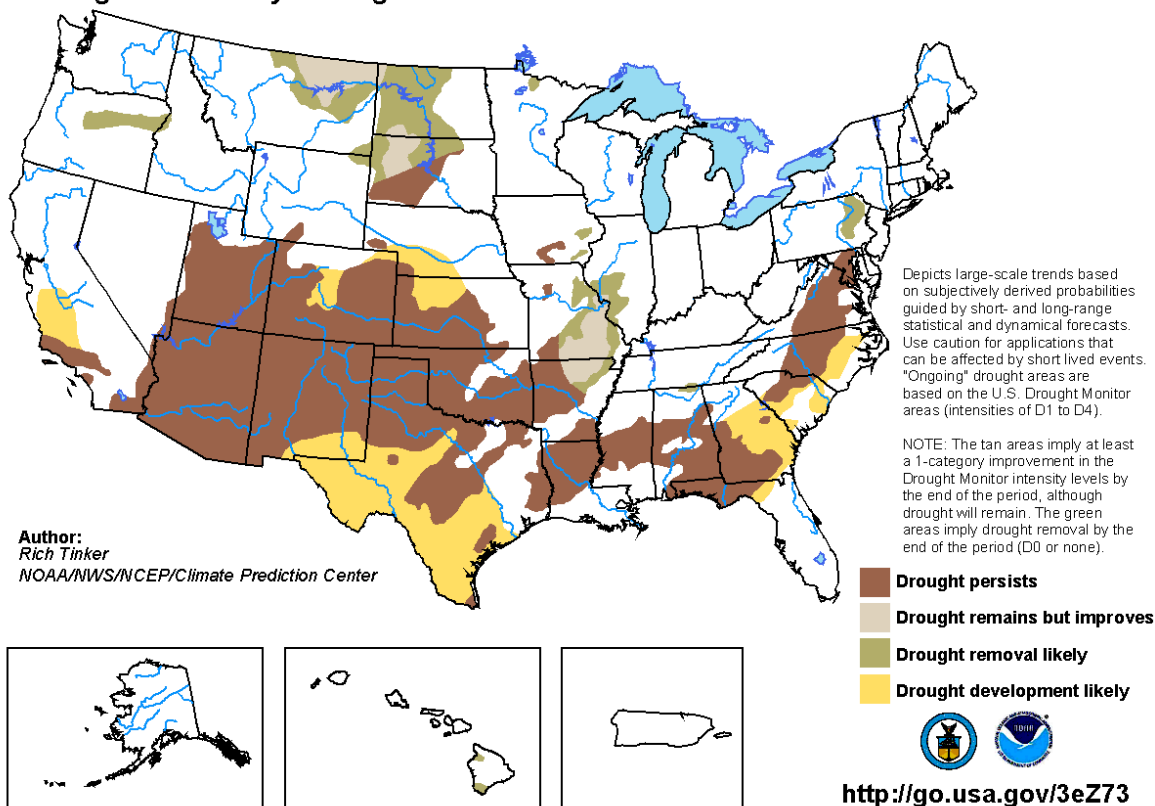


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

## 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 inches of precipitation (left) and percent of normal precipitation (right). In comparison to other months, the Missouri Basin usually receives a very small amount of precipitation in January. **Figure 3** shows that the much of the upper Basin received less than 0.5 inch of precipitation, which is less than 70% of average in the Dakotas. Areas that received between 0.5 and 1.0 inch of precipitation, which is about average precipitation, included central and southern Montana, central and eastern Wyoming, and Nebraska.

November-December-January precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the ongoing above-normal precipitation pattern in the Rocky Mountains of Montana and Wyoming, as well as above-normal precipitation in central Montana and northern Wyoming. Precipitation accumulations greater than 150% of normal have occurred over much of this area, and greater than 200% of normal have occurred in the Upper

Yellowstone Basin and Upper Missouri Basin in Montana. In contrast, North Dakota, South Dakota and much of the lower Basin below Sioux City, IA have received less than 50% of normal precipitation since November 1, 2017.

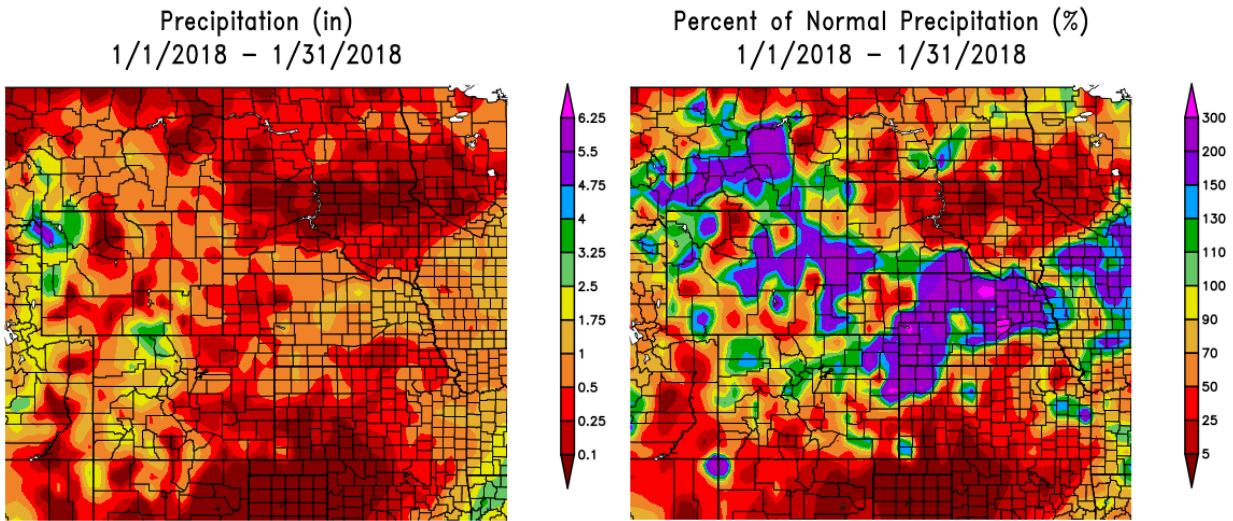


Figure 3. January 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

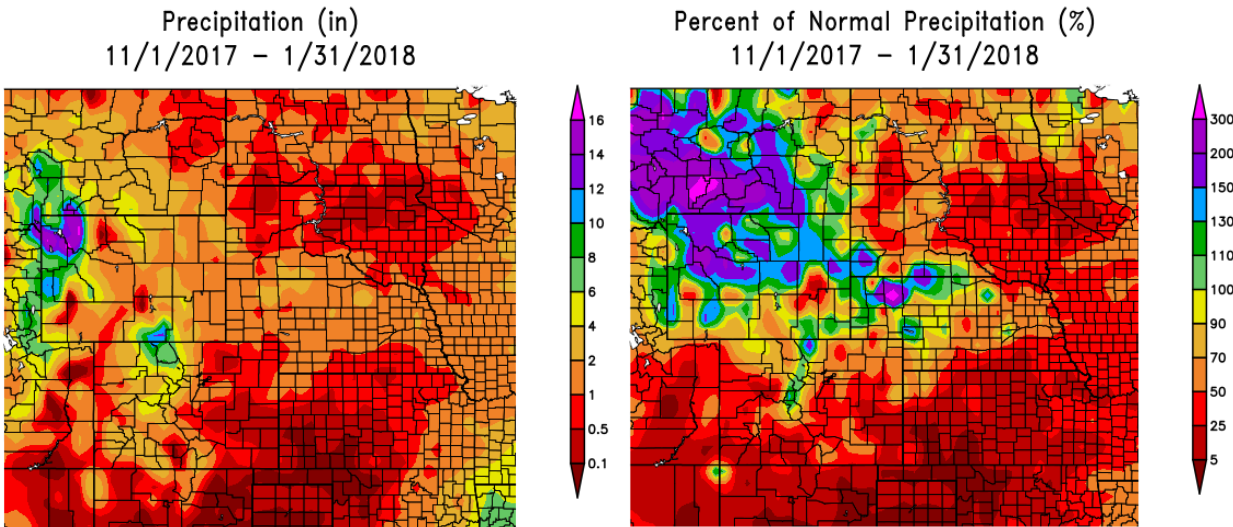


Figure 4. November-December-January 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

January temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** indicate below-normal temperatures extending across northern and central Montana, South Dakota and the lower Basin. Warmer-than-normal temperatures occurred in the Rocky Mountains, and much of North Dakota. November-December-January temperature departures, in the right image of **Figure 5**, were relatively normal. Colder-than-normal temperatures have

occurred over northern Montana, while warmer-than-normal temperatures have been present in the Rocky Mountains in central and southern Wyoming, and Colorado.

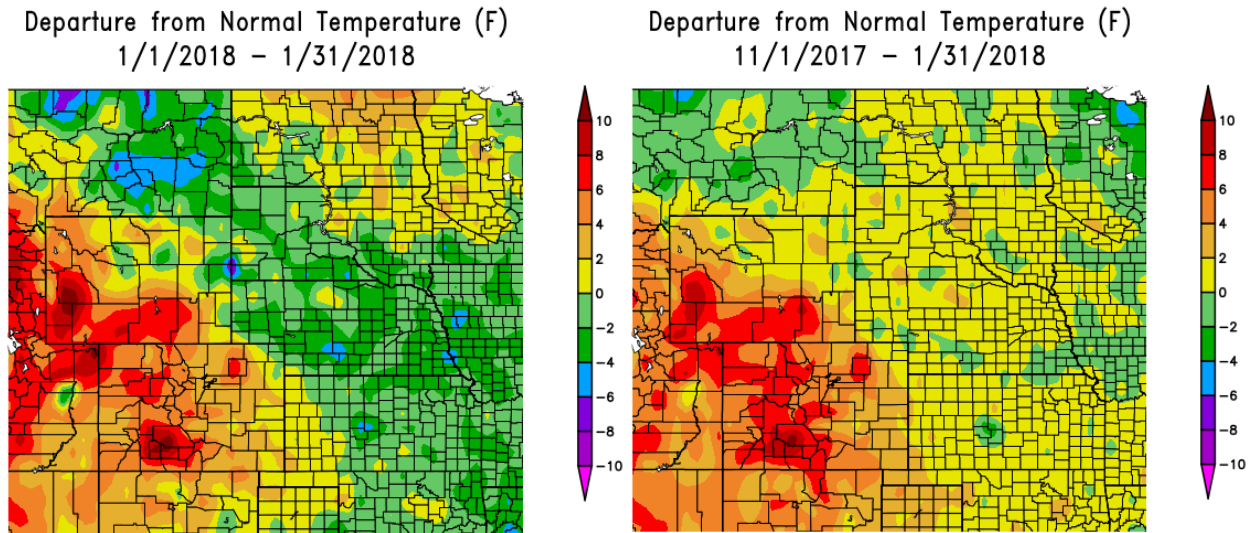


Figure 5. January 2017 and November-December-January 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

### 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.

The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on January 31, 2018. Soil moisture conditions have been a reflection of the precipitation patterns over the past three months. Soil moisture anomalies and percentiles are above normal in western and central Montana, Wyoming, Colorado, eastern South Dakota and central Nebraska. Spring runoff could potentially be above normal under normal winter precipitation and snowfall accumulations due to the above-normal soil moisture conditions in western Montana and Wyoming. In contrast, soil moisture anomalies and percentiles are below normal in North and South Dakota, Kansas, Iowa, and much of Missouri. As a result, spring runoff could potentially be below normal under normal winter precipitation and snowfall accumulations in the Dakotas and the lower Basin.

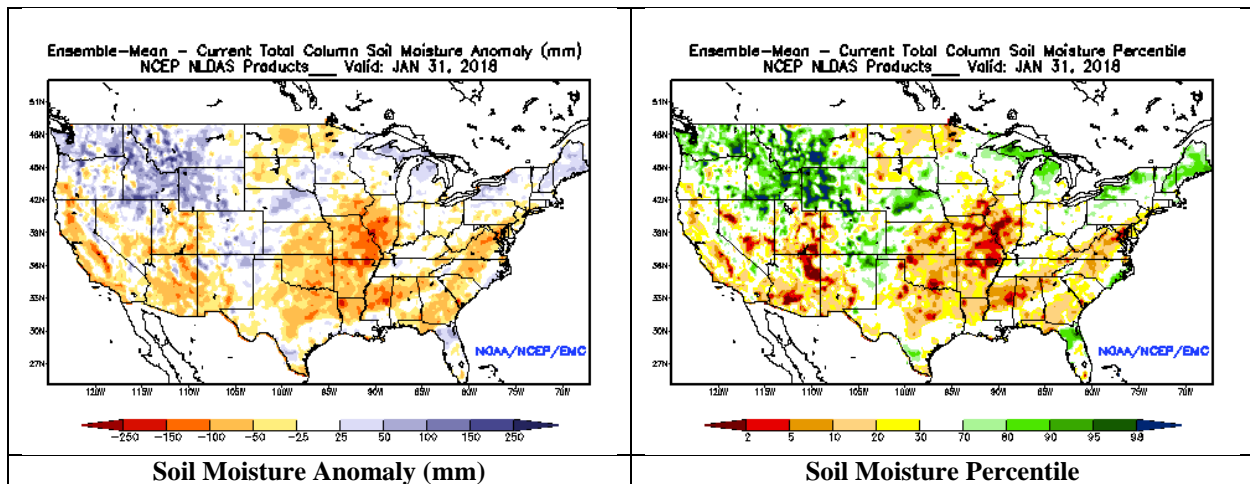


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

## 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 5, shown in **Figure 7**, indicates that Montana has received the greatest plains snowpack accumulations during the winter. As of February 5, 1 to 3 inches of snow water equivalent (SWE) have accumulated in a broad region of Montana. Accumulations of up to 4 inches of SWE extend from Havre, MT to Billings, MT, Miles City, MT, and Sheridan, WY. In the Dakotas, plains SWE generally ranges from trace to 1-inch amounts, though there are slightly greater accumulations in the Upper James Basin, and in a region spanning northeastern Nebraska, southeastern South Dakota, and northwestern Iowa. The lower Basin also had trace to 1-inch snowpack as of February 5.

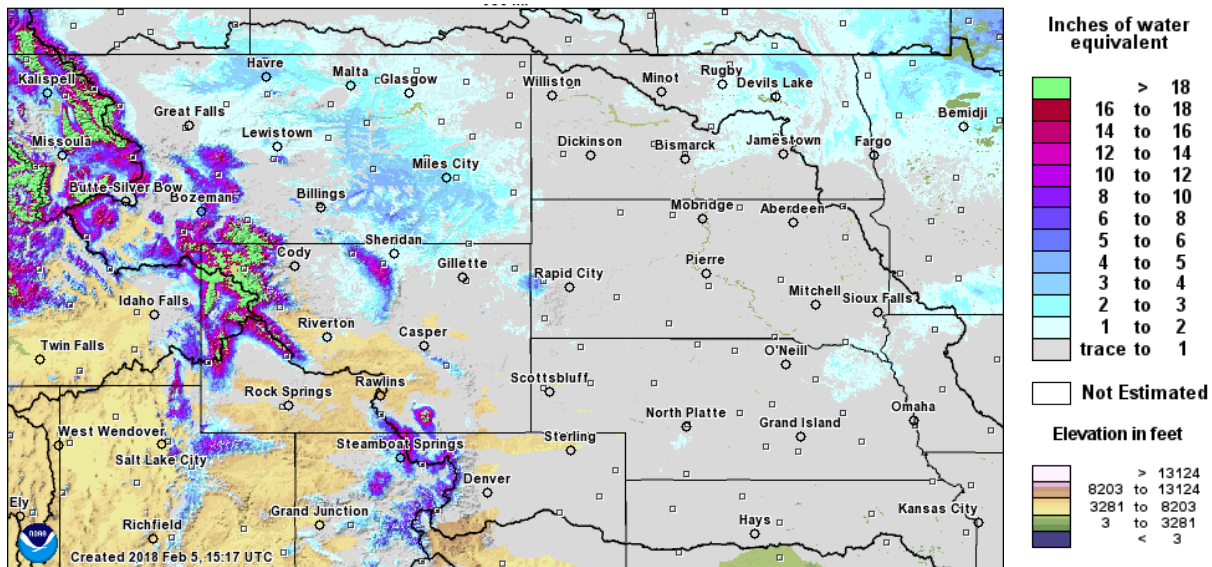


Figure 7. February 5, 2018 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. <http://www.nohrsc.nws.gov/interactive/html/map.html>

### Mountain Snowpack

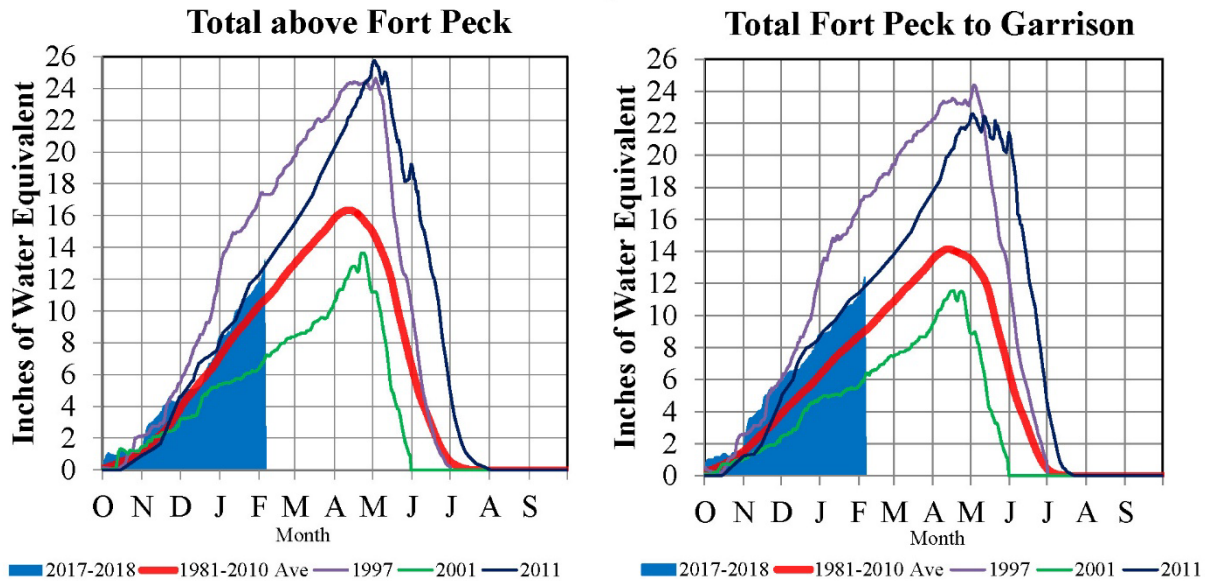
Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. It is typically NOT a factor influencing runoff at the beginning of a calendar year.

**Figure 8** includes time series plots of the average mountain SWE beginning on October 1, 2017 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).

On February 1, 2018, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 11.9 inches, which was 114% 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 11.1 inches, which was 124% of average based on the 1981-2010 average SWE for the Garrison reach. As of February 5, 2018, the average mountain SWE in the Fort Peck reservoir reach was 13.3 inches, which was 124% of average. In the reservoir reach between Fort Peck Dam and Garrison Dam, the average mountain SWE was 12.4 inches, which was 134% of average. Typically by February 1, 64% of the total accumulation has occurred.

# Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

February 5, 2018



The Missouri River Basin mountain snowpack normally peaks near April 15. On February 5, 2018 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 13.3”, 124% of the average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 12.4”, 134% of the average. Normally by February 1, about 64% of the peak mountain SWE has occurred in both reaches.

\*Generally considered the high and low year of the last 20-year period, respectively.

Provisional data. Subject to revision.

**Figure 8. Mountain snowpack water content on February 5, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.**

## 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.

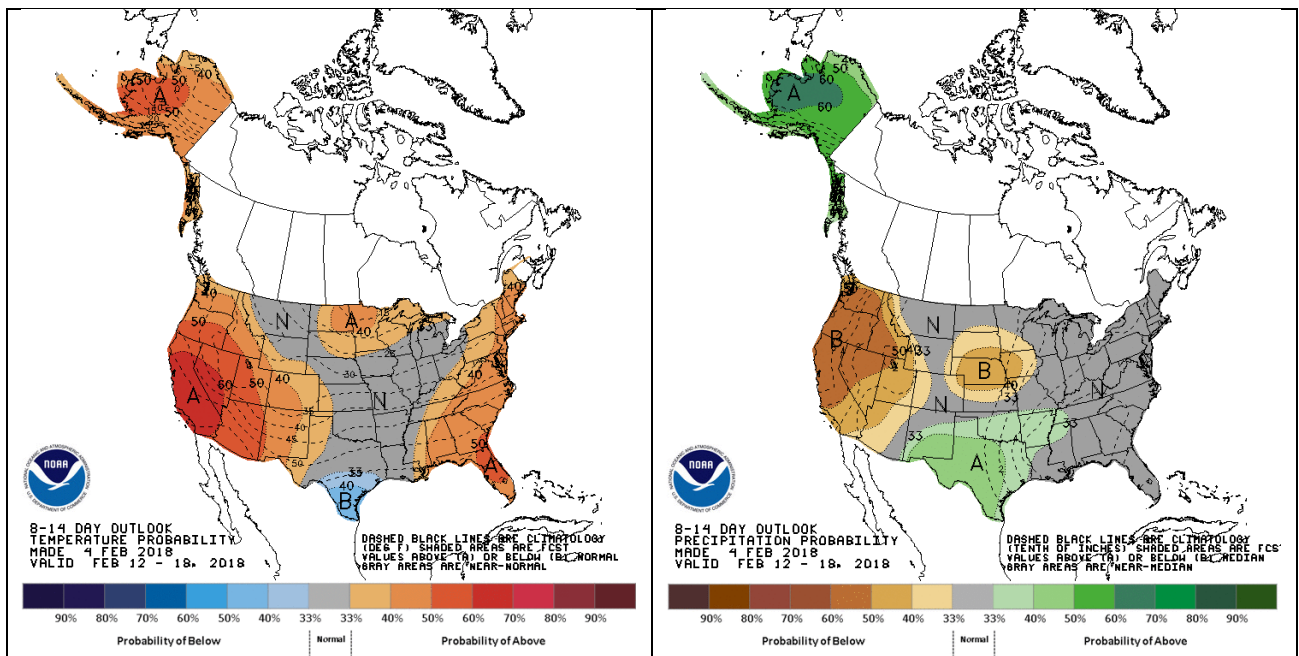
### **ENSO (El Niño Southern Oscillation)**

The latest ENSO Outlook indicates that La Niña conditions are present and likely to persist during the Northern Hemisphere winter, with a transition to ENSO-neutral conditions expected during the spring. During a La Niña phase of ENSO, there are increased probabilities for above-normal precipitation and below-normal temperatures in the upper Missouri Basin during the winter season.

## 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 18 (**Figure 9**) indicates increased chances for above-normal temperatures in the Dakotas, but equal chances for above-normal, normal and below-normal temperatures in the rest of the upper Basin. The precipitation outlook indicates an area of increased chances for below-normal precipitation in an area extending from South Dakota, into Nebraska, northern Kansas and Iowa. There are equal chances in most of Montana, North Dakota and Wyoming.



**Figure 9. CPC 8-14 Day temperature and precipitation outlooks through February 18, 2018.**

The February CPC temperature outlook in **Figure 10** indicates increased chances for below-normal temperatures in eastern Montana, the Dakotas, northeastern Nebraska and Iowa. There is a slight increase in the chances for above-normal temperatures in the Rocky Mountains, and equal chances in all other areas. With regard to precipitation, there are increased chances for above-normal precipitation in the upper Basin centered over Montana. There are equal chances for above-normal, normal and below-normal precipitation in all other areas of the Missouri Basin.

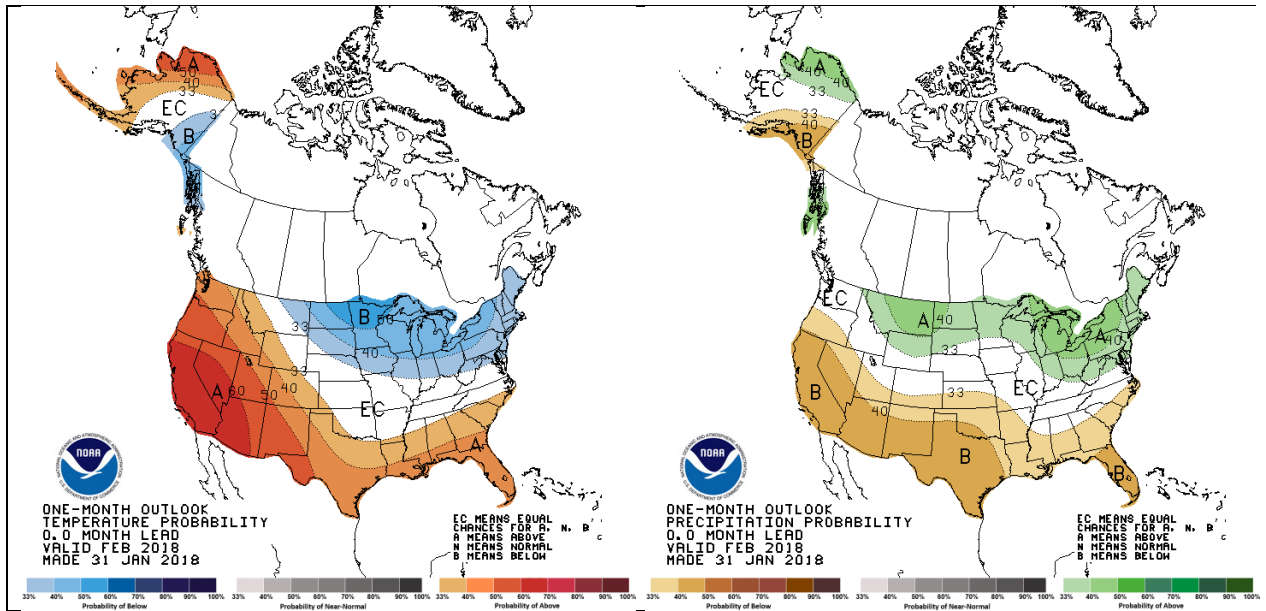


Figure 10. CPC February 2018 temperature and precipitation outlooks.

During the March-April-May 2018 period, the CPC temperature outlook in **Figure 11** indicates mostly equal chances for temperatures across most of the upper Missouri Basin with the exception of a slight increase in the chance for below-normal temperatures in northwestern Montana. There is an increased chance for above-normal temperatures in the lower Basin. With regard to the precipitation outlook, the weak La Niña may slightly increase the chance for above-normal precipitation in Montana, North Dakota and southern South Dakota. There are equal chances for precipitation in all other areas of the upper Basin and much of the lower Basin.

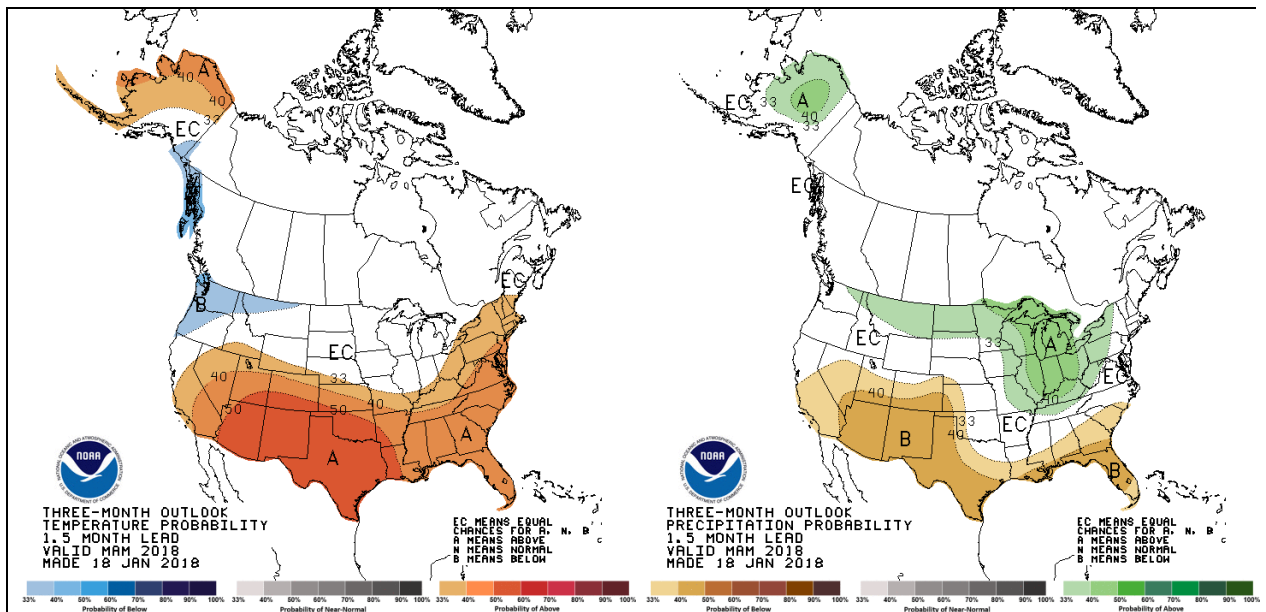


Figure 7. CPC March-April-May 2018 temperature and precipitation outlooks.

During the June-July-August period, CPC outlooks in **Figure 12** indicate increased chances for above-normal temperatures in the upper Basin, although equal chances are indicated in the eastern Dakotas, eastern Nebraska Iowa, and much of Missouri. The precipitation outlook indicates a slight increase in the chances for below-normal precipitation over western Montana and northwestern Wyoming, while there are equal chances for precipitation indicated throughout all of the Missouri Basin.

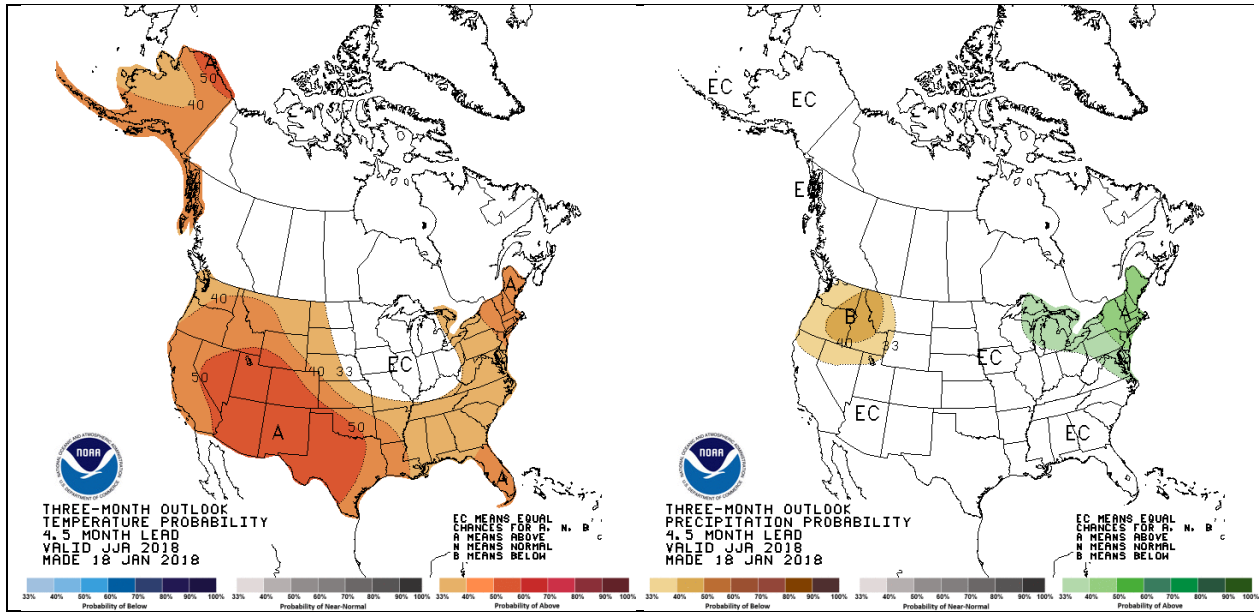
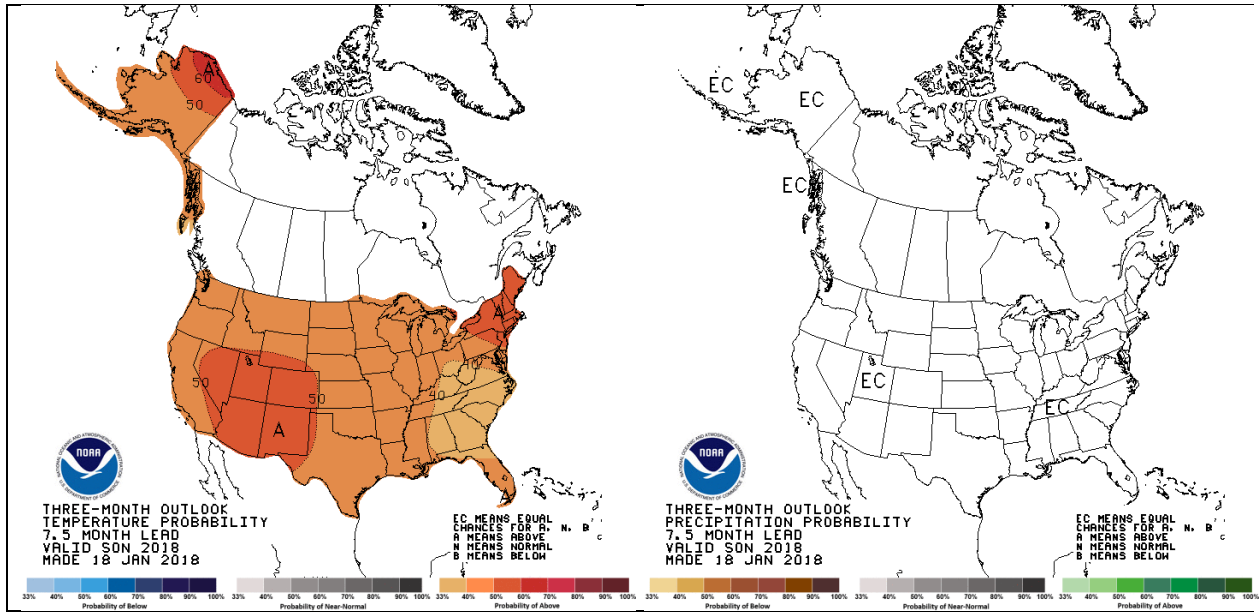


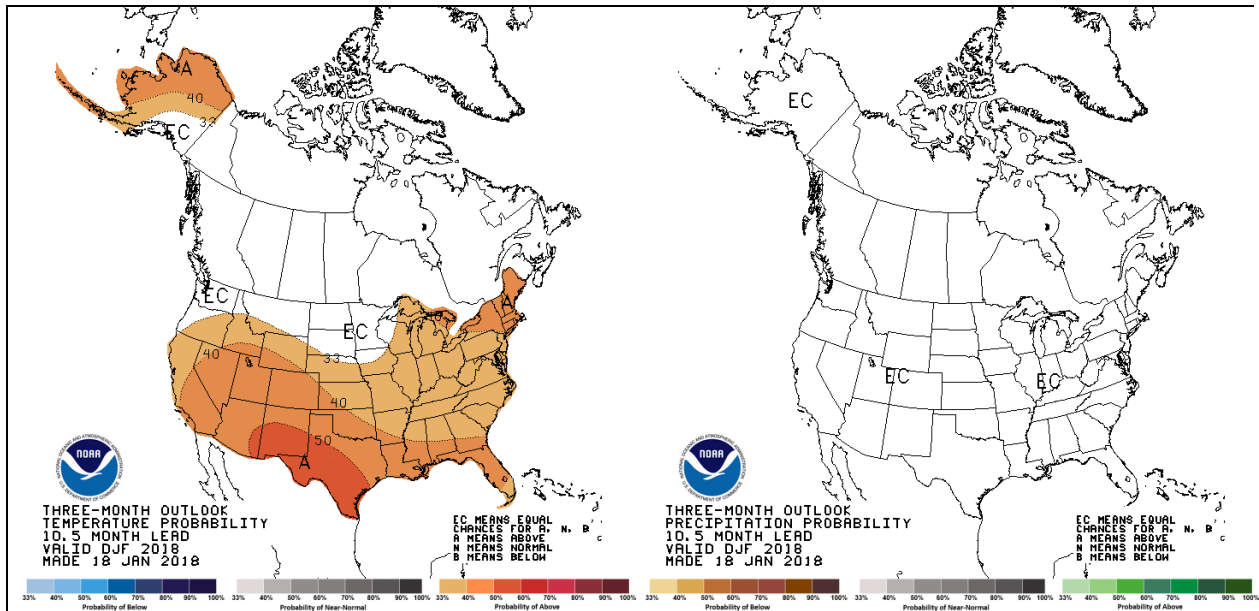
Figure 12. CPC June-July-August 2018 temperature and precipitation outlooks.

During the September-October-November period, CPC outlooks in **Figure 13** indicate increased chances for above-normal temperatures in the Missouri Basin, and equal chances for precipitation.



**Figure 13. CPC September-October-November 2018 temperature and precipitation outlooks.**

During the December 2018-January-February 2019 period, CPC outlooks in **Figure 14** also indicate equal chances for temperatures in Montana and the Dakotas, and a slight increase in the chance for above-normal temperatures in all other areas of the Missouri Basin. There are equal chances for precipitation. The average runoff forecast from August through December 2018 is a reflection of the equal chances precipitation outlook during this same time period.

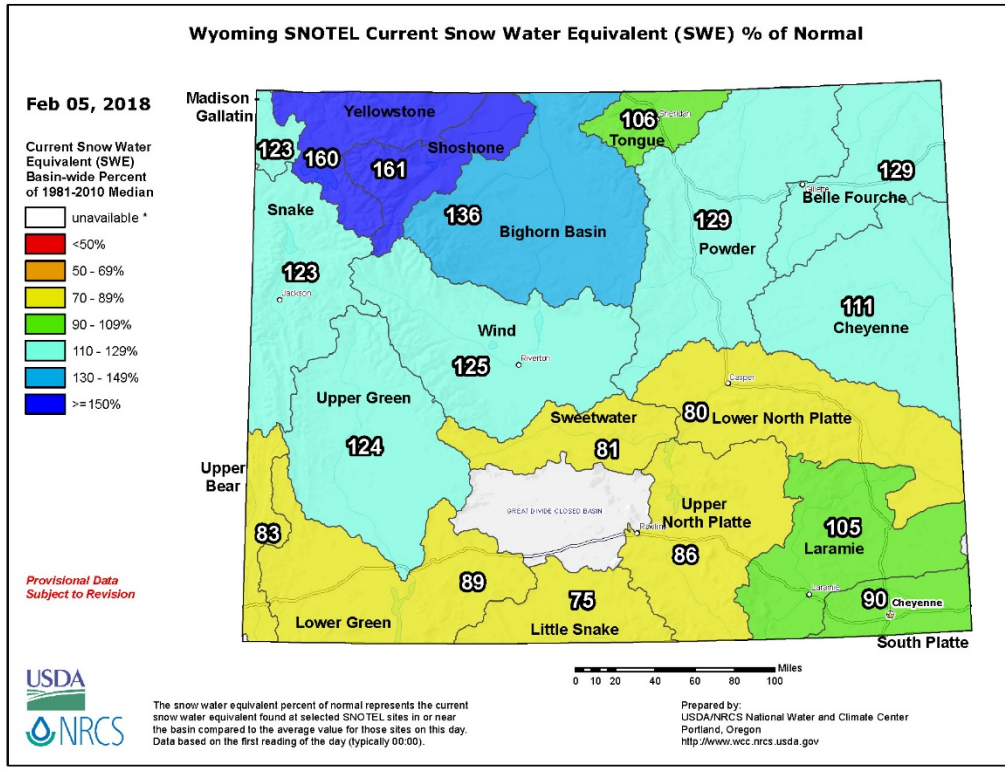
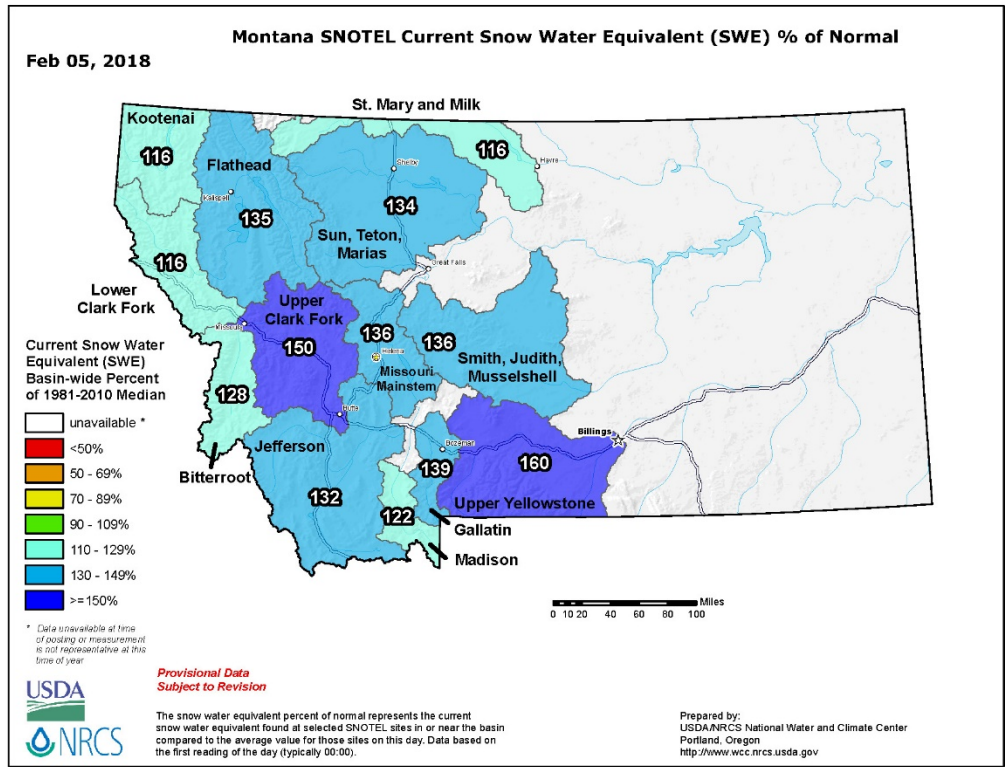


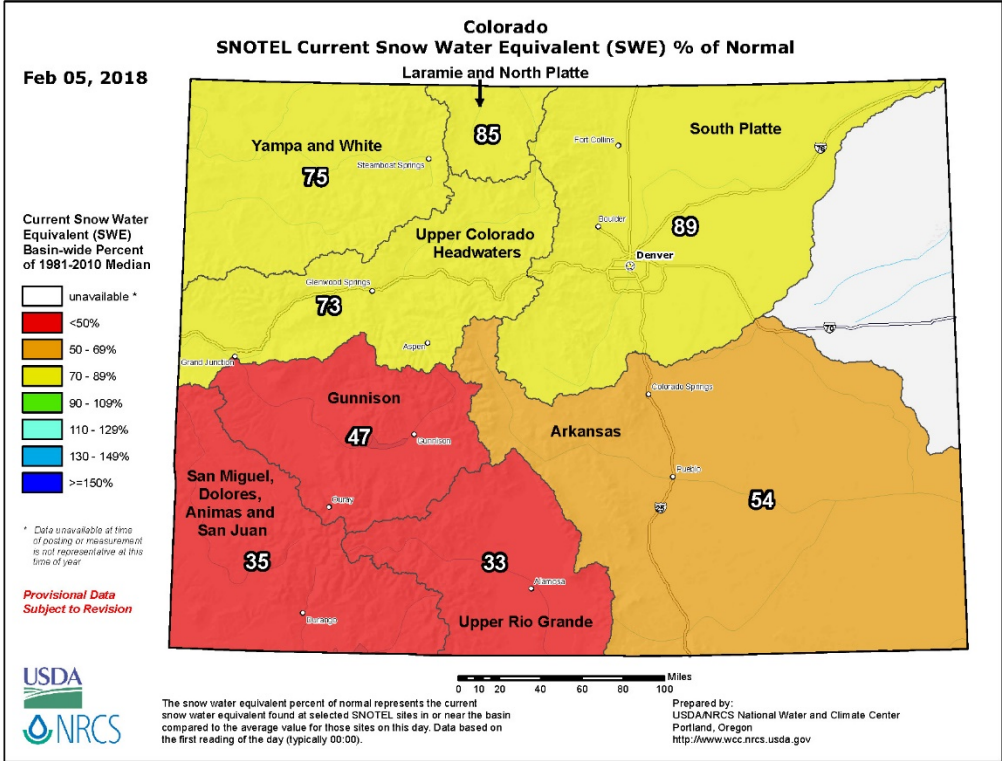
**Figure 14. CPC December 2018-January-February 2019 temperature and precipitation outlooks.**

## **Summary**

In summary, the 2018 calendar year runoff forecast is **26.4 MAF, 104% of average**. Above-average runoff is forecast to continue in February. In March and April, the plains snowpack in Montana is forecast to result in above-average runoff in the Fort Peck and Garrison reaches; however, drought conditions in the Dakotas could result in below-average runoff in the lower reaches. May through July runoff in the Fort Peck and Garrison reaches will be influenced by the above-average mountain snowpack in both reaches. As noted in the Climate Outlook section, average runoff is forecast from August to December based on the equal chances forecast for precipitation during the same time period.

# Additional Figures





USDA NRCS National Water & Climate Center

\* - DATA CURRENT AS OF: February 05, 2018 05:36:53 PM

- Based on February 01, 2018 forecast values

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Wind R ab Bull Lake Ck	APR-JUL	650	143	805	715	585	495	455
	APR-SEP	710	145	880	780	645	545	490
Bull Lake Ck nr Lenore (2)	APR-JUL	157	113	191	170	143	123	139
	APR-SEP	190	112	230	205	174	151	169
Boysen Reservoir Inflow (2)	APR-JUL	775	127	1140	925	630	415	610
	APR-SEP	850	128	1230	1000	695	465	665
Greybull R at Meeteetse	APR-JUL	145	111	200	168	122	89	131
	APR-SEP	196	111	260	225	170	131	177
Shell Ck nr Shell	APR-JUL	60	109	75	66	54	45	55
	APR-SEP	72	109	89	79	65	55	66
Bighorn R at Kane (2)	APR-JUL	1070	127	1570	1270	865	565	840
	APR-SEP	1160	128	1700	1380	945	620	905
NF Shoshone R at Wapiti	APR-JUL	680	148	785	720	635	575	460
	APR-SEP	755	147	870	805	710	640	515
SF Shoshone R nr Valley	APR-JUL	305	142	365	330	280	245	215
	APR-SEP	350	143	420	380	325	285	245
Buffalo Bill Reservoir Inflow	APR-JUL	1010	150	1200	1090	930	815	675
	APR-SEP	1110	149	1320	1200	1030	900	745
Bighorn R nr St. Xavier (2)	APR-JUL	1930	140	2550	2180	1680	1310	1380
	APR-SEP	2070	142	2750	2350	1790	1390	1460
Tongue R nr Dayton (2)	APR-JUL	63	73	91	74	51	34	86
	APR-SEP	72	73	104	85	60	41	98
Tongue River Reservoir Inflow (2)	APR-JUL	129	67	235	171	87	25	193
	APR-SEP	147	68	255	191	103	38	215
NF Powder R nr Hazelton	APR-JUL	11.7	129	15.0	13.1	10.4	8.4	9.1
	APR-SEP	12.6	127	16.0	14.0	11.2	9.2	9.9
Powder R at Moorhead	APR-JUL	220	124	355	275	166	86	177
	APR-SEP	240	122	375	295	185	105	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	6.5	105	10.3	8.0	5.0	2.8	6.2
	APR-JUL	5.3	102	8.7	6.7	4.0	1.97	5.2
Pactola Reservoir Inflow (2)	MAR-JUL	24	96	40	30	17.5	8.0	25
	APR-JUL	21	95	36	27	14.7	5.7	22

**Upper Missouri River Basin  
March 2018 Calendar Year Runoff Forecast  
March 6, 2018**

**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 1.1 MAF, 103% of average. Runoff during February was about average in all reaches except the Fort Randall reach, which was below average, and the Sioux City reach, which was well-above average.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on March 1, is **29.0 MAF (115% of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **26.6 MAF (115% 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 39.7 MAF upper basic forecast to the 19.8 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 much wetter or drier conditions, respectively. Given that ten months are being forecast for this March 1 forecast (2 months observed/10 months forecast), the range of wetter-than-expected (upper basic) and drier-

than-expected (lower basic) conditions is attributed to all 6 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 February 27, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows drought conditions in all states of the Missouri Basin and over much of the upper Basin. Severe Drought (D2) conditions are present in northeastern Montana and western South Dakota, while there are Moderate (D1) Drought conditions over a broader area of the upper Basin. Areas in the upper Basin currently not impacted by drought include western and southern Montana and much of Wyoming. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of May, indicates drought is expected to improve in eastern Montana and the western Dakotas with the potential for removal in the broader area of D1 Drought. Drought conditions will very likely persist in North Dakota and northeastern South Dakota.

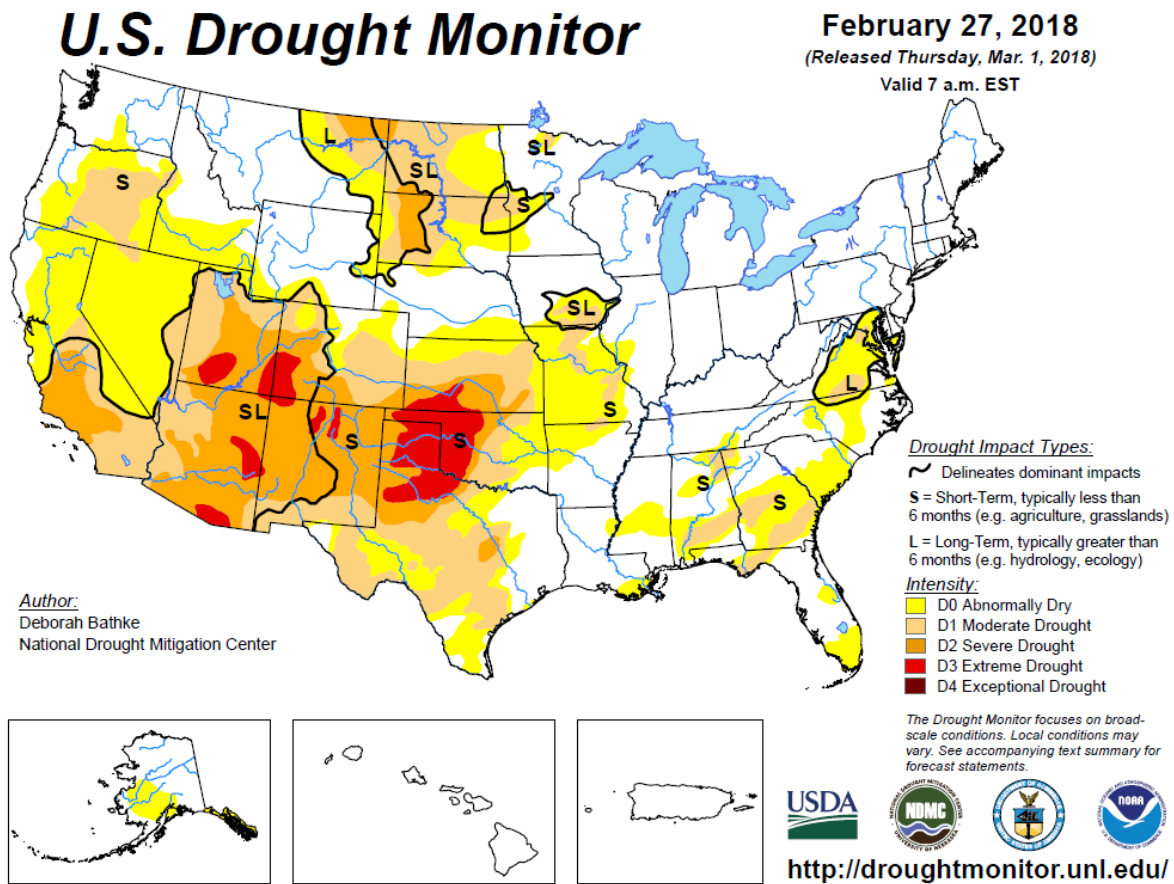


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for February 27, 2018.

## U.S. Seasonal Drought Outlook Drought Tendency During the Valid Period

Valid for February 15 - May 31, 2018  
Released February 15, 2018

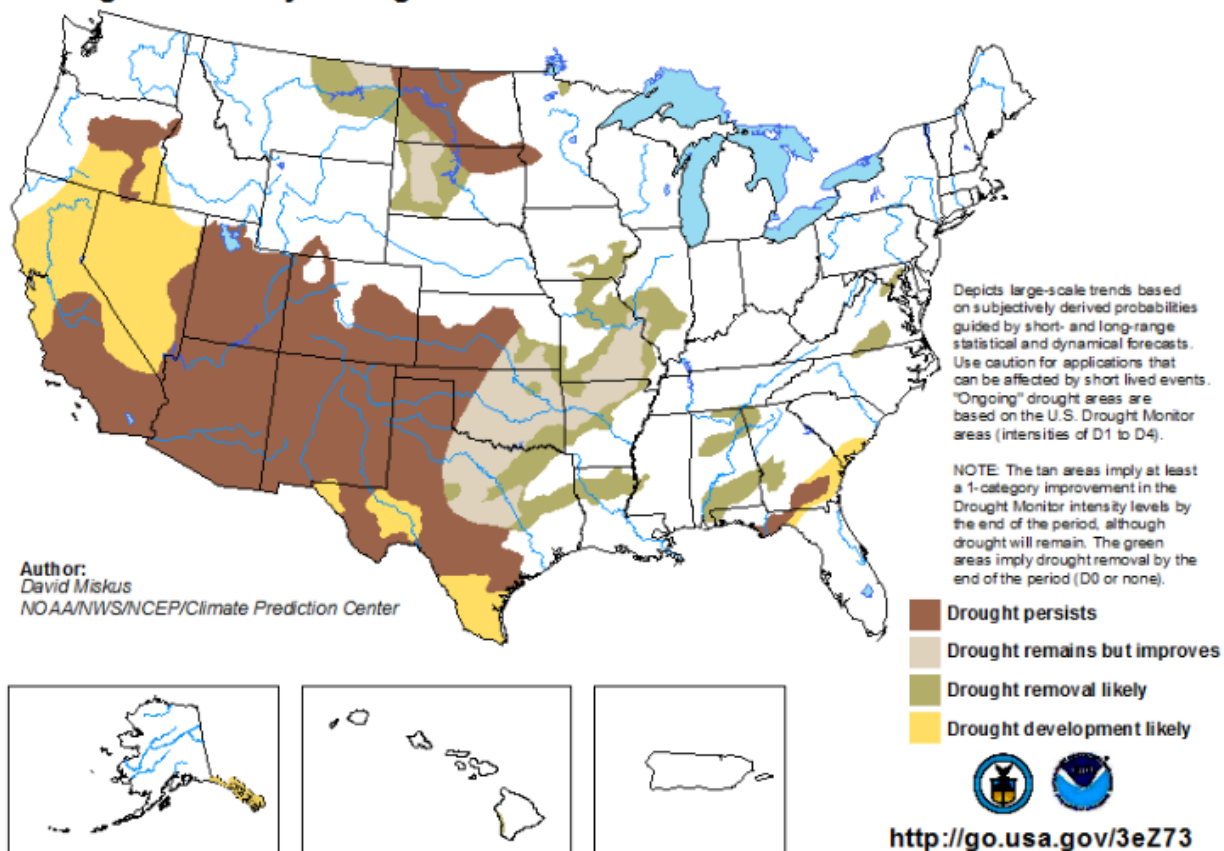


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

### 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 inches of precipitation (left) and percent of normal precipitation (right). In comparison to other months, the Missouri Basin usually receives a very small amount of precipitation in February. **Figure 3** shows that much of the Basin received less than 1.0 inch of precipitation, while areas in the plains of Montana and Wyoming received up to 3.5 inches of precipitation. Montana, Wyoming, western South Dakota, and northern Nebraska received up to 400 percent of normal precipitation in some areas during February.

December-January-February precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the ongoing above-normal precipitation pattern in the Rocky Mountains of Montana and Wyoming, extending into the plains of Montana, Wyoming, South Dakota, and Nebraska. Precipitation accumulations greater than 200% of normal have occurred

over much of this area. In contrast, North Dakota and Kansas have received less than 50% of normal precipitation since December 1, 2017.

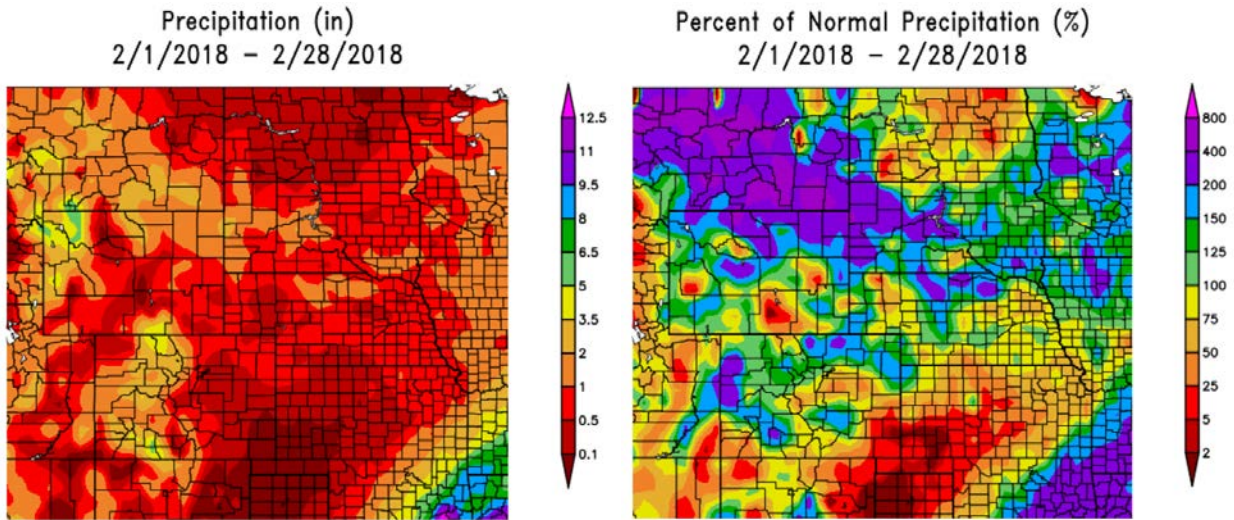


Figure 3. February 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

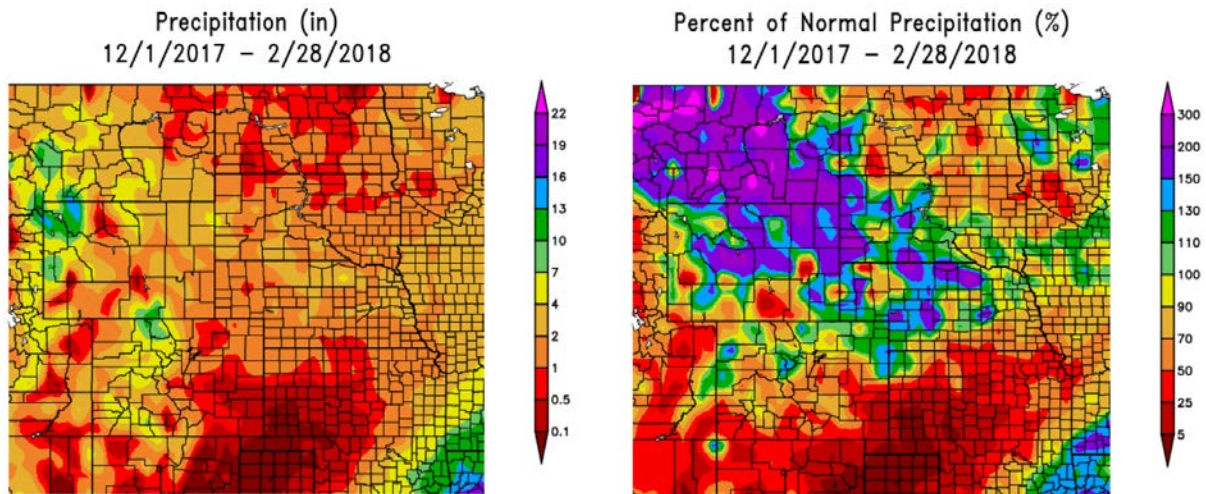


Figure 4. December-January-February 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

February temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** indicate below-normal temperatures extending across the entire Basin, with the exception of some areas in Missouri. December-January-February temperature departures, in the right image of **Figure 5**, reflect the same pattern with colder-than-normal temperatures over the majority of the Basin. Warmer-than-normal temperatures have only been present in southwestern Wyoming and Colorado.

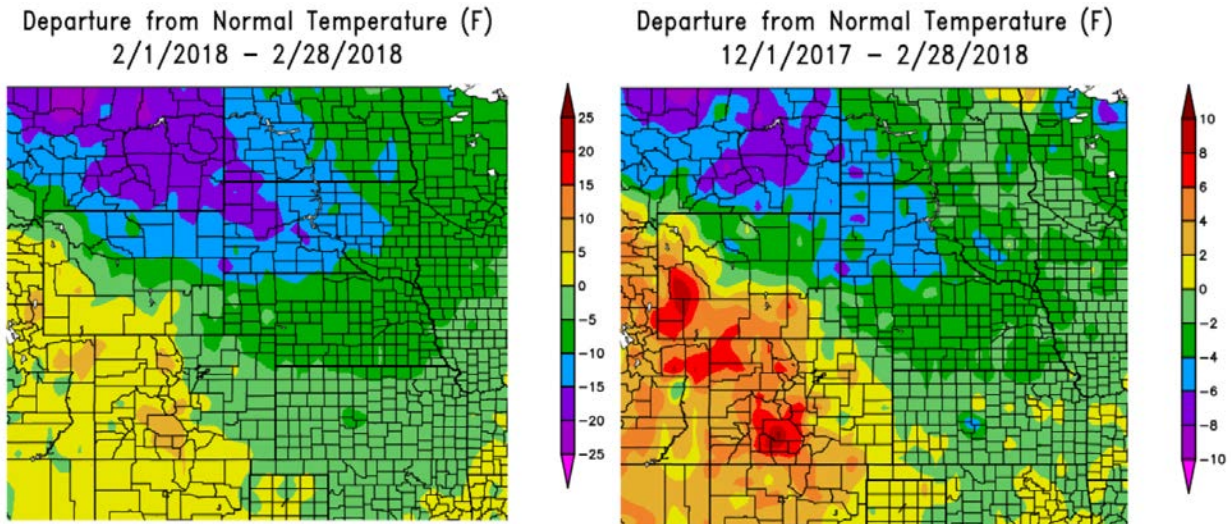


Figure 5. February 2018 and December-January-February 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

### 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.

The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on March 2, 2018. Soil moisture conditions have been a reflection of the precipitation patterns over the past three months. Soil moisture anomalies and percentiles are above normal in western and central Montana, Wyoming, Colorado, eastern South Dakota and Nebraska. Spring runoff could potentially be above normal under normal winter precipitation and snowfall accumulations due to the above-normal soil moisture conditions in western Montana and Wyoming. In contrast, soil moisture anomalies and percentiles are below normal in North and South Dakota, Kansas, Iowa, and Missouri. As a result, spring runoff could potentially be below normal under normal winter precipitation and snowfall accumulations in the Dakotas and the lower Basin.

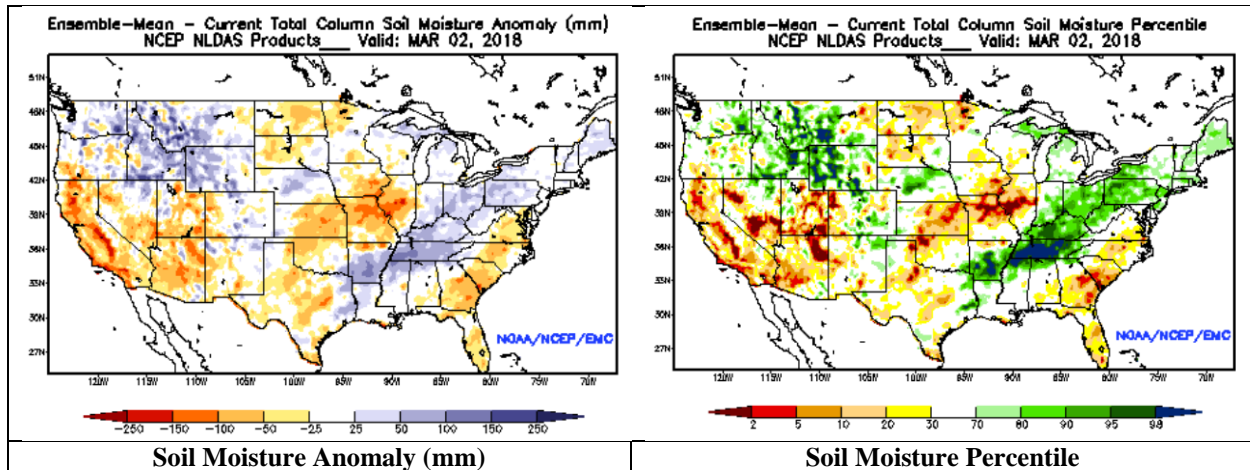


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

### 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 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 5, shown in **Figure 7**, indicates that Montana has received the greatest plains snowpack accumulations during the winter. As of March 5, 2 to 8 inches of snow water equivalent (SWE) have accumulated in areas of Montana. Basin-wide averages are around 2-3 inches for both the Fort Peck and Garrison reaches, based on both the GlobSno and SSMI estimates from the Corps’ Plains Snowpack Assessment Tool under development (see images in **Additional Figures**). In the Dakotas, plains SWE ranges from trace to 4-inch amounts. Nebraska and Iowa had trace to 1-inch amounts of SWE as of March 5<sup>th</sup>, with no snow in the remainder of the lower Basin.

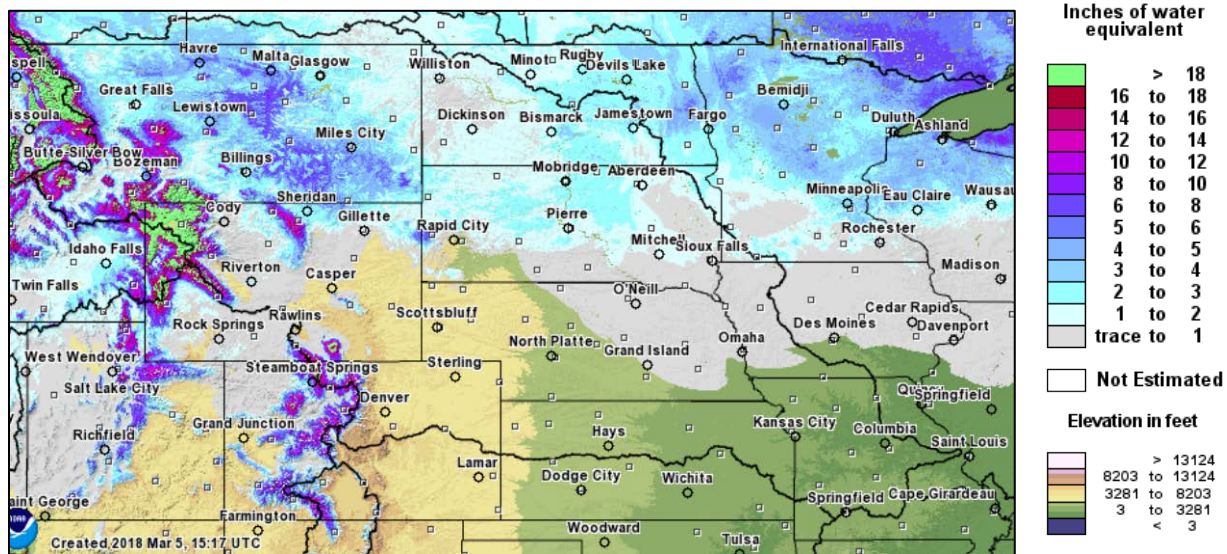


Figure 7. March 5, 2018 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. <http://www.nohrsc.nws.gov/interactive/html/map.html>

## Mountain Snowpack

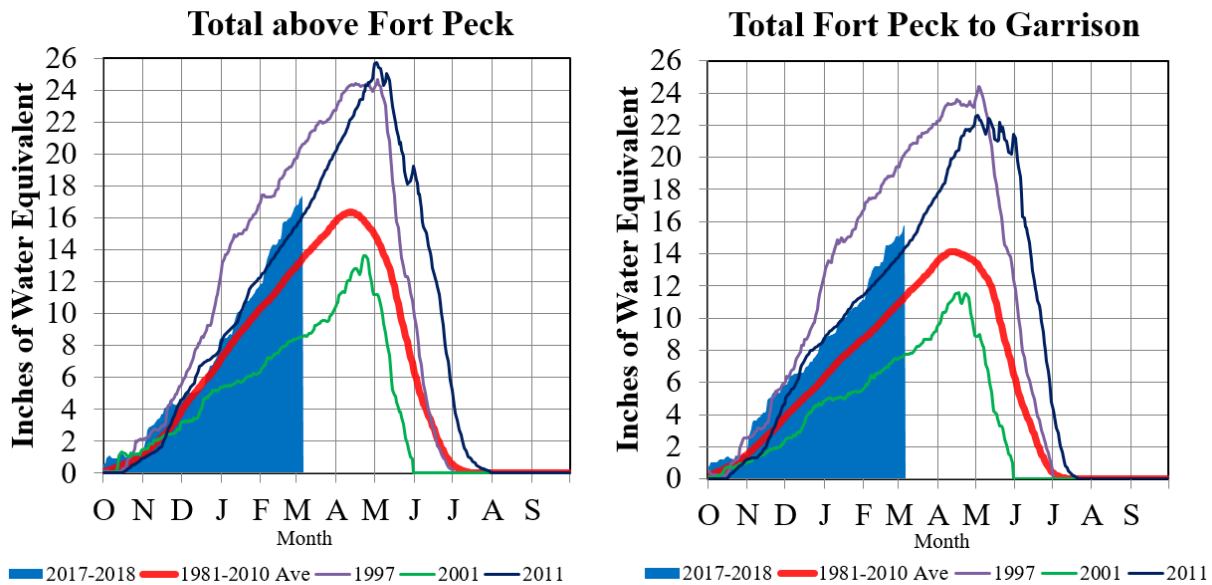
Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. It is typically NOT a factor influencing runoff at the beginning of a calendar year.

**Figure 8** includes time series plots of the average mountain SWE beginning on October 1, 2017 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).

On March 5, 2018, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 17.4 inches, which was 130% 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 15.7 inches, which was 136% of average based on the 1981-2010 average SWE for the Garrison reach. Typically by March 1, 79% of the total accumulation has occurred.

# Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

March 5, 2018



The Missouri River Basin mountain snowpack normally peaks near April 15. On March 5, 2018 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 17.4”, 130% of the average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 15.7”, 136% of the average. Normally by March 1, about 79% of the peak mountain SWE has occurred in both reaches. The March 5, SWE for the “Total Above Fort Peck” reach is 106% of the normal April 15 peak. The March 5, SWE for the “Fort Peck to Garrison” reach is 108% of the normal April 15 peak.

\*Generally considered the high and low year of the last 20-year period, respectively.

Provisional data. Subject to revision.

**Figure 8. Mountain snowpack water content on March 5, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.**

## 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 Niña conditions are present and likely to persist during the Northern Hemisphere winter, with a transition to ENSO-neutral conditions expected during the spring. During a La Niña phase of ENSO, there are increased probabilities for above-normal precipitation and below-normal temperatures in the upper Missouri Basin during the

winter season. ENSO-neutral conditions typically do not effect temperature or precipitation chances for the Missouri River Basin.

### 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 20 (**Figure 9**) indicates increased chances for below-normal temperatures in the upper Basin, with increased chances for above-normal temperatures in the lower Basin. The precipitation outlook indicates increased chances for above-normal precipitation in most of the Basin.

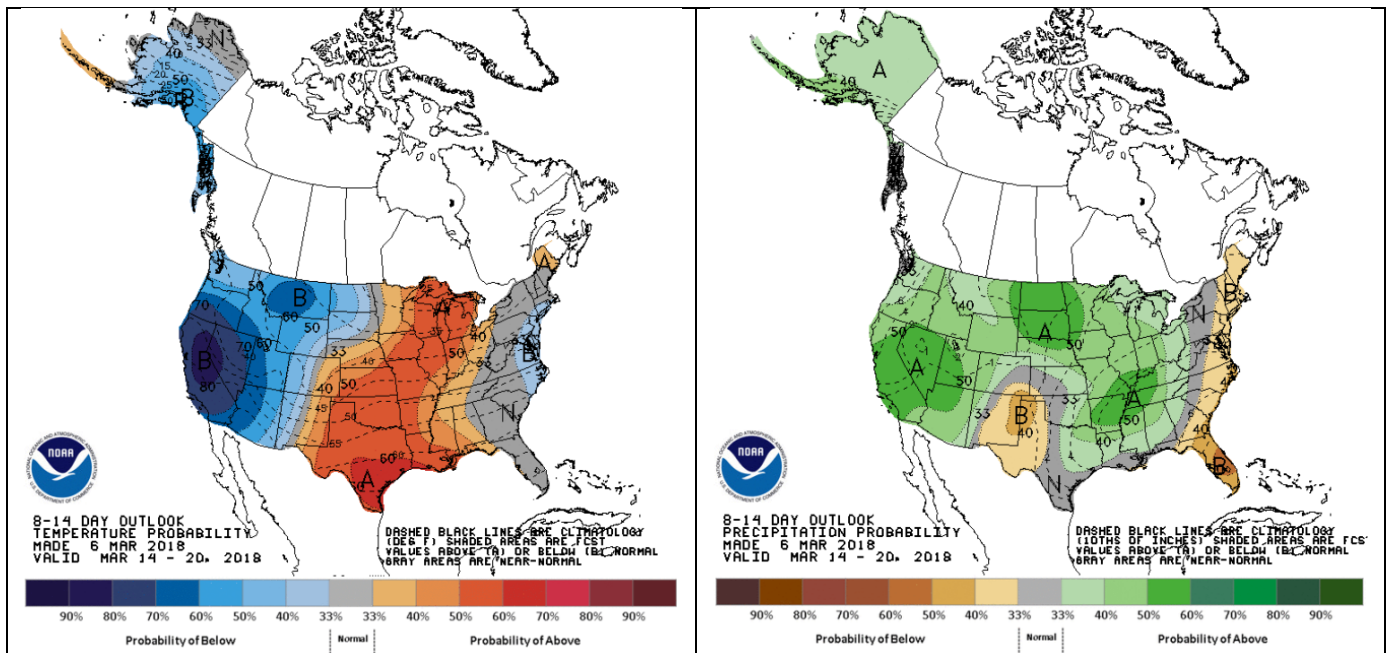


Figure 9. CPC 8-14 Day temperature and precipitation outlooks through March 20, 2018.

The March CPC temperature outlook in **Figure 10** indicates increased chances for below-normal temperatures in Montana, the Dakotas, and Wyoming. There is a slight increase in the chances for above-normal temperatures in Nebraska, Colorado, Kansas, Iowa, and Missouri. With regard to precipitation, there are increased chances for above-normal precipitation in Montana, the Dakotas, Iowa, and Missouri. There is an increased chance for below-normal precipitation in Colorado, extending slightly into Wyoming, Nebraska, and Kansas.

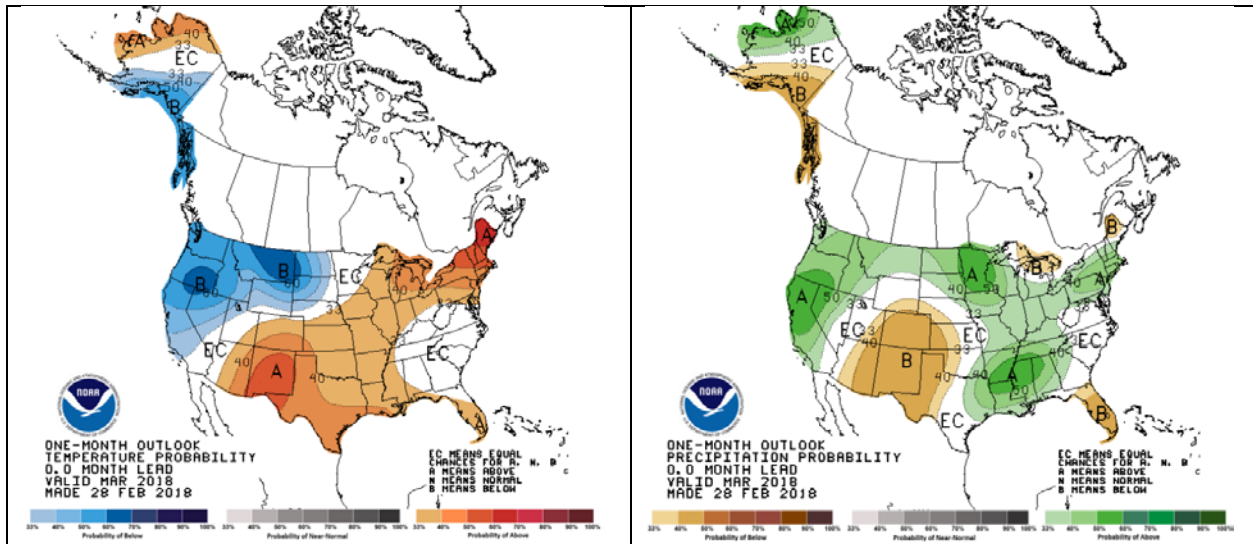


Figure 10. CPC March 2018 temperature and precipitation outlooks.

During the April-May-June 2018 period, the CPC temperature outlook in **Figure 11** indicates equal chances for temperatures across most of the upper Missouri Basin with an increase in the chance for above-normal temperatures in the lower Basin. With regard to the precipitation outlook, the weak La Niña may slightly increase the chance for above-normal precipitation in Montana and North Dakota. There are equal chances for precipitation in most other areas of the Basin.

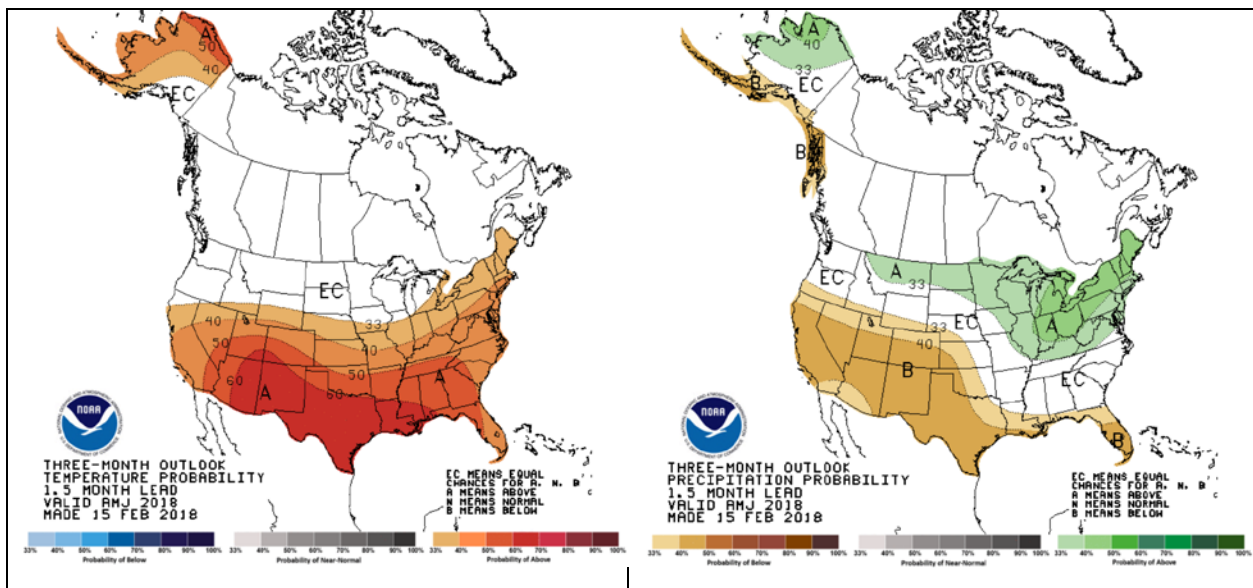


Figure 7. CPC April-May-June 2018 temperature and precipitation outlooks.

During the July-August-September period, CPC outlooks in **Figure 12** indicate increased chances for above-normal temperatures in most of the Basin, although equal chances are indicated in the Dakotas and northwestern Iowa. The precipitation outlook indicates a slight

increase in the chances for below-normal precipitation over Nebraska and Kansas, extending into the surrounding states slightly.

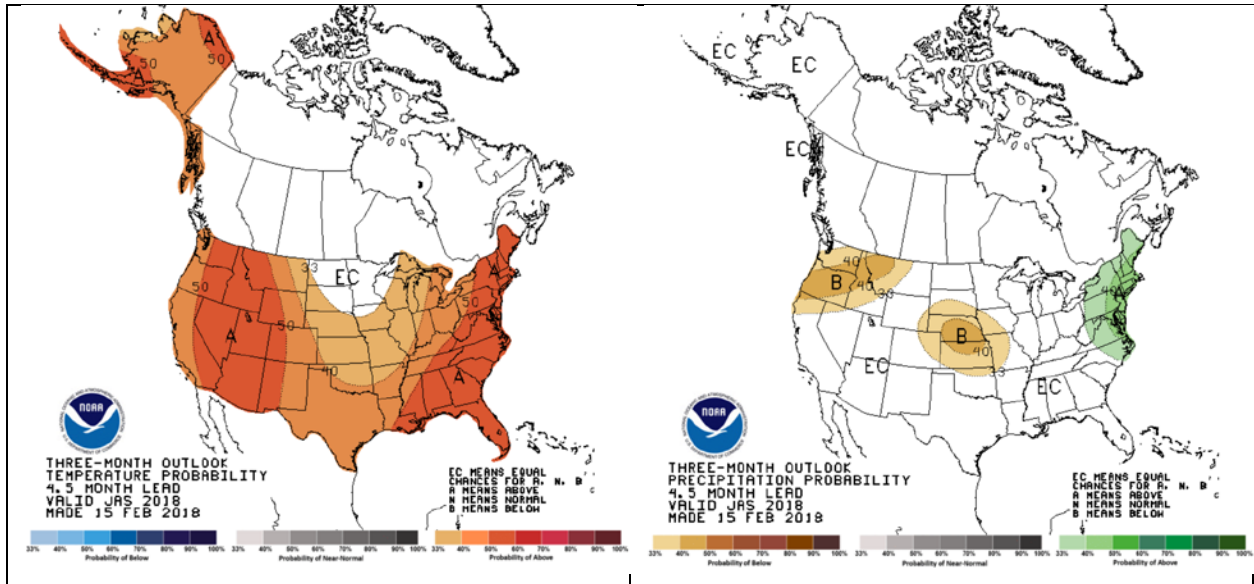


Figure 12. CPC July-August-September 2018 temperature and precipitation outlooks.

During the October-November-December period, CPC outlooks in **Figure 13** indicate increased chances for above-normal temperatures in the Missouri Basin, and equal chances for precipitation.

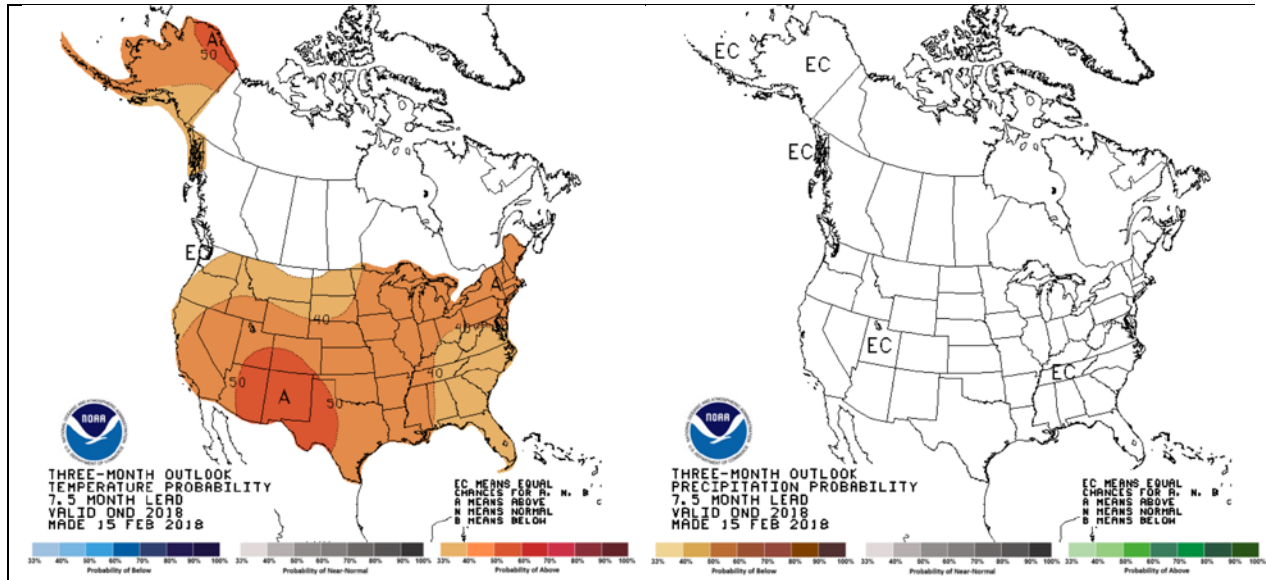


Figure 13. CPC October-November-December 2018 temperature and precipitation outlooks.

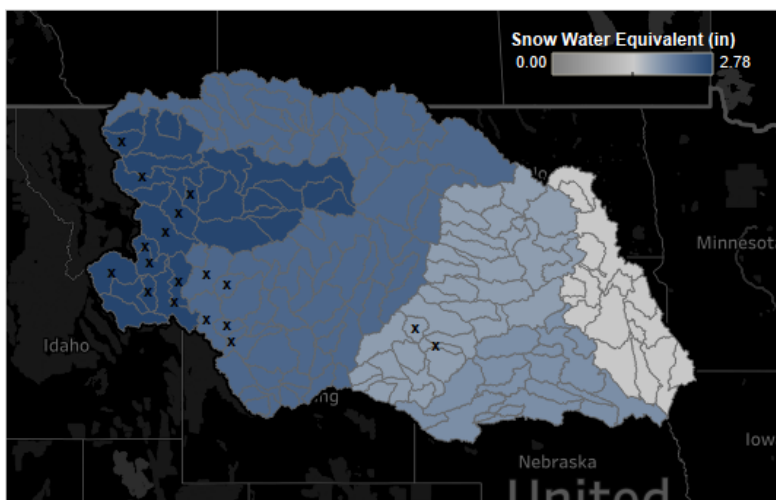
## Summary

In summary, the 2018 calendar year runoff forecast is **29.0 MAF, 115% of average**. During the March-April runoff season, runoff is expected to be above average for the Fort Peck and Garrison reaches as the plains snowpack melts. The forecast for May through July runoff in the Fort Peck and Garrison reaches – the two reaches that are affected by mountain snowpack – is mostly influenced by the above-average mountain snowpack in both reaches, as well as the above-normal precipitation outlook for Montana and the current soil moisture content. For the lower four reaches - Oahe to Sioux City - near average runoff is forecast for the March through July period, based on plains snowpack, soil moisture conditions, precipitation outlooks and current runoff trends. Average runoff is forecast for the entire Basin from September through December, since runoff during this period is based on precipitation events which are difficult to predict more than a week or so in advance.

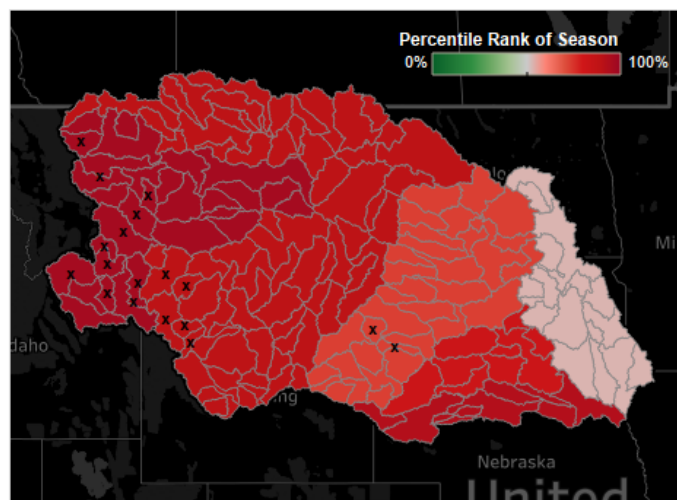
## Additional Figures

### Missouri River Basin Snow Water Equivalent GlobSnow Satellite-based estimates of SWE by HUC-8 and river reaches

BASIN-AVERAGED MAXIMUM SWE FOR THE WEEK ENDING 2018-02-24



PERCENTILE RANK OF SEASON FOR 2018-02-24



Choose Dataset:  
GlobSnow

Display Data by:  
REACH

Select a Date to Display:  
2018-02-24

Include Lewis and Clark Lake  
HUC (10170101) in Reach:  
Fort Randall to Gavins Point

"x" marks in maps and  
red values in tables  
indicate HUCs with greater  
SWE uncertainty due to:

- mountainous terrain
- heavily forested area

**SELECT REACH IN A MAP ABOVE  
TO DISPLAY STATISTICAL CHART**

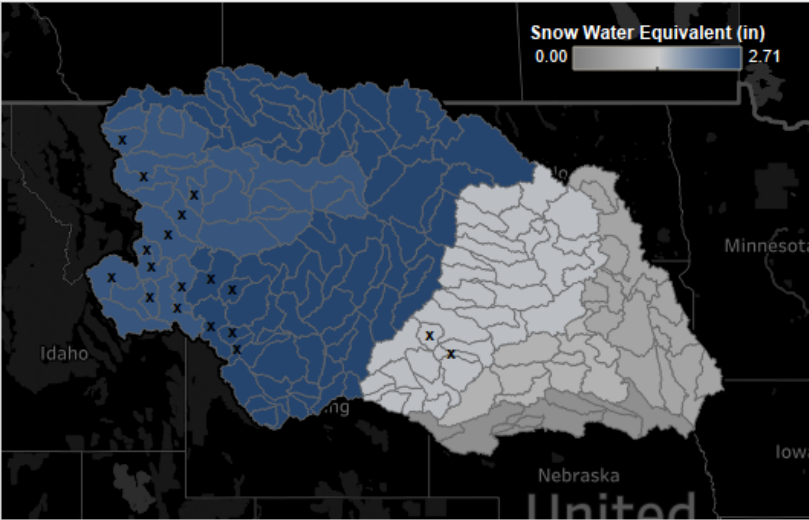
DETAILED DATA FOR 2018-02-24

Region	Basin-Averaged SWE (in)	Percentile Rank of Season	Historical Median SWE (in)	% of Median SWE
Above Fort Peck	2.78	97%	0.92	304%
Fort Peck to Garrison	2.34	90%	1.05	224%
Garrison to Oahe	1.79	73%	0.71	253%
Oahe to Fort Randall	1.93	83%	0.72	269%
Fort Randall to Gavins Point	1.94	93%	0.41	469%
Gavins Point to Sioux City	1.37	53%	1.10	124%

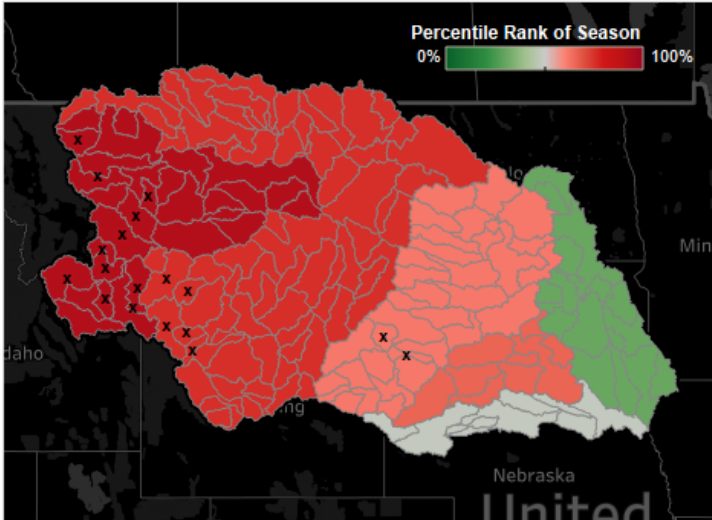
# Missouri River Basin Snow Water Equivalent

SSM/I Satellite-based estimates of SWE by HUC-8 and river reaches

BASIN-AVERAGED MAXIMUM SWE FOR THE WEEK ENDING 2018-02-24



PERCENTILE RANK OF SEASON FOR 2018-02-24



Choose Dataset:  
SSM/I

Display Data by:  
REACH

Select a Date to Display:  
2018-02-24

Include Lewis and Clark Lake  
HUC (10170101) in Reach:  
Fort Randall to Gavins Point

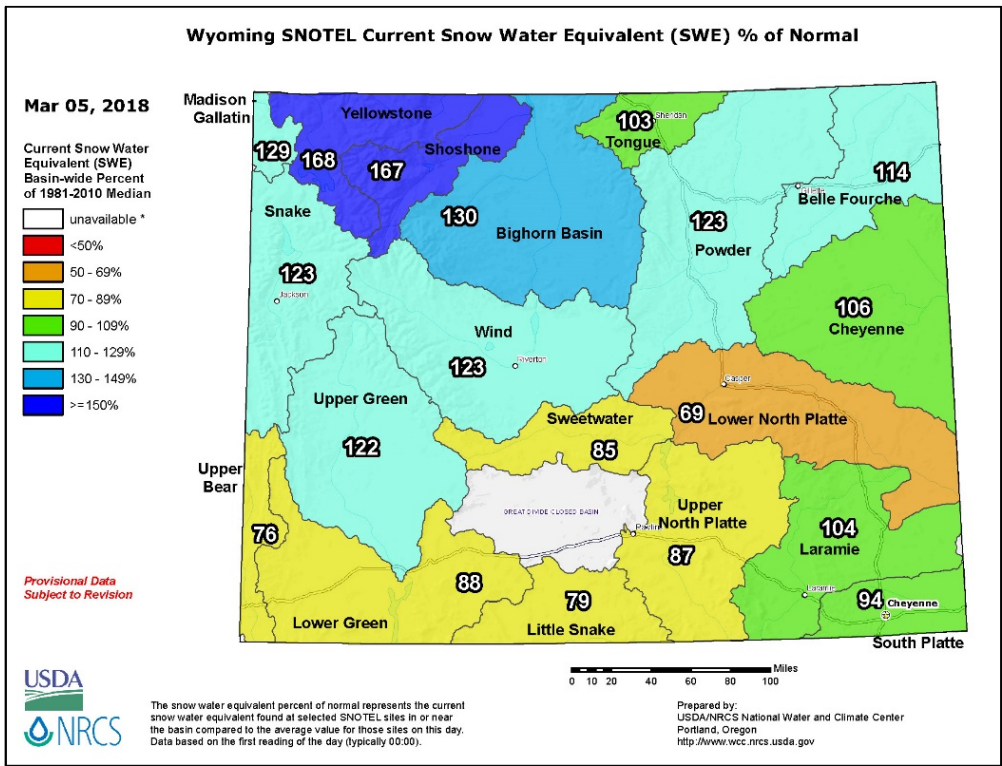
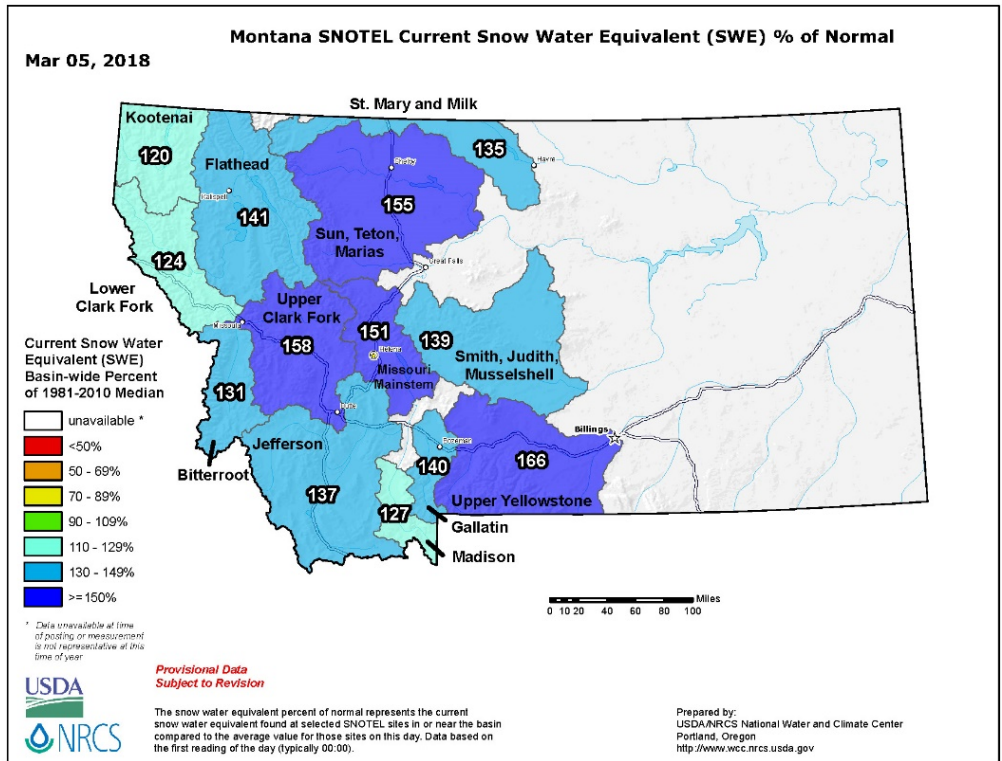
"x" marks in maps and  
red values in tables  
indicate HUCs with greater  
SWE uncertainty due to:

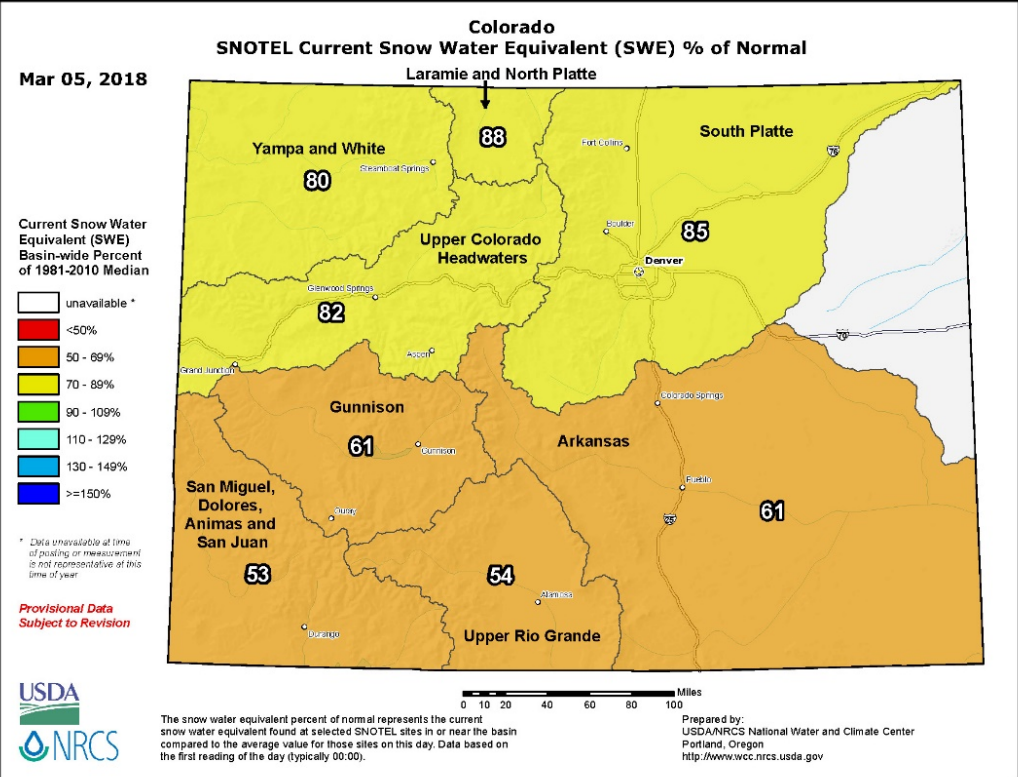
- mountainous terrain
- heavily forested area

**SELECT REACH IN A MAP ABOVE  
TO DISPLAY STATISTICAL CHART**

DETAILED DATA FOR 2018-02-24

Region	Basin-Averaged SWE (in)	Percentile Rank of Season	Historical Median SWE (in)	% of Median SWE
Above Fort Peck	2.48	93%	1.07	230%
Fort Peck to Garrison	2.71	76%	1.20	226%
Garrison to Oahe	1.45	62%	0.99	147%
Oahe to Fort Randall	0.93	66%	0.46	201%
Fort Randall to Gavins Point	0.30	48%	0.30	100%
Gavins Point to Sioux City	0.66	30%	1.05	63%





USDA NRCS National Water & Climate Center

\* - DATA CURRENT AS OF: March 05, 2018 04:04:29 PM

- Based on March 01, 2018 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	113	116	134	121	105	92	97
	APR-SEP	129	115	152	138	120	106	112
St. Mary R at Intl Boundary (2)	APR-JUL	520	120	635	565	475	410	435
	APR-SEP	595	118	720	645	545	475	505
Lima Reservoir Inflow (2)	APR-JUL	56	75	89	69	42	22	75
	APR-SEP	60	75	97	75	44	22	80
Clark Canyon Reservoir Inflow (2)	APR-JUL	75	74	132	98	52	17.9	101
	APR-SEP	92	77	159	119	65	25	120
Jefferson R nr Three Forks (2)	APR-JUL	985	133	1360	1140	835	615	740
	APR-SEP	1040	130	1460	1210	870	620	800
Hebgen Lake Inflow (2)	APR-JUL	415	112	490	445	385	340	370
	APR-SEP	525	112	615	560	490	435	470
Ennis Lake Inflow (2)	APR-JUL	680	109	825	740	620	535	625
	APR-SEP	845	109	1020	915	775	670	775
Missouri R at Toston (2)	APR-JUL	2290	128	2930	2550	2030	1650	1790
	APR-SEP	2600	126	3340	2900	2300	1860	2070
Smith R bl Eagle Ck (2)	APR-JUL	126	119	182	149	103	70	106
	APR-SEP	139	120	205	166	112	73	116
Gibson Reservoir Inflow (2)	APR-JUL	560	142	660	600	520	460	395
	APR-SEP	610	139	720	655	565	500	440
Marias R nr Shelby (2)	APR-JUL	450	125	605	510	390	295	360
	APR-SEP	470	125	630	535	405	310	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	77	131	87	81	73	67	59
	APR-SEP	100	135	112	105	95	88	74
Wind R ab Bull Lake Ck	APR-JUL	650	143	795	710	595	510	455
	APR-SEP	710	145	870	775	645	550	490
Bull Lake Ck nr Lenore (2)	APR-JUL	153	110	187	167	139	119	139
	APR-SEP	186	110	225	200	169	144	169
Boysen Reservoir Inflow (2)	APR-JUL	770	126	1140	920	625	405	610
	APR-SEP	830	125	1220	990	675	440	665
Greybull R at Meeteetse	APR-JUL	141	108	200	165	116	80	131
	APR-SEP	190	107	260	220	161	118	177
Shell Ck nr Shell	APR-JUL	69	125	85	75	63	53	55
	APR-SEP	81	123	98	88	74	64	66
Bighorn R at Kane (2)	APR-JUL	1090	130	1630	1310	870	545	840
	APR-SEP	1170	129	1750	1400	930	580	905
NF Shoshone R at Wapiti	APR-JUL	710	154	815	755	670	605	460
	APR-SEP	790	153	910	840	745	675	515
SF Shoshone R nr Valley	APR-JUL	320	149	375	340	300	265	215
	APR-SEP	370	151	435	395	345	305	245
Buffalo Bill Reservoir Inflow	APR-JUL	1060	157	1250	1140	980	870	675
	APR-SEP	1170	157	1380	1250	1090	960	745
Bighorn R nr St. Xavier (2)	APR-JUL	2000	145	2680	2270	1730	1320	1380
	APR-SEP	2140	147	2890	2440	1840	1390	1460
Little Bighorn R nr Hardin	APR-JUL	88	90	146	111	65	30	98
	APR-SEP	100	90	164	126	74	36	111

Tongue R nr Dayton (2)	APR-JUL	73	85	104	86	61	43	86
	APR-SEP	85	87	118	98	71	51	98
Tongue River Reservoir Inflow (2)	APR-JUL	161	83	270	205	117	52	193
	APR-SEP	184	86	300	230	137	68	215
NF Powder R nr Hazelton	APR-JUL	13.3	146	17.2	14.9	11.8	9.5	9.1
	APR-SEP	14.2	143	18.2	15.8	12.6	10.2	9.9
Powder R at Moorhead	APR-JUL	220	124	365	280	161	75	177
	APR-SEP	245	125	395	305	185	96	196
Powder R nr Locate	APR-JUL	245	123	405	310	183	88	199
	APR-SEP	275	125	445	345	205	107	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	7.2	116	10.9	8.7	5.8	3.6	6.2
	APR-JUL	6.0	115	9.3	7.3	4.7	2.7	5.2
Pactola Reservoir Inflow (2)	MAR-JUL	28	112	44	34	21	11.7	25
	APR-JUL	24	109	40	31	18.2	9.1	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	199	88	325	250	147	72	225
	APR-SEP	220	88	360	275	163	79	250
Encampment R nr Encampment (2)	APR-JUL	92	71	149	115	69	35	129
	APR-SEP	97	70	157	121	73	37	138
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	51	104	68	58	44	33	49
	APR-SEP	54	104	72	61	46	35	52
Seminole Reservoir Inflow (2)	APR-JUL	610	85	975	760	465	245	715
	APR-SEP	660	86	1040	815	505	275	770
Sweetwater R nr Alcova	APR-JUL	34	58	67	48	21	1.70	59
	APR-SEP	38	59	73	52	23	2.3	64
La Prele Ck nr Douglas	APR-JUL	7.9	40	25	15.0	0.75	0.100	19.9
	APR-SEP	8.2	41	26	15.4	1.00	0.100	19.9
North Platte R bl Glendo Reservoir (2)	APR-JUL	635	77	1140	840	430	128	820
	APR-SEP	660	78	1190	875	450	138	850
North Platte R bl Guernsey Reservoir (2)	APR-JUL	630	77	1150	840	420	106	820
	APR-SEP	655	77	1190	870	435	116	850
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	112	97	170	135	89	54	115
	APR-SEP	123	98	186	148	98	60	126
Little Laramie R nr Filmore	APR-JUL	54	106	76	63	45	32	51
	APR-SEP	58	105	82	68	48	34	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 2018 Calendar Year Runoff Forecast  
April 5, 2018**

**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 3.8 MAF, 131% of average in the upper Missouri Basin above Sioux City. Runoff was above average in all reaches except the Oahe reach. About half of the March runoff occurred during the last week of March as a result of plains snowmelt and river ice breakup.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on April 1, is **30.2 MAF (119% of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **27.3 MAF (119% 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 39.8 MAF upper basic forecast to the 21.9 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 much wetter or drier conditions, respectively. Given that 9 months are being forecast for this April 1 forecast (3 months observed/9 months forecast), the range of wetter-than-expected (upper basic) and drier-

than-expected (lower basic) conditions is attributed to all 6 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 March 27, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows drought conditions in all states of the Missouri Basin. Severe Drought (D2) conditions with Long-Term drought impacts are present in northeastern Montana, western South Dakota, and southwestern North Dakota. Moderate (D1) Drought conditions with Short-Term drought impacts cover a broader area northeastern Montana and the western Dakotas, while Abnormally Dry (D0) conditions extend into the eastern Dakotas. In the lower Basin in Kansas, southern Nebraska, Missouri and southern Iowa, drought conditions range from D0 to D2. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of June, indicates drought conditions are expected to improve in isolated areas in northeastern Montana, southwestern North Dakota, and western South Dakota. Drought removal is likely in the larger areas in the upper basin due to snowmelt and forecast precipitation.

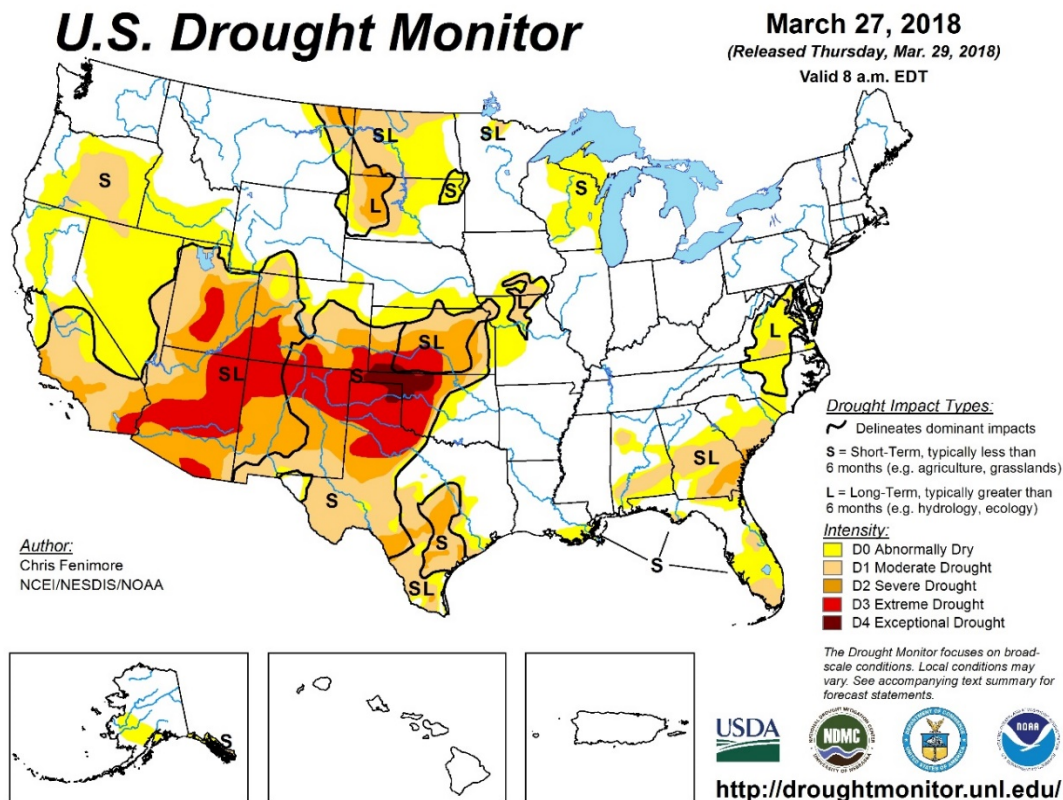


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for March 27, 2018.

**U.S. Seasonal Drought Outlook**  
**Drought Tendency During the Valid Period**

Valid for March 15 - June 30, 2018  
 Released March 15, 2018

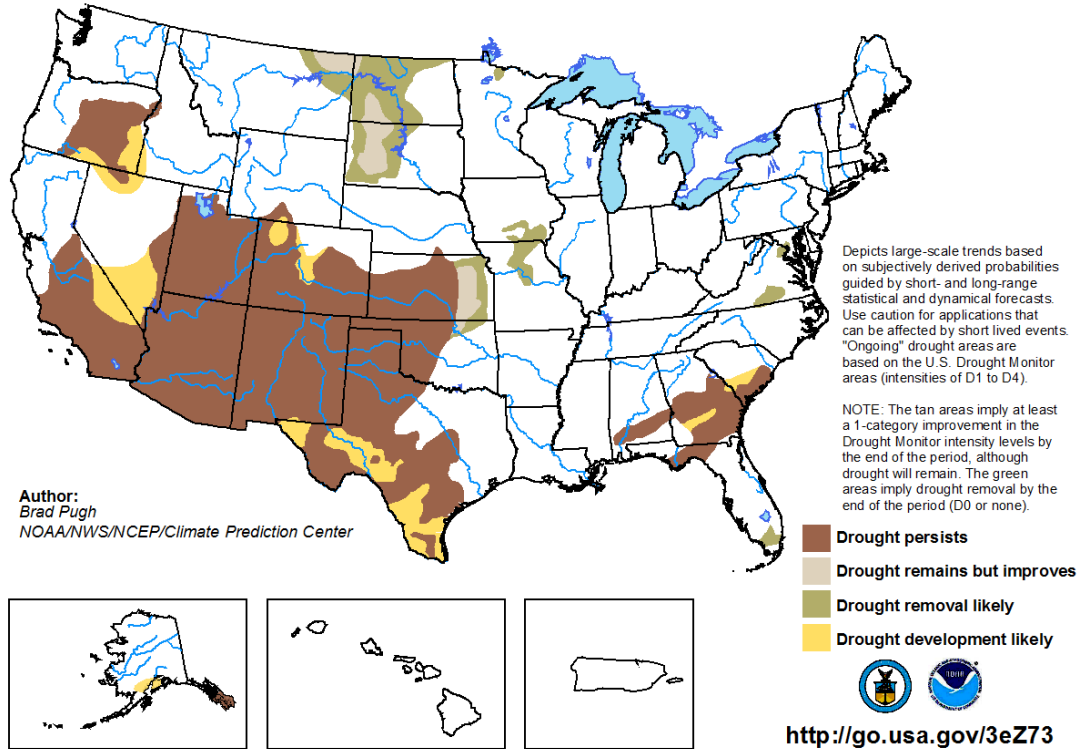


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

**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 inches of precipitation (left) and percent of normal precipitation (right). In comparison to other months, the Missouri Basin usually receives a very small amount of precipitation in March. **Figure 3** shows that much of the Basin received less than 1.0 inch of precipitation, while areas in southwestern Montana, northwestern Wyoming, eastern South Dakota and northwestern Iowa received greater than 2.5 inches of precipitation. As a percent of normal, precipitation was predominantly greater than 100% of normal in the upper Basin, and below normal in the lower Basin (right image of **Figure 3**).

January-February-March precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the ongoing above-normal precipitation pattern in the Rocky Mountains of Montana and Wyoming, extending into central and eastern Montana, northeastern Wyoming, and western North Dakota. Precipitation accumulations greater than 200% of normal have occurred over much of this area. In contrast, southern Nebraska and Kansas have received less than 70% of normal precipitation since January 1, 2018.

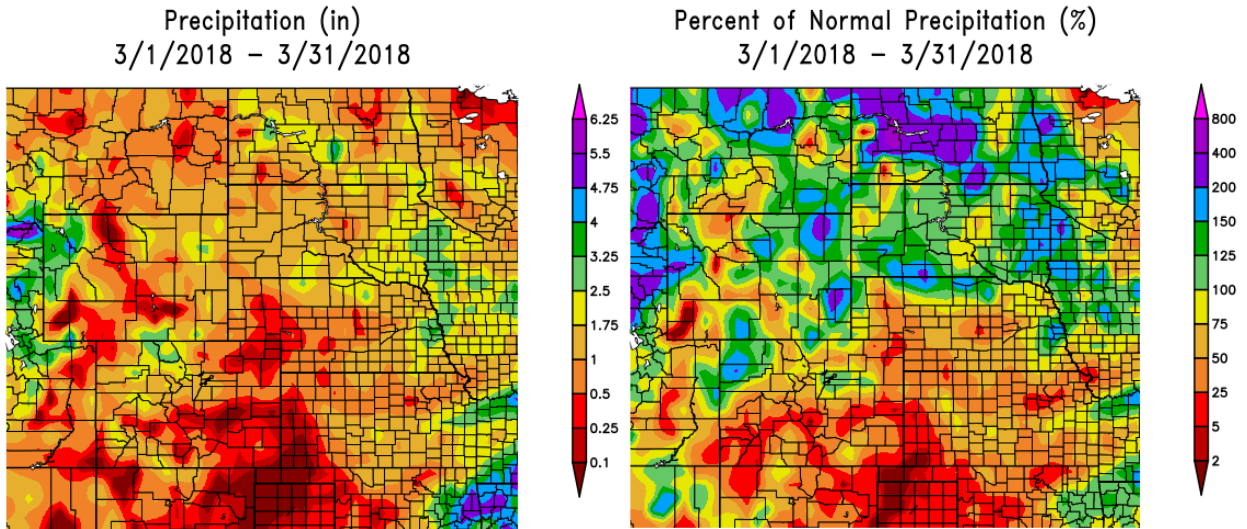


Figure 3. March 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

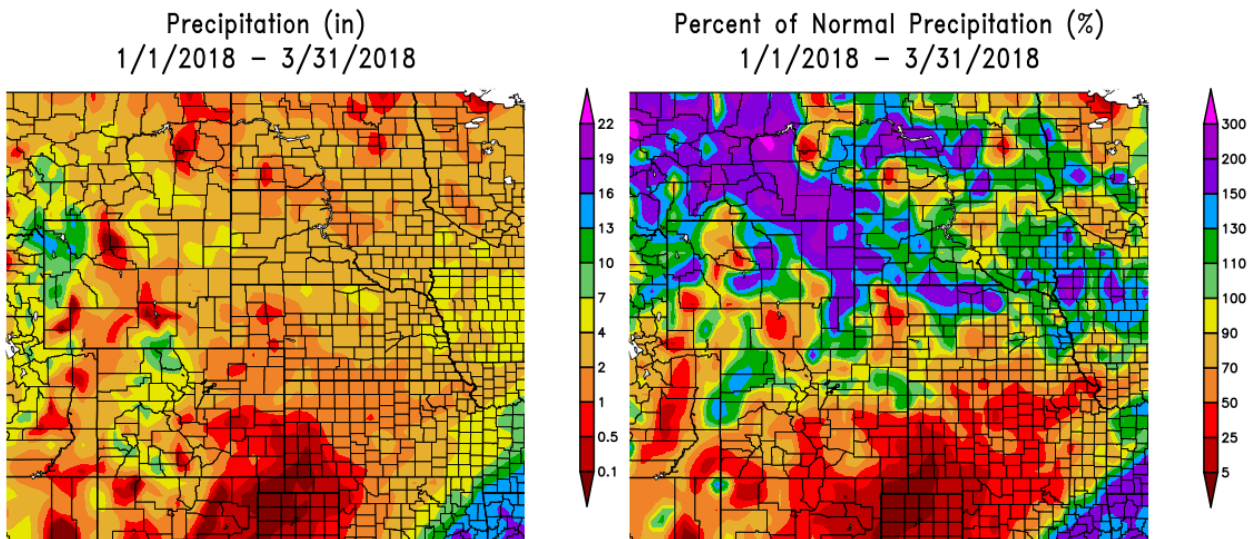


Figure 4. January-February-March 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

March temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** indicate below-normal temperatures extending across the upper Basin, with the exception of central Wyoming. March temperatures in the lower Basin were normal to slightly above normal. January-February-March temperature departures, in the right image of **Figure 5**, reflect a colder-than-normal pattern over the majority of the Basin. Warmer-than-normal temperatures have only been present in southwestern Wyoming and Colorado.

Departure from Normal Temperature (F)  
3/1/2018 – 3/31/2018

Departure from Normal Temperature (F)  
1/1/2018 – 3/31/2018

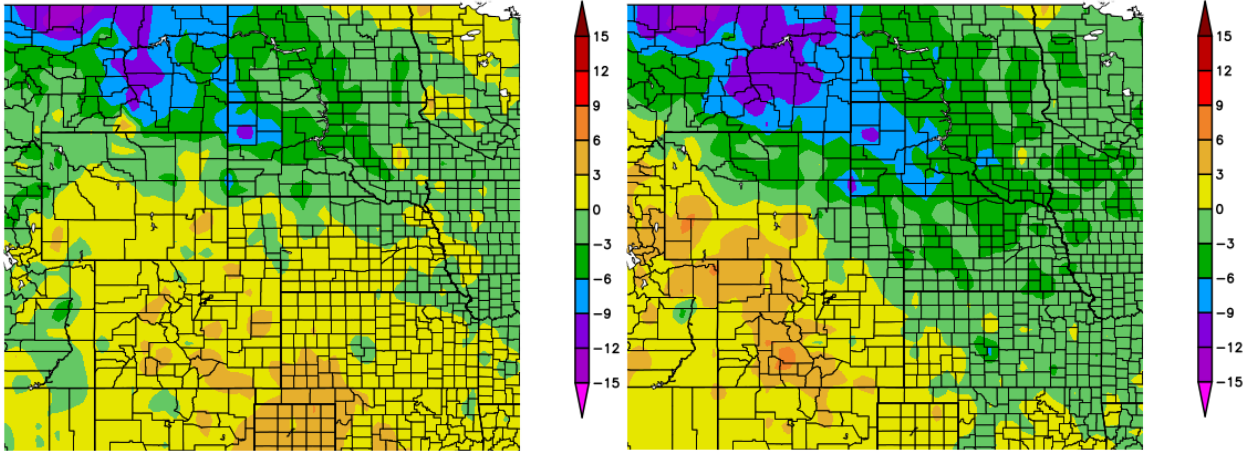


Figure 5. March 2018 and January-February-March 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

### 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. The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on March 29, 2018.

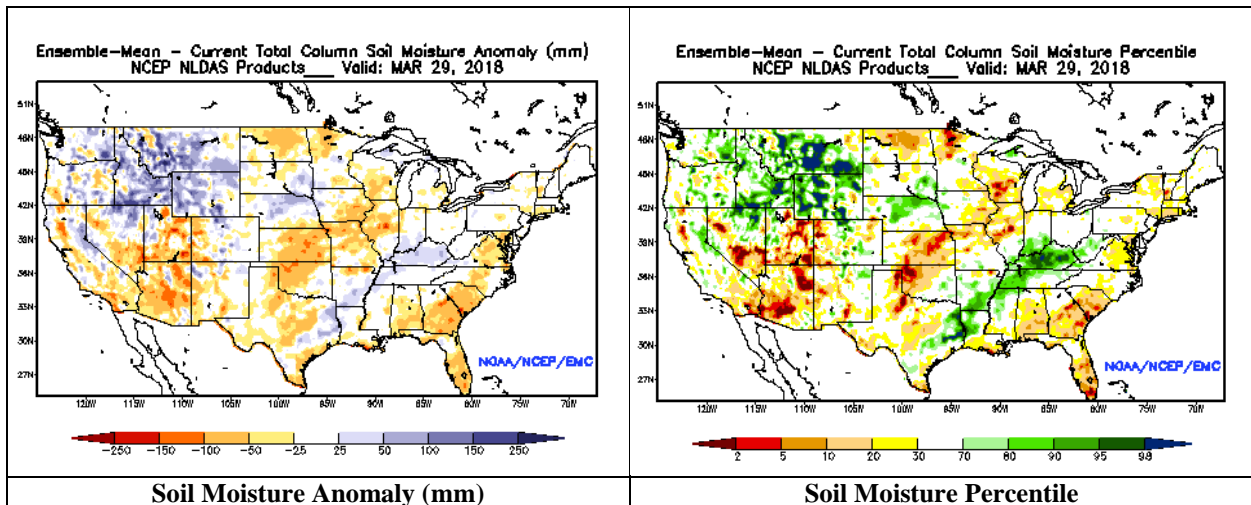


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

Soil moisture conditions have been a reflection of the precipitation patterns over the past three months. Soil moisture anomalies and percentiles are above normal in western and central

Montana, Wyoming, Colorado, eastern South Dakota and Nebraska. Spring runoff could continue to be above normal under normal spring precipitation due to the above-normal soil moisture conditions in much of Montana, Wyoming, eastern South Dakota, and northern Nebraska. In contrast, soil moisture anomalies and percentiles are below normal in North Dakota and western South Dakota, southern Nebraska, Kansas and Missouri.

### 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 includes long-term precipitation outlooks.

The National Weather Service’s National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from April 1, shown in **Figure 7**. Much of the plains snow has already melted in many areas of the upper Basin; however, the National Weather Service’s National Operational Hydrologic Remote Sensing Center (NOHRSC), currently indicates heavy plains snow water equivalents (SWE) is still present in some regions of the upper Basin. Amounts range from 2 to 6 inches in north-central, central and southeastern Montana. SWE ranging from 1 to 3 inches is also present in the upper James River basin in North Dakota.

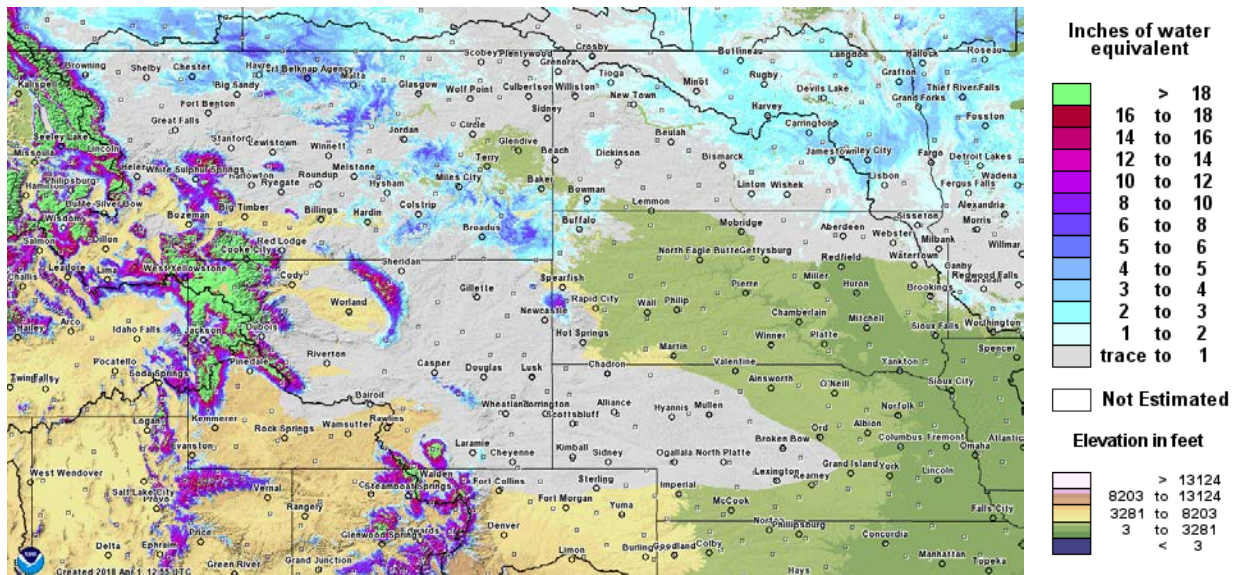


Figure 7. April 1, 2018 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. <http://www.nohrsc.nws.gov/interactive/html/map.html>

Based on the Corps' Plains Snowpack Assessment Tool, which is under development (see images in **Additional Figures**), basin-wide averages are around 1.5 to 2 inches for both the Fort Peck and Garrison reaches using the GlobSnow product, and around 2 to 2.5 inches using the SSM/I satellite product. In the lower four reservoir reaches, plains SWE is generally 0 to 1 inch.

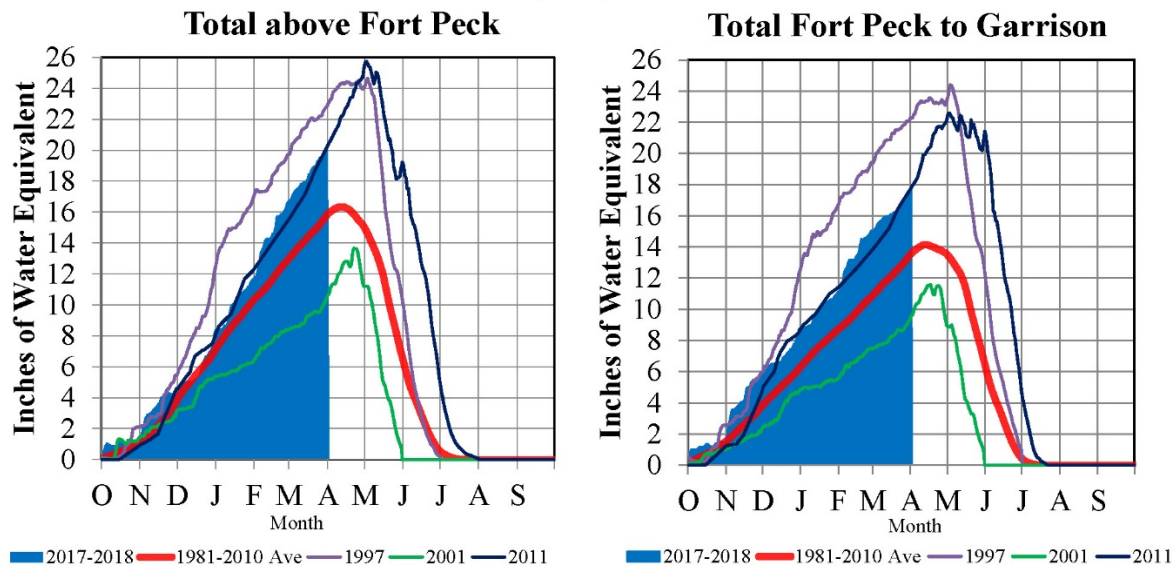
### Mountain Snowpack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. By April 1, mountain snowpack is a good indicator of the total May-June-July runoff. Usually, by April 1, about 97% of the eventual peak has accumulated. Mountain snowpack accumulation normally peaks in mid-April.

**Figure 8** includes time series plots of the average mountain SWE beginning on October 1, 2017 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).

## Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

April 1, 2018



The Missouri River Basin mountain snowpack normally peaks near April 15. On April 1, 2018 the mountain Snow Water Equivalent (SWE) in the "Total above Fort Peck" reach was 20.1", 127% of the average. The mountain SWE in the "Total Fort Peck to Garrison" reach was 17.7", 127% of the average. Normally by April 1, about 97% of the peak mountain SWE has occurred in both reaches. The April 1 SWE for the "Total Above Fort Peck" reach is 123% of the normal April 15 peak. The April 1 SWE for the "Fort Peck to Garrison" reach is 122% of the normal April 15 peak.

\*Generally considered the high and low year of the last 20-year period, respectively.

Provisional data. Subject to revision.

**Figure 8. Mountain snowpack water content on April 1, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.**

On April 1, 2018, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 20.1 inches, which was 127% 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 17.7 inches, which was 127% of average based on the 1981-2010 average SWE for the Garrison reach. Based on the forecasted April precipitation and temperature for the northern Rocky Mountains, we expect mountain snowpack to continue to accumulate for at least the next two weeks.

## **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 Niña conditions are present and likely to persist into the Northern Hemisphere spring. A transition from La Niña to ENSO-neutral conditions is forecasted for this spring and summer. ENSO-neutral conditions typically do not influence the chances for spring and early summer precipitation and temperatures.

### **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 16 in **Figure 9** indicates increased chances for below-normal temperatures in the upper Basin. The precipitation outlook indicates increased chances for above-normal precipitation in the upper Basin.

The April CPC temperature outlook in **Figure 10** indicates increased chances for below-normal temperatures in almost all of the Missouri Basin. With regard to precipitation, there are increased chances for above-normal precipitation extending from Montana into western South Dakota and Nebraska. There are equal chances for precipitation in central and southern Wyoming and much of North Dakota.

During the May-June-July 2018 period in **Figure 11**, the CPC temperature outlook indicates equal chances for temperatures across most of the upper Missouri Basin with an increase in the chance for above-normal temperatures in the lower Basin. With regard to the precipitation outlook, there is an increased chance for below normal precipitation in southwestern Montana,

Wyoming, Colorado, western Nebraska and western Kansas. There are equal chances for precipitation in all other areas of the Missouri Basin.

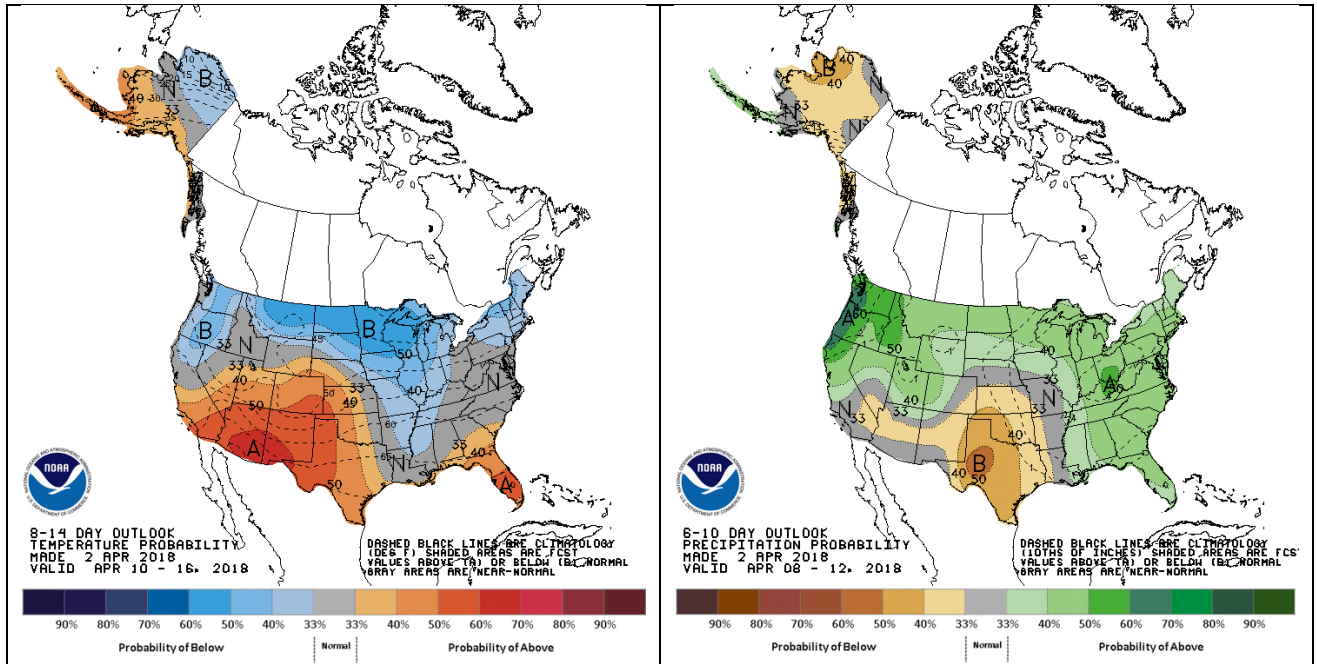


Figure 9. CPC 8-14 Day temperature and precipitation outlooks through April 16, 2018.

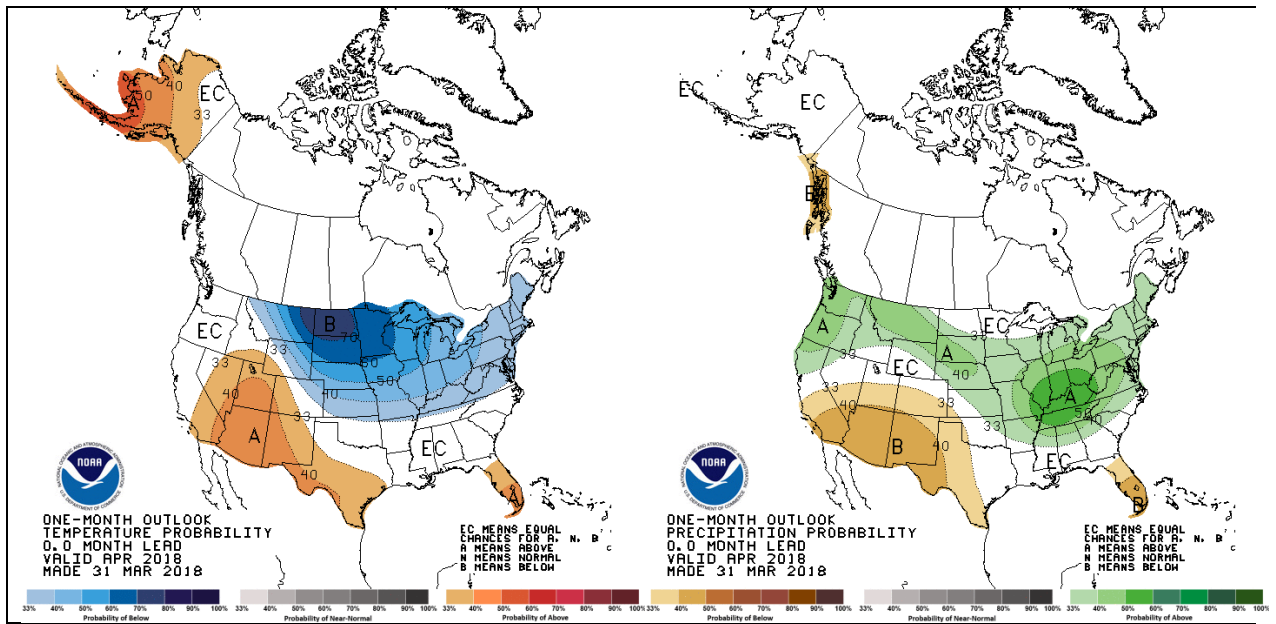


Figure 10. CPC April 2018 temperature and precipitation outlooks.

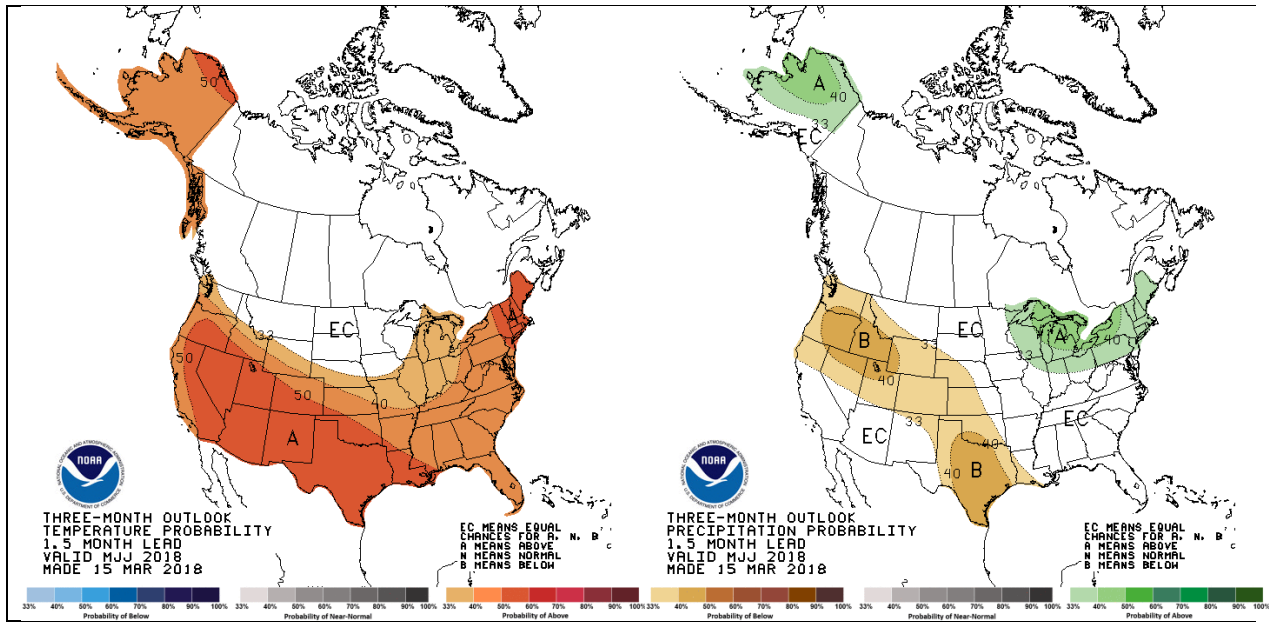


Figure 11. CPC May-June-July 2018 temperature and precipitation outlooks.

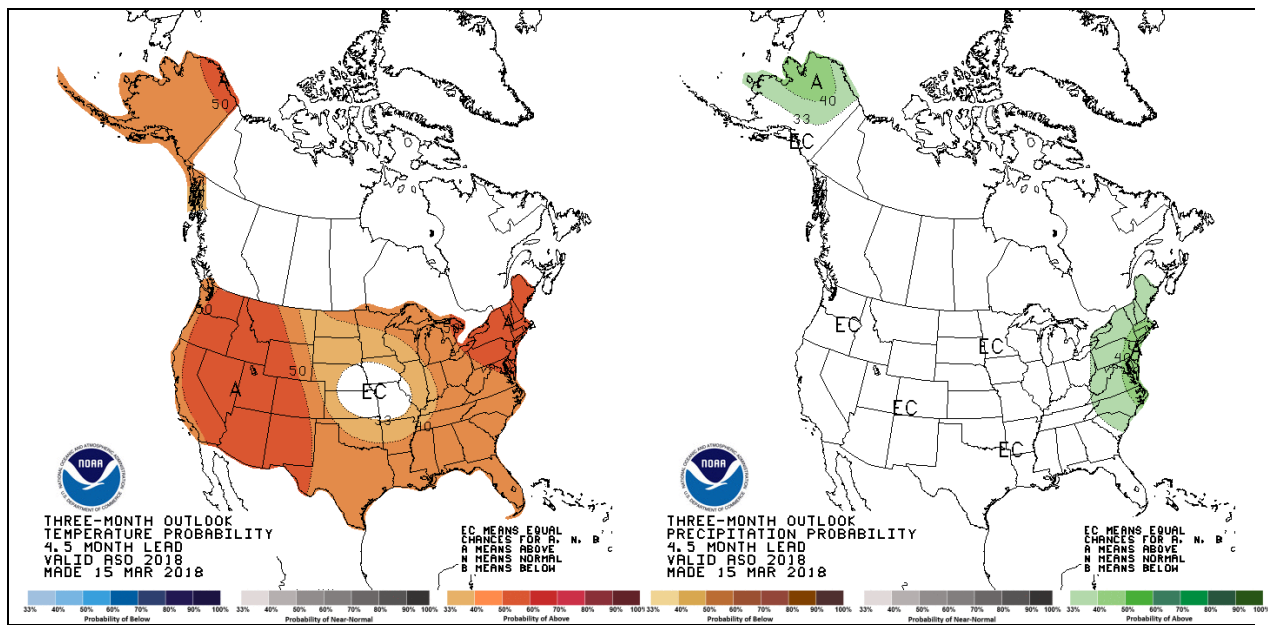


Figure 12. CPC August-September-October 2018 temperature and precipitation outlooks.

During the August-September-October period in **Figure 12**, CPC outlooks indicate increased chances for above-normal temperatures in most of the upper Basin, although equal chances are indicated in some of the lower Basin. There are equal chances for above-normal, normal and below-normal precipitation in all of the Missouri Basin through October.

During the November-December-January period in **Figure 13**, CPC outlooks indicate increased chances for above-normal temperatures in much of the Missouri Basin, though equal chances in northern Montana and northwestern North Dakota. With regard to precipitation there are equal chances throughout the Missouri Basin.

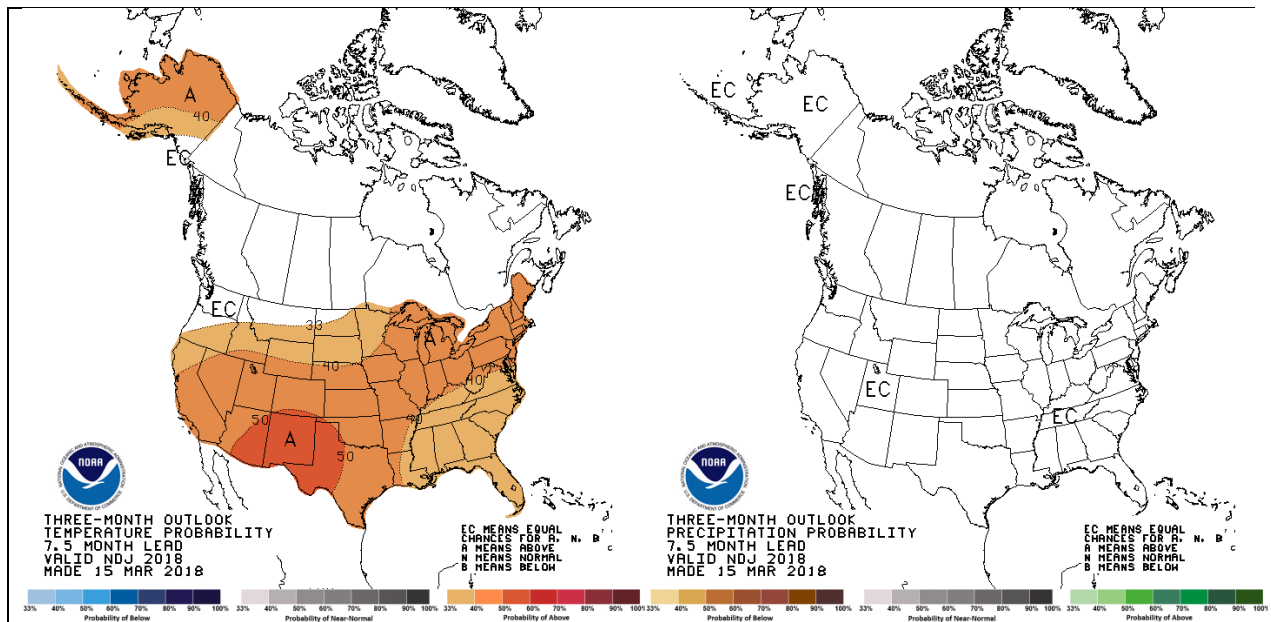


Figure 13. CPC November-December 2018-January 2019 temperature and precipitation outlooks.

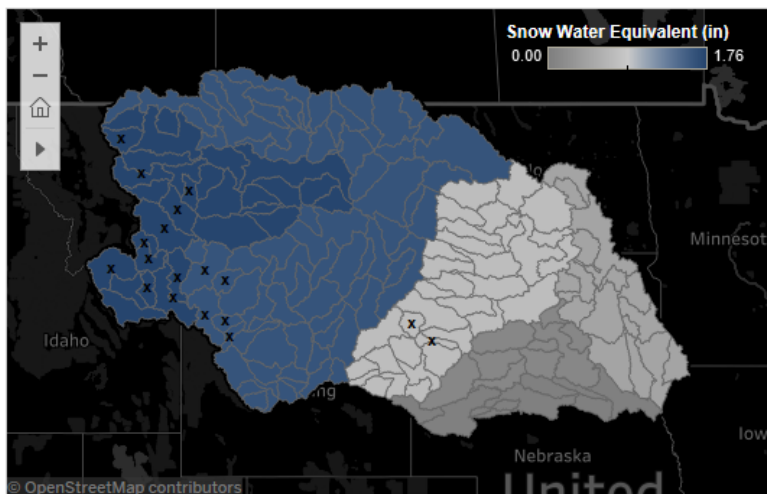
## Summary

In summary, the annual runoff forecast for the Missouri Basin above Sioux City, IA is **30.2 MAF, 119% of average**. Looking short-term, runoff in April is forecast to be above average for the upper Basin – about 120% -- particularly in the Fort Peck and Garrison reaches due to the remaining plains snowpack, wet soil moisture conditions, and precipitation outlooks. Looking a bit further down the road, the runoff forecast for the May through July period in the Fort Peck and Garrison reaches – the two reaches that are affected by mountain snowpack – is 130% of average. Runoff in these two reaches is mostly influenced by the above-average mountain snowpack, as well as the above-normal precipitation outlook for Montana and the current soil moisture content. For the lower four reaches - Oahe to Sioux City – May through July runoff is forecast near average, based on soil moisture conditions, precipitation outlooks and current runoff trends.

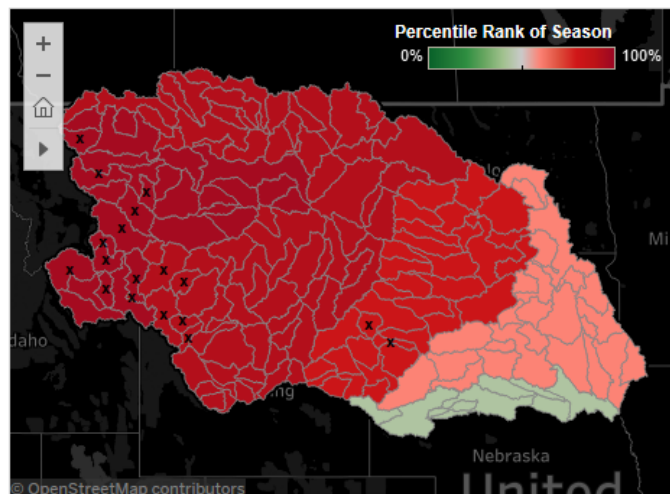
## Additional Figures

### Missouri River Basin Snow Water Equivalent GlobSnow Satellite-based estimates of SWE by HUC-8 and river reaches

BASIN-AVERAGED MAXIMUM SWE FOR THE WEEK ENDING 2018-03-31



PERCENTILE RANK OF SEASON FOR 2018-03-31



Choose Dataset:

GlobSnow

Display Data by:

REACH

Select a Date to Display:

2018-03-31

Include Lewis and Clark Lake HUC (10170101) in Reach:

Fort Randall to Gavins Point

"x" marks in maps and red values in tables indicate HUCs with greater SWE uncertainty due to:

- mountainous terrain
- heavily forested area

DETAILED DATA FOR 2018-03-31

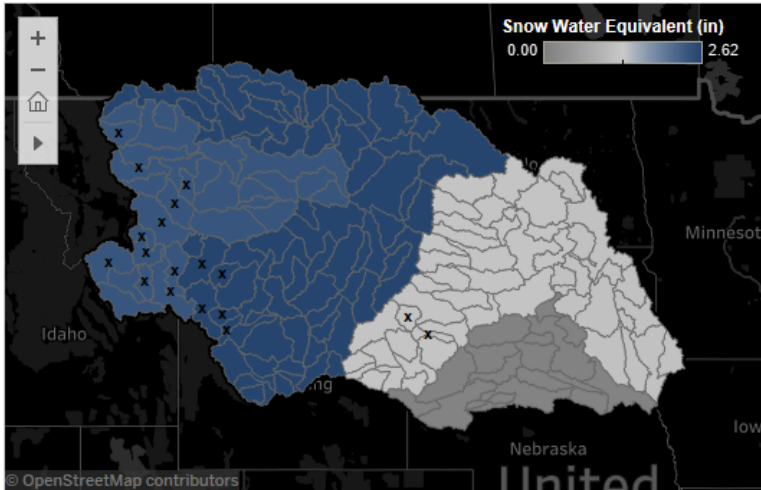
Region	Basin-Averaged SWE (in)	Percentile Rank of Season	Historical Median SWE (in)	% of Median SWE
Above Fort Peck	1.76	97%	0.32	542%
Fort Peck to Garrison	1.63	93%	0.16	1025%
Garrison to Oahe	0.74	83%	0.09	809%
Oahe to Fort Randall	0.10	60%	0.01	1266%
Fort Randall to Gavins Point	0.01	43%	0.01	72%
Gavins Point to Sioux City	0.43	60%	0.08	523%

**SELECT REACH IN A MAP ABOVE TO DISPLAY STATISTICAL CHART**

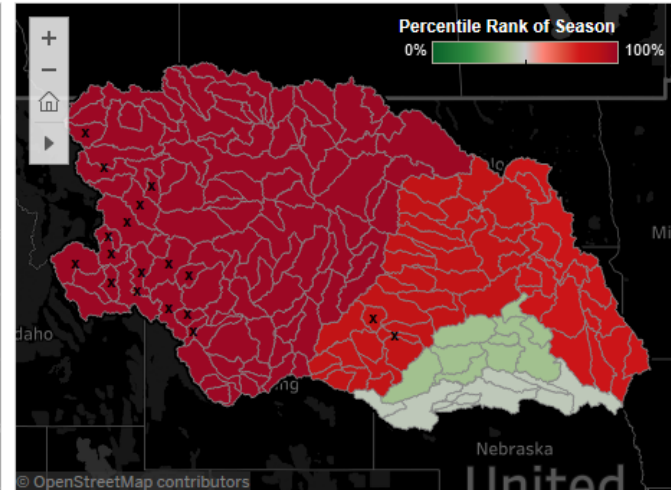
## Missouri River Basin Snow Water Equivalent

SSM/I Satellite-based estimates of SWE by HUC-8 and river reaches

**BASIN-AVERAGED MAXIMUM SWE FOR THE WEEK ENDING 2018-03-31**



**PERCENTILE RANK OF SEASON FOR 2018-03-31**



Choose Dataset:

Display Data by:

Select a Date to Display:

Include Lewis and Clark Lake HUC (10170101) in Reach:

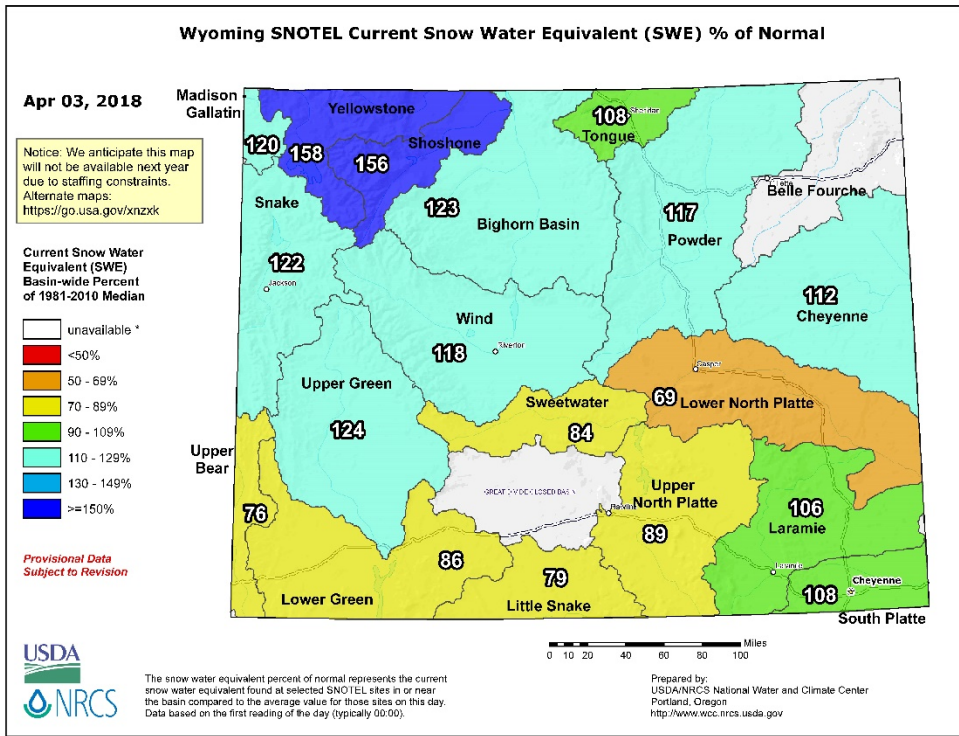
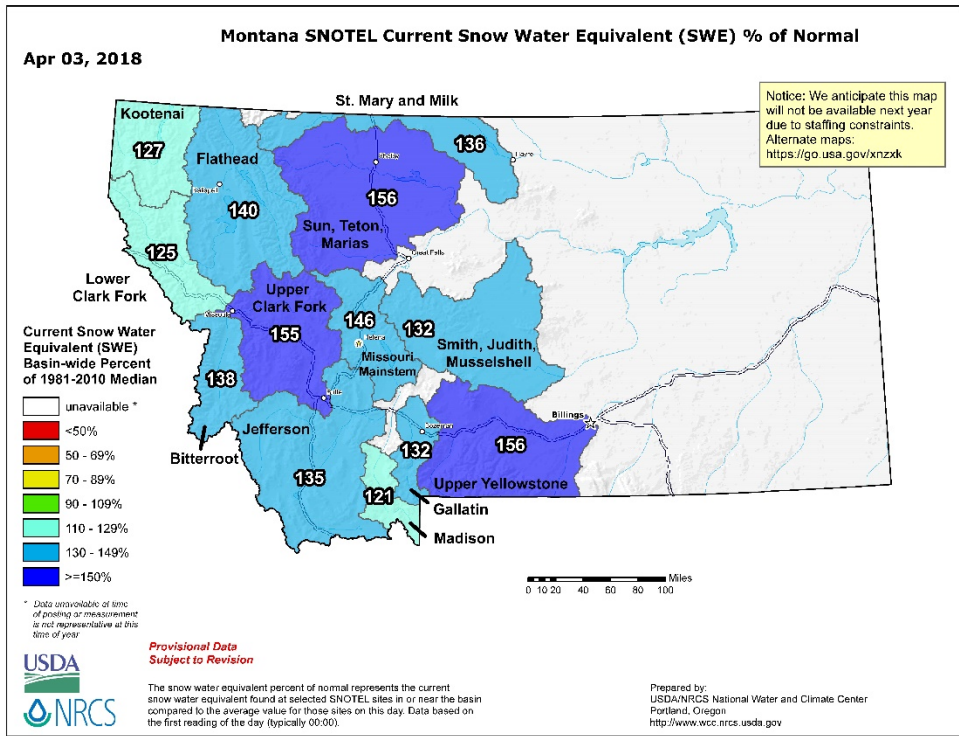
"x" marks in maps and red values in tables indicate HUCs with greater SWE uncertainty due to:

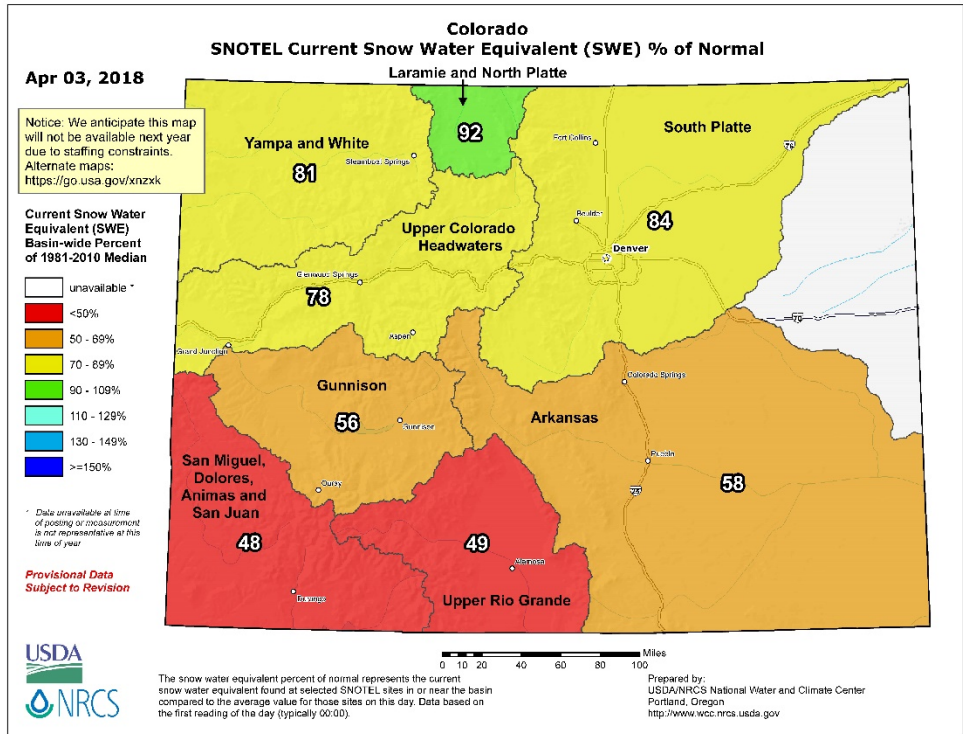
- mountainous terrain
- heavily forested area

**SELECT REACH IN A MAP ABOVE TO DISPLAY STATISTICAL CHART**

**DETAILED DATA FOR 2018-03-31**

Region	Basin-Averaged SWE (in)	Percentile Rank of Season	Historical Median SWE (in)	% of Median SWE
Above Fort Peck	2.41	100%	0.56	431%
Fort Peck to Garrison	2.62	100%	0.29	903%
Garrison to Oahe	1.22	87%	0.18	698%
Oahe to Fort Randall	0.04	40%	0.00	1337%
Fort Randall to Gavins Point	0.08	47%	0.01	905%
Gavins Point to Sioux City	1.17	83%	0.12	960%





USDA NRCS National Water & Climate Center  
 \* - DATA CURRENT AS OF: April 04, 2018 02:03:04 PM  
 - Based on April 01, 2018 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	115	119	133	122	108	98	97
	APR-SEP	131	117	151	139	123	111	112
St. Mary R at Intl Boundary (2)	APR-JUL	535	123	630	570	495	435	435
	APR-SEP	610	121	715	650	565	500	505
Lima Reservoir Inflow (2)	APR-JUL	75	100	101	86	65	49	75
	APR-SEP	82	103	110	93	70	53	80
Clark Canyon Reservoir Inflow (2)	APR-JUL	96	95	144	115	77	49	101
	APR-SEP	118	98	173	140	96	63	120
Jefferson R nr Three Forks (2)	APR-JUL	1050	142	1370	1180	920	735	740
	APR-SEP	1110	139	1470	1250	965	750	800
Hebgen Lake Inflow (2)	APR-JUL	410	111	480	440	380	340	370
	APR-SEP	515	110	600	550	480	430	470
Ennis Lake Inflow (2)	APR-JUL	715	114	845	770	660	585	625
	APR-SEP	880	114	1040	945	815	725	775
Missouri R at Toston (2)	APR-JUL	2300	128	2840	2520	2080	1760	1790
	APR-SEP	2610	126	3250	2870	2340	1960	2070
Smith R bl Eagle Ck (2)	APR-JUL	145	137	197	166	124	93	106
	APR-SEP	159	137	220	185	133	96	116
Gibson Reservoir Inflow (2)	APR-JUL	555	141	635	590	520	475	395
	APR-SEP	605	138	695	640	570	515	440
Marias R nr Shelby (2)	APR-JUL	445	124	570	495	390	315	360
	APR-SEP	460	123	600	520	405	325	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	76	129	84	79	73	68	59
	APR-SEP	98	132	109	102	94	87	74
Wind R ab Bull Lake Ck	APR-JUL	685	151	825	740	625	540	455
	APR-SEP	745	152	900	810	680	590	490
Bull Lake Ck nr Lenore (2)	APR-JUL	150	108	183	163	137	117	139
	APR-SEP	180	107	220	196	164	140	169
Boysen Reservoir Inflow (2)	APR-JUL	790	130	1150	935	645	435	610
	APR-SEP	855	129	1230	1010	700	475	665
Greybull R at Meeteetse	APR-JUL	137	105	198	162	112	75	131
	APR-SEP	185	105	260	215	155	111	177
Shell Ck nr Shell	APR-JUL	67	122	82	73	61	52	55
	APR-SEP	78	118	95	85	71	61	66
Bighorn R at Kane (2)	APR-JUL	1100	131	1630	1310	880	560	840
	APR-SEP	1170	129	1740	1400	945	605	905
NF Shoshone R at Wapiti	APR-JUL	710	154	795	745	675	625	460
	APR-SEP	790	153	885	830	750	690	515
SF Shoshone R nr Valley	APR-JUL	320	149	365	340	300	275	215
	APR-SEP	370	151	425	390	350	315	245
Buffalo Bill Reservoir Inflow	APR-JUL	1060	157	1220	1120	995	900	675
	APR-SEP	1170	157	1350	1240	1100	995	745
Bighorn R nr St. Xavier (2)	APR-JUL	2010	146	2650	2270	1750	1380	1380
	APR-SEP	2140	147	2840	2420	1860	1440	1460
Little Bighorn R nr Hardin	APR-JUL	83	85	133	103	63	33	98
	APR-SEP	95	86	151	118	72	39	111

Tongue R nr Dayton (2)	APR-JUL	71	83	98	82	60	44	86
	APR-SEP	82	84	112	94	70	52	98
Tongue River Reservoir Inflow (2)	APR-JUL	163	84	265	205	123	63	193
	APR-SEP	184	86	290	225	141	78	215
NF Powder R nr Hazelton	APR-JUL	14.3	157	17.8	15.7	12.9	10.8	9.1
	APR-SEP	15.2	154	18.9	16.7	13.7	11.6	9.9
Powder R at Moorhead	APR-JUL	250	141	390	305	193	108	177
	APR-SEP	275	140	420	335	215	132	196
Powder R nr Locate	APR-JUL	280	141	435	345	215	125	199
	APR-SEP	310	141	470	375	245	146	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	6.1	117	9.1	7.3	4.9	3.1	5.2
Pactola Reservoir Inflow (2)	APR-JUL	25	114	37	30	19.7	12.1	22

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 2018 Calendar Year Runoff Forecast  
May 4, 2018**

**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 5.3 MAF, 182% of average in the upper Missouri Basin above Sioux City. Runoff was above average in all reaches except the Oahe reach. Most of the April runoff was due to plains snowmelt.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on May 1, is **33.2 MAF (131% of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **30.0 MAF (130% of average)**.

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 41.6 MAF upper basic forecast to the 25.9 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 much wetter or drier conditions, respectively. Given that 8 months are being forecast for this May 1 forecast (4 months observed/8 months forecast), the range of wetter-than-expected (upper basic) and drier-

than-expected (lower basic) conditions is attributed to all 6 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 April 24, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows drought conditions in all states of the Missouri Basin. Severe Drought (D2) conditions with Long-Term drought impacts are present in northeastern Montana, Kansas, and Wyoming. Moderate (D1) Drought conditions with Short-Term drought impacts are present in some areas of all states in the Basin. Extreme (D3) Drought conditions are present in Kansas and Colorado. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of July, indicates drought conditions are expected to improve in most areas of the Basin. Drought is expected to remain, but improve, in areas of Kansas, Iowa, Missouri, and Colorado. Drought removal is likely in the Dakotas and most of Montana due to snowmelt and forecast precipitation.

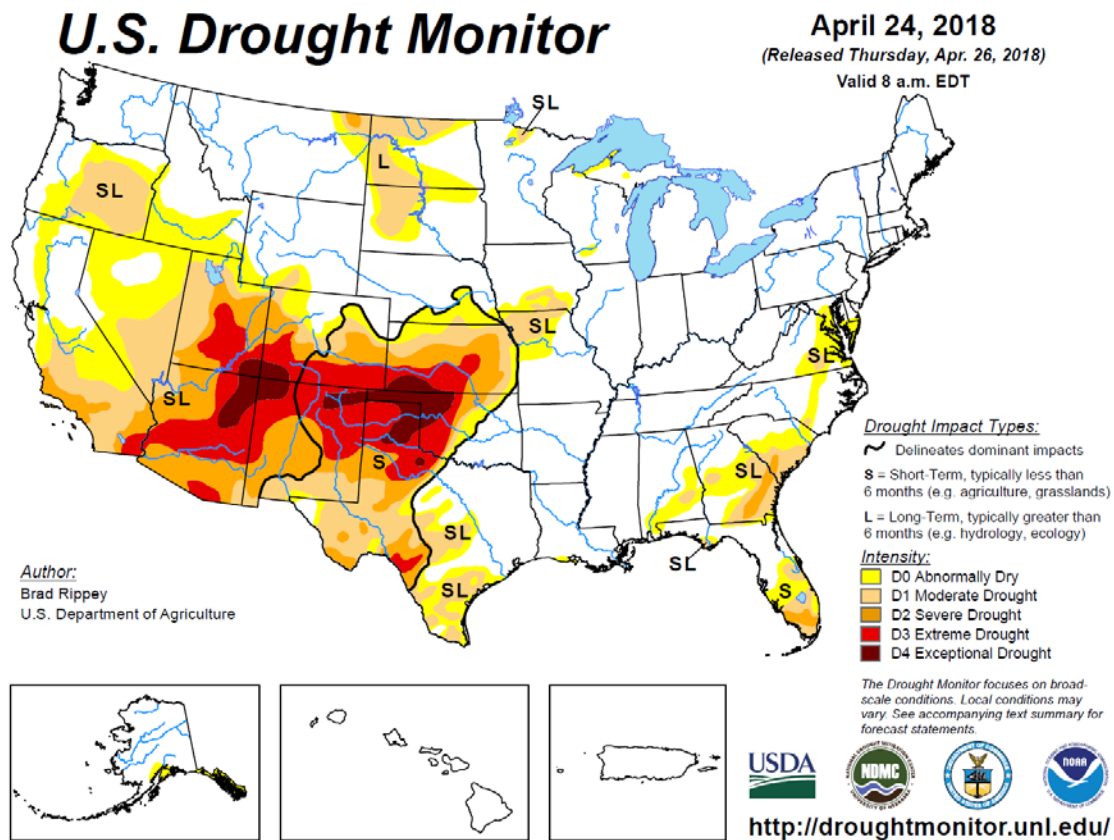


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for April 24, 2018.

# U.S. Seasonal Drought Outlook Drought Tendency During the Valid Period

Valid for April 19 - July 31, 2018  
Released April 19, 2018

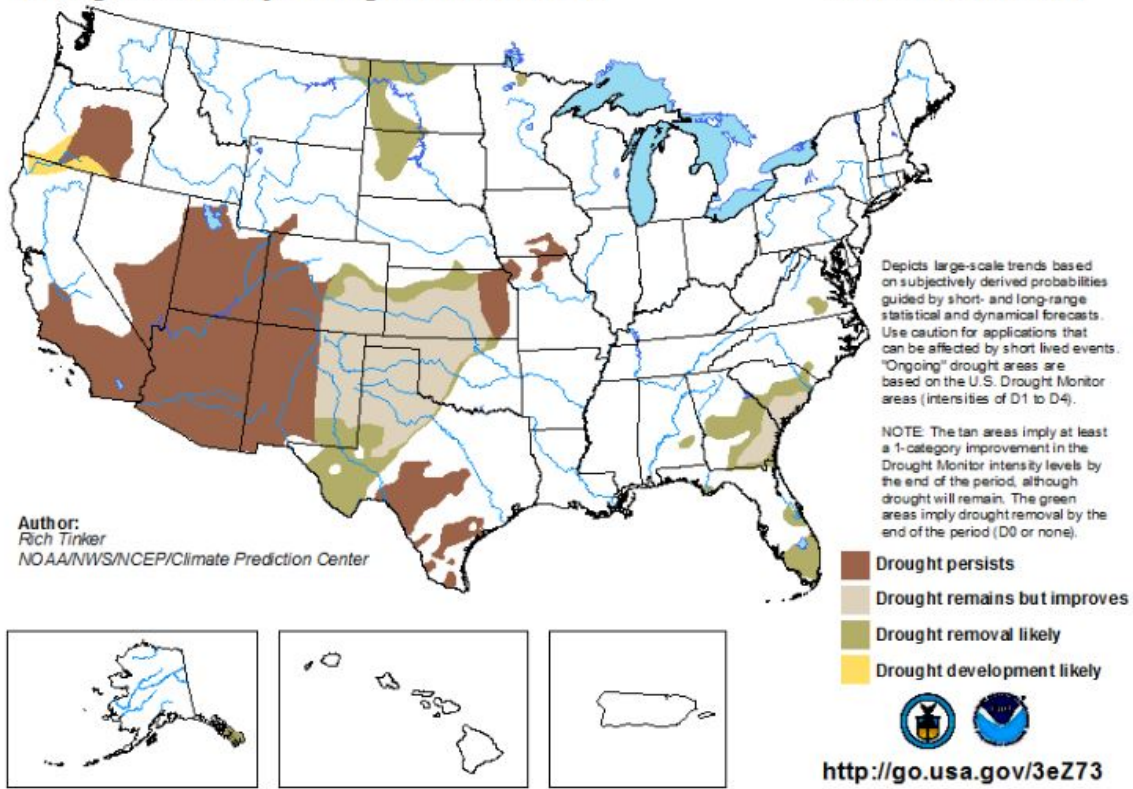


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

## 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 inches of precipitation (left) and percent of normal precipitation (right). **Figure 3** shows that much of the lower Basin received less than 1.0 inch of precipitation, while areas in southwestern Montana, northwestern Wyoming, and central Colorado received greater than 4 inches of precipitation. As a percent of normal, precipitation was above average for most of Montana and in isolated areas of the other upper Basin states (right image of **Figure 3**).

February-March-April precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the ongoing above-normal precipitation pattern in the Rocky Mountains of Montana and Wyoming, extending into central and eastern Montana, northern Wyoming, the western Dakotas, and western Nebraska. Precipitation accumulations greater than 150% of normal have occurred over much of this area. In contrast, large areas of the lower Basin have received less than 50% of normal precipitation since February 1, 2018.

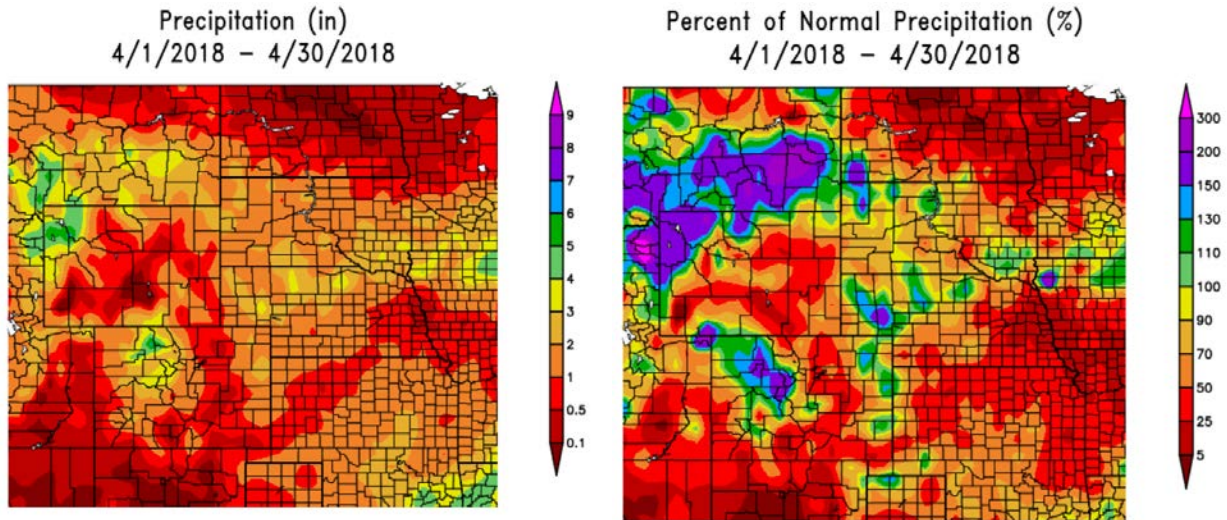


Figure 3. April 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

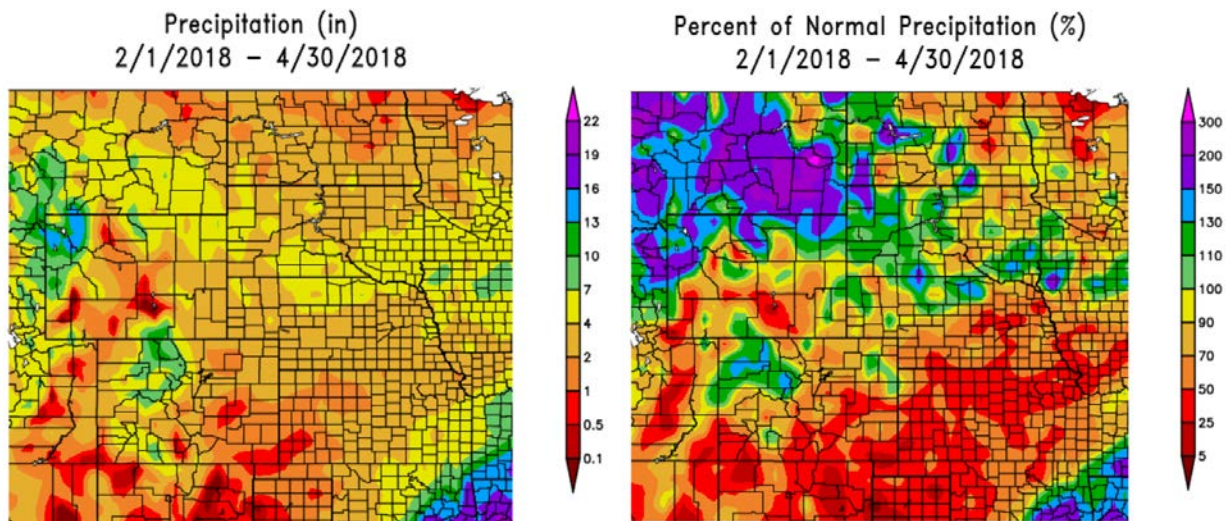
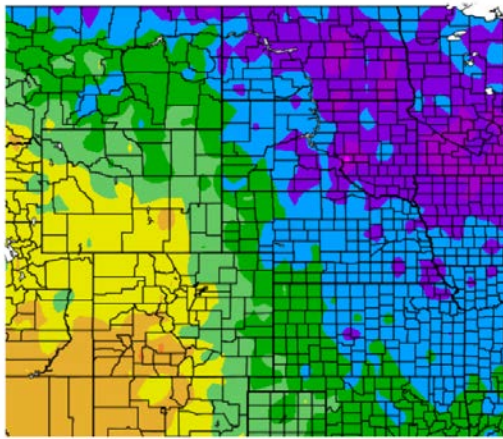


Figure 4. February-March-April 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

April temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** indicate below-normal temperatures extending across most of the Basin, with the exception of western Wyoming and Colorado. February-March-April temperature departures, in the right image of **Figure 5**, reflect a colder-than-normal pattern over the majority of the Basin. Warmer-than-normal temperatures have only been present in southwestern Wyoming and Colorado.

Departure from Normal Temperature (F)  
4/1/2018 – 4/30/2018



Departure from Normal Temperature (F)  
2/1/2018 – 4/30/2018

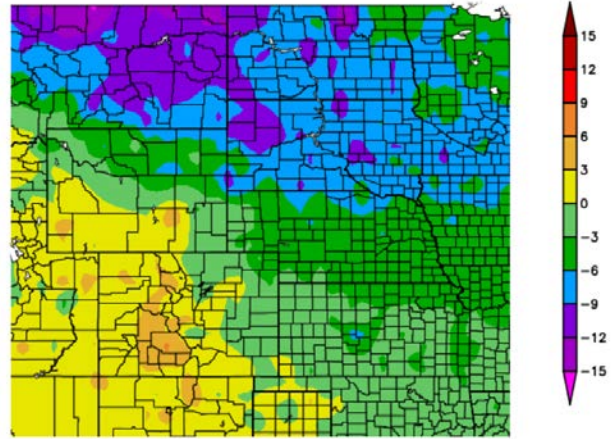


Figure 5. April 2018 and February-March-April 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

### 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. The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on April 28, 2018.

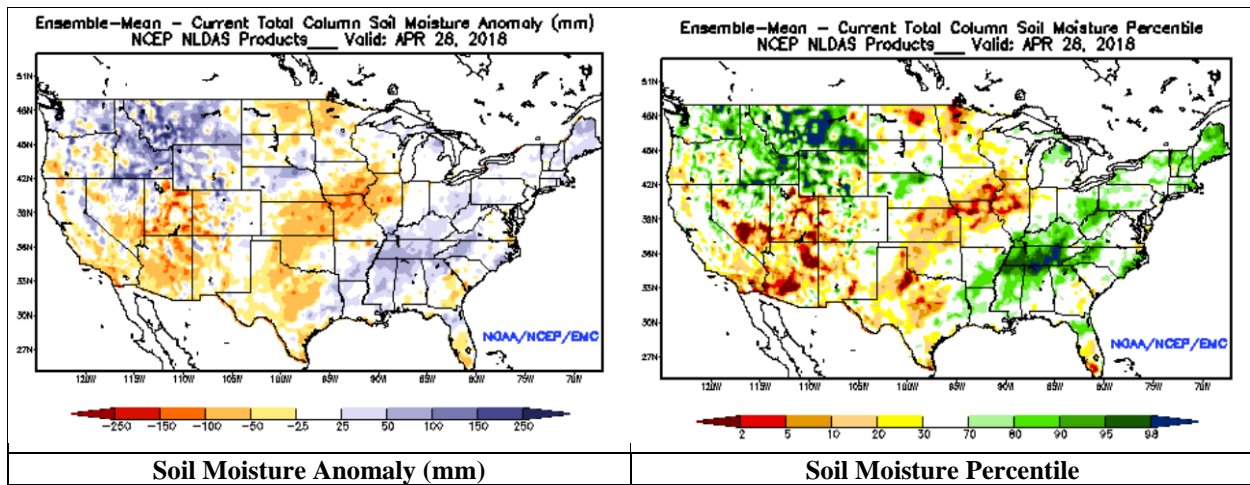


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

Soil moisture conditions have been a reflection of the precipitation patterns over the past three months. Soil moisture anomalies and percentiles are above normal in western and central Montana, Wyoming, eastern South Dakota and Nebraska. Spring runoff could continue to be

above normal under normal spring precipitation due to the above-normal soil moisture conditions in much of Montana, Wyoming, eastern South Dakota, and northern Nebraska. In contrast, soil moisture anomalies and percentiles are below normal in North Dakota, western South Dakota, southern Nebraska, Kansas, Missouri, and Iowa.

### 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 includes long-term precipitation outlooks.

The National Weather Service’s National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from May 1, is shown in **Figure 7**. No plains snow is remaining in the Basin. Based on the NOHRSC maps over time, it appears all snow in the Basin was melted by approximately April 26th.

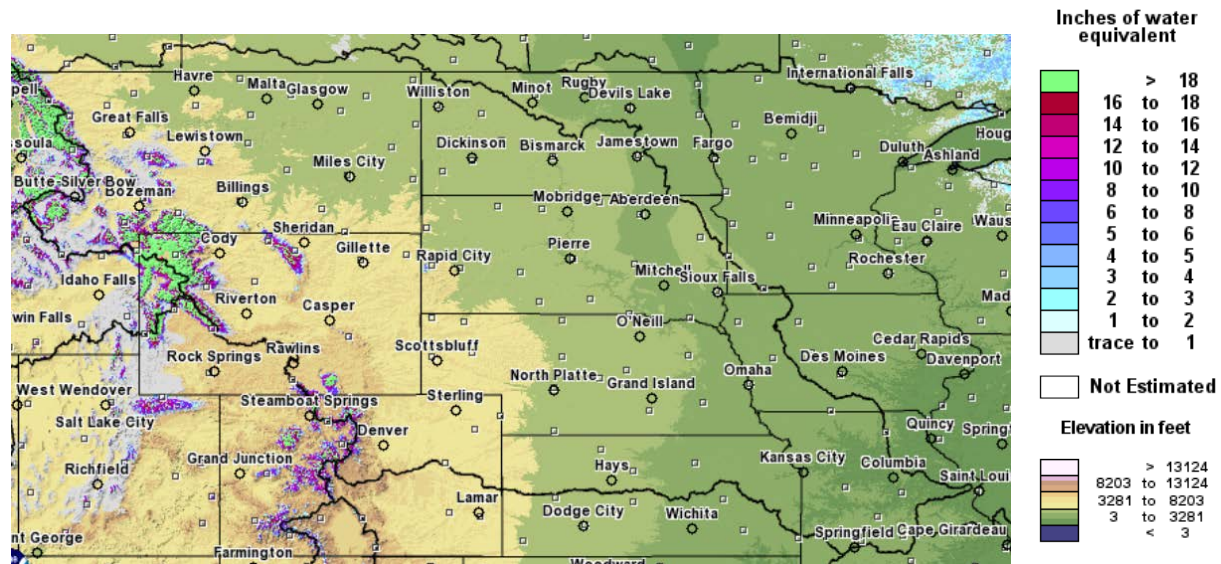
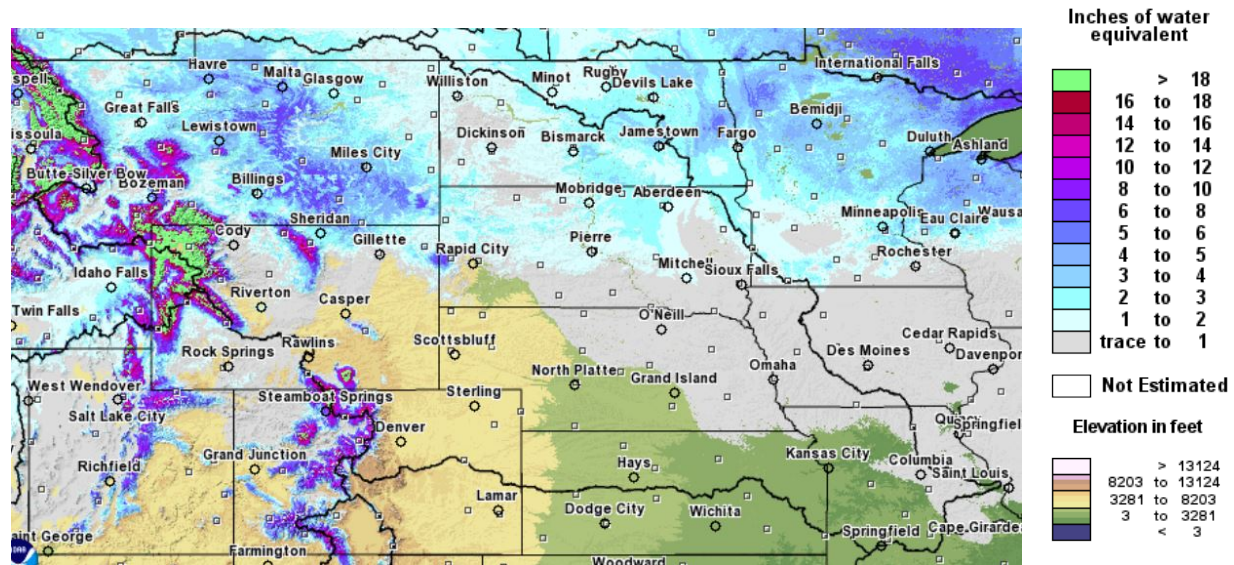


Figure 7. May 1, 2018 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. <http://www.nohrsc.nws.gov/interactive/html/map.html>

Plains snowpack appears to have peaked around March 7<sup>th</sup> in most areas (**Figure 8**). Areas of Montana had up to 8” of SWE around March 7<sup>th</sup>, and areas of North Dakota had up to 4” of SWE. The rest of the upper Basin had trace to 3” of SWE at that time.



**Figure 8.** March 7, 2018 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. <http://www.nohrsc.nws.gov/interactive/html/map.html>

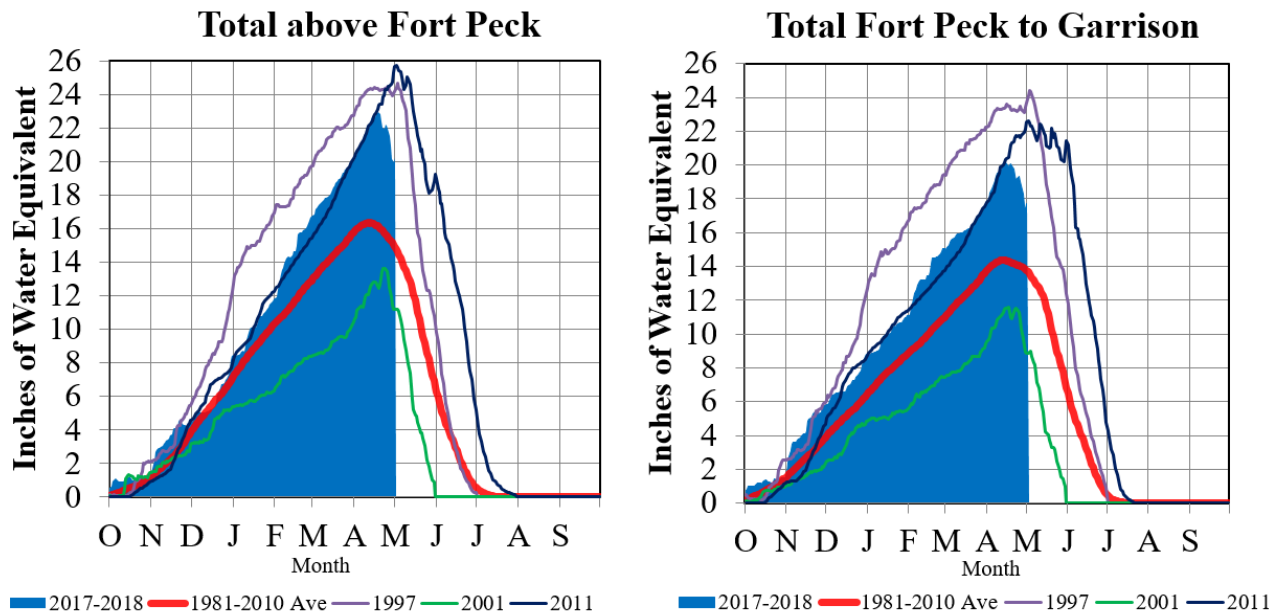
### Mountain Snowpack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. By May 1, mountain snowpack is a good indicator of the total May-June-July runoff. Mountain snowpack accumulation has peaked in both reaches: on April 19<sup>th</sup> at 23.0” (141% of the normal April 15 peak) for the reach above Fort Peck Dam, and on April 15<sup>th</sup> at 20.1” (137% of the normal April 15 peak) for the reach between Fort Peck and Garrison Dams.

**Figure 9** includes time series plots of the average mountain SWE beginning on October 1, 2017 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).

# Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

May 1, 2018



On May 1, 2018 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 20.2”, 135% of average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 17.7”, 129% of average. It appears that snowpack has peaked in both reaches. The “Total above Fort Peck” reach appears to have peaked on April 19, at 23.0”, 141% of the normal April 15 peak. The “Total Fort Peck to Garrison” reach appears to have peaked on April 15, at 20.1”, 137% of the normal April 15 peak.

\*Generally considered the high and low year of the last 30-year period, respectively.

Provisional data. Subject to revision.

**Figure 9. Mountain snowpack water content on May 1, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.**

On May 1, 2018, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 20.2 inches (~3” less than the peak), which was 135% 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 17.7 inches (~2.5” less than the peak), which was 129% of average based on the 1981-2010 average SWE for the Garrison reach. Based on the forecasted May precipitation and temperature for the northern Rocky Mountains over the next couple weeks, we expect mountain snowpack to continue melting at a fairly high rate in May.

## 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 temperature and precipitation patterns in the Missouri Basin.

## ENSO (El Niño Southern Oscillation)

The latest ENSO Outlook indicates that La Niña conditions are present and likely to persist into the Northern Hemisphere spring. A transition from La Niña to ENSO-neutral conditions is forecasted for this spring and summer. ENSO-neutral conditions typically do not influence the chances for spring and early summer precipitation and temperatures.

## 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 16 in **Figure 10** indicates increased chances for above-normal temperatures throughout the Basin. The precipitation outlook indicates equal chances for precipitation over the majority of the Basin.

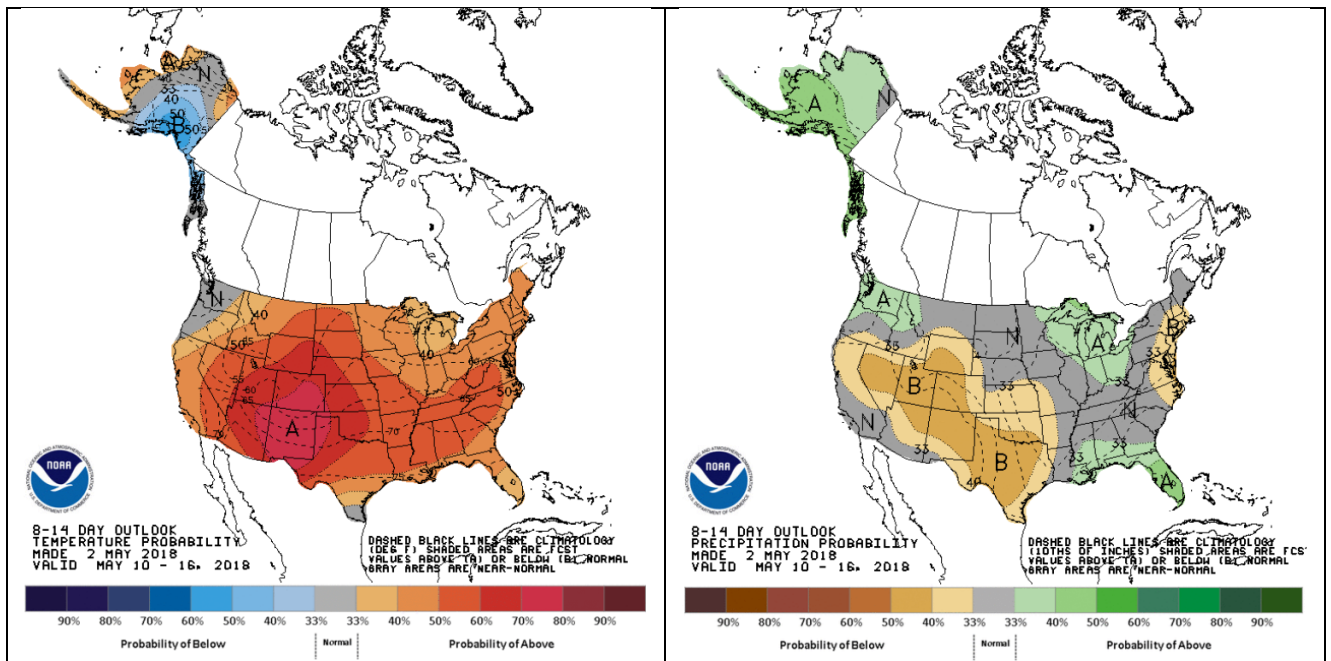


Figure 10. CPC 8-14 Day temperature and precipitation outlooks through April 16, 2018.

The May CPC temperature outlook in **Figure 11** indicates increased chances for above-normal temperatures over the entire Basin. With regard to precipitation, there are increased chances for above-normal precipitation extending from Wyoming into South Dakota, Nebraska, Kansas, Iowa, Missouri, and Colorado. There are equal chances for precipitation in Montana and North Dakota.

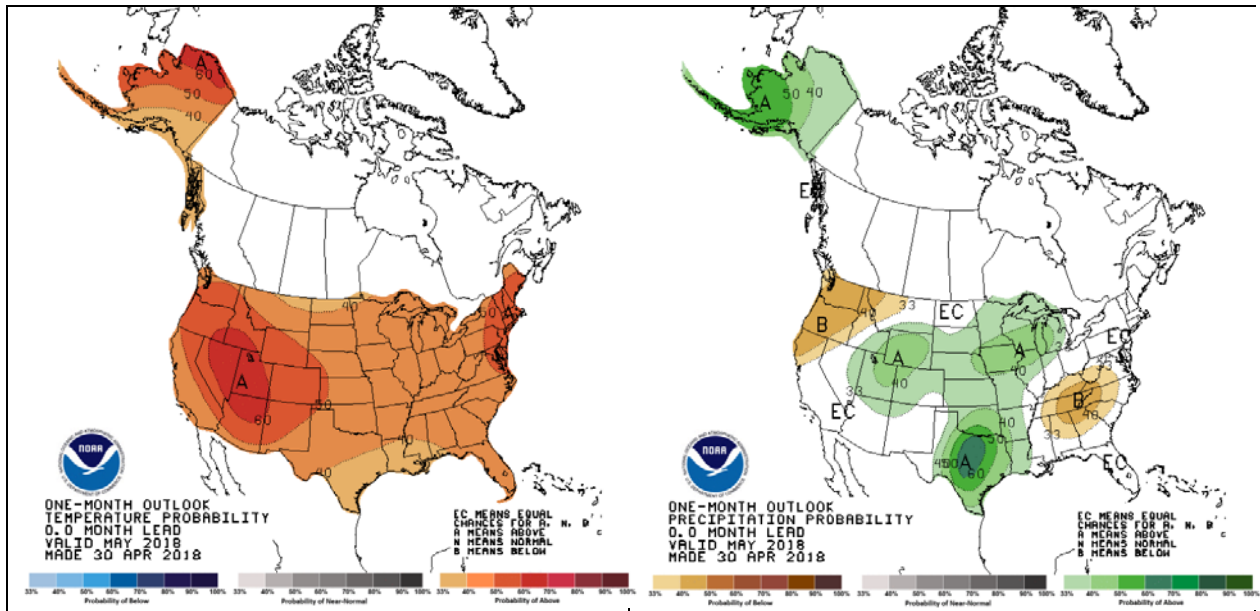


Figure 11. CPC May 2018 temperature and precipitation outlooks.

During the June-July-August 2018 period in **Figure 12**, the CPC outlooks indicate equal chances for temperature and precipitation across most of the Missouri River Basin, with an increase in the chance for below-normal precipitation in Montana and Wyoming.

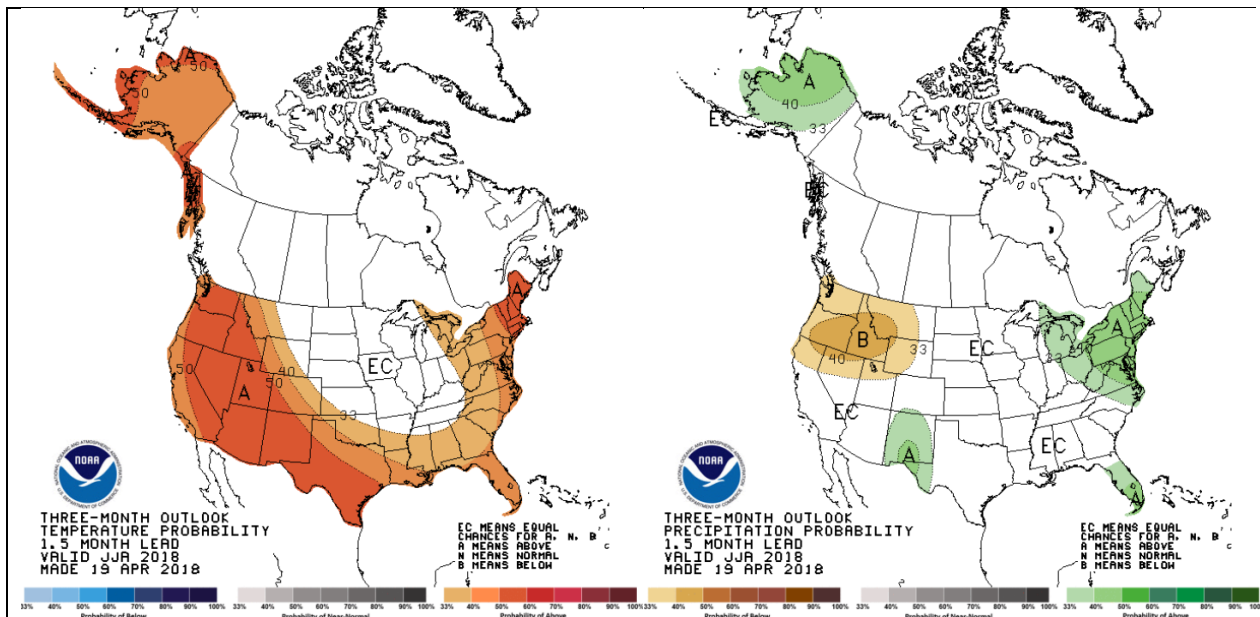


Figure 12. CPC June-July-August 2018 temperature and precipitation outlooks.

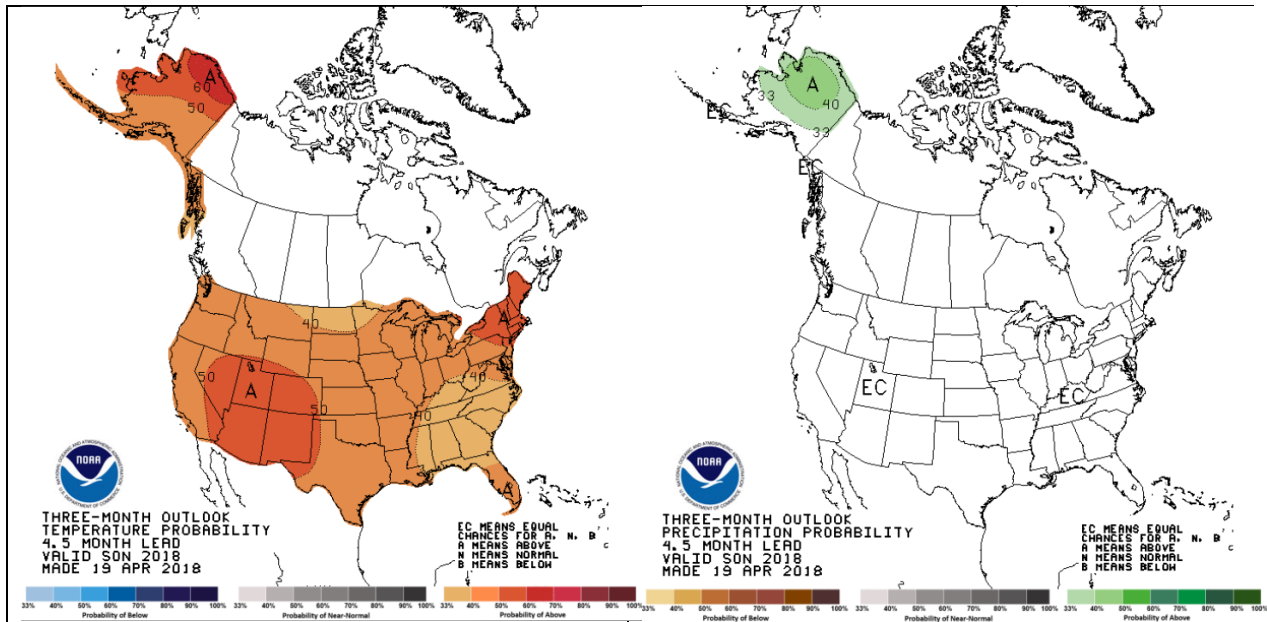


Figure 13. CPC September-October-November 2018 temperature and precipitation outlooks.

During the September-October-November period in **Figure 13**, CPC outlooks indicate increased chances for above-normal temperatures over the Basin. There are equal chances for above-normal, normal and below-normal precipitation in the Missouri River Basin through November.

During the December 2018-January 2019-February 2019 period in **Figure 14**, CPC outlooks indicate equal chances for temperature and precipitation over the entire Missouri River Basin.

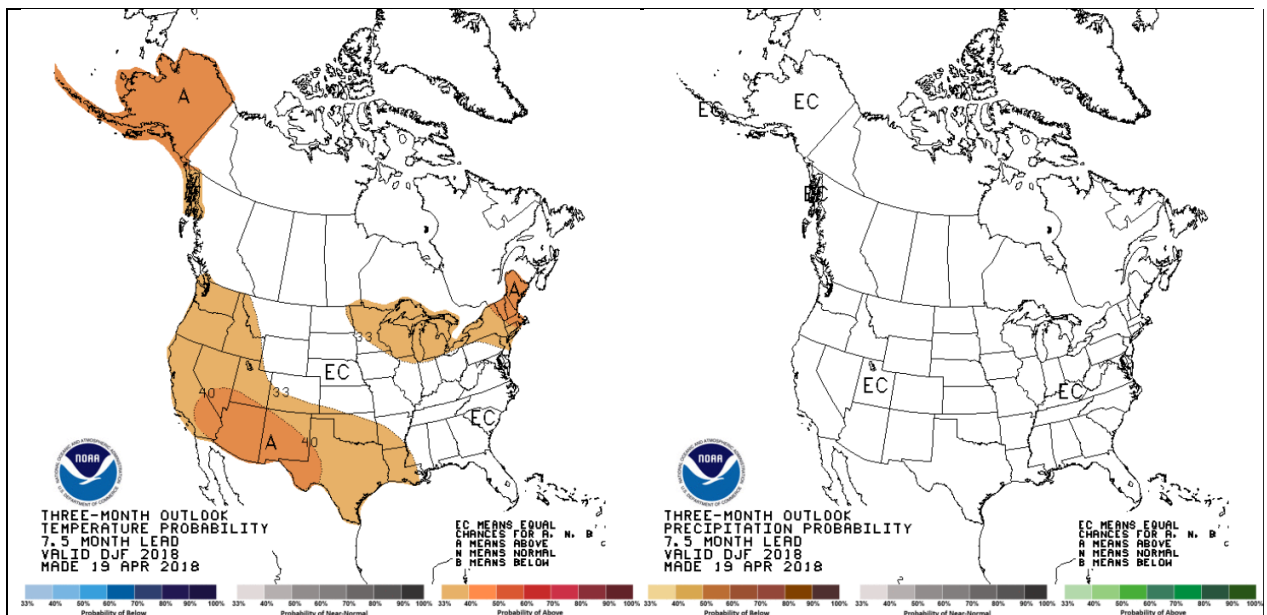
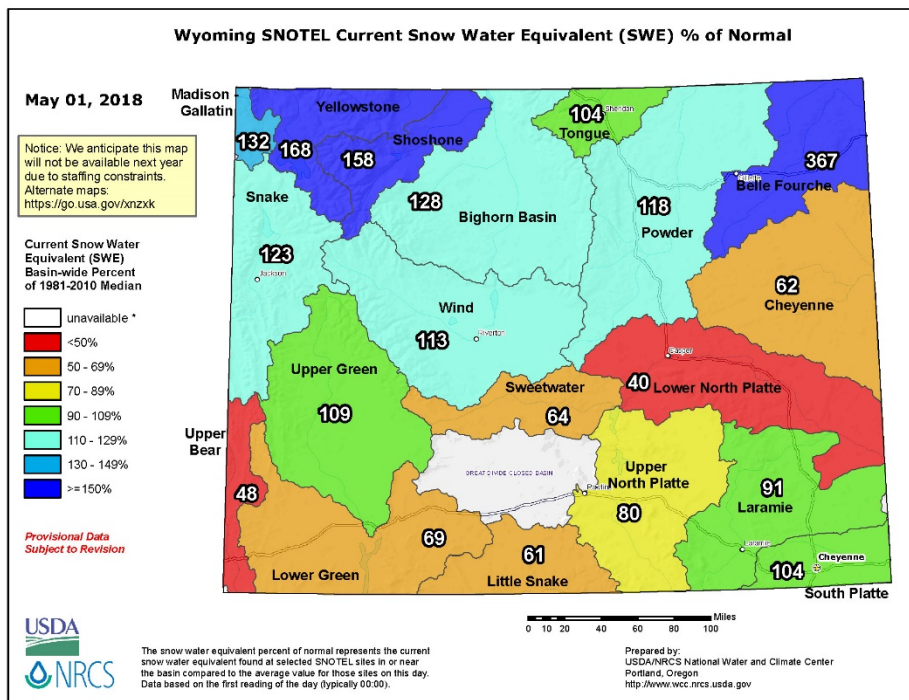
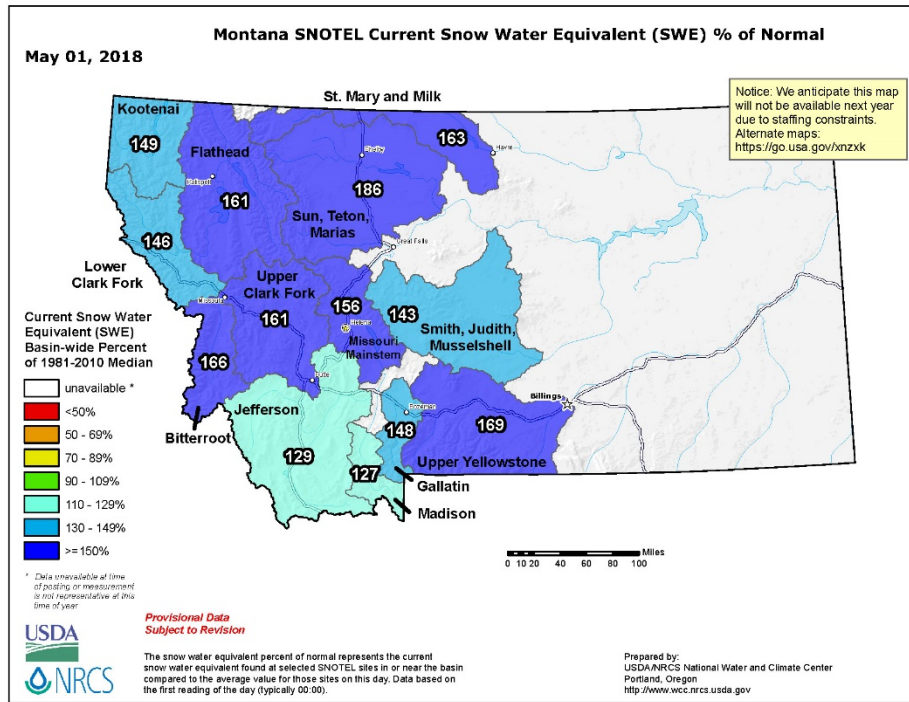


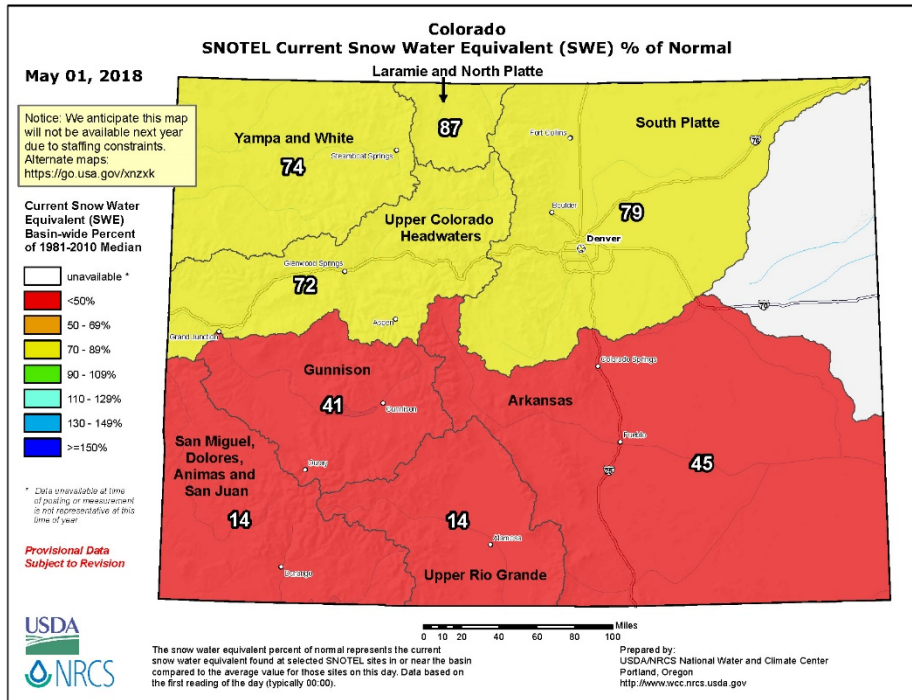
Figure 14. CPC December 2018-January 2019-February 2019 temperature and precipitation outlooks.

## **Summary**

In summary, the annual runoff forecast for the Missouri Basin above Sioux City, IA is **33.2 MAF, 131% of average**. Looking short-term, we're expecting runoff in May to be above average for the Fort Peck and Garrison reaches – about 150% -- due to the above-average mountain snowpack, wet soil moisture conditions, and temperature outlooks. For the lower four reaches - Oahe to Sioux City - we're forecasting near average runoff for the May– July period, based on soil moisture conditions, precipitation outlooks and current runoff trends. Looking much further out – September through December – we're forecasting average runoff throughout the entire upper Basin.

# Additional Figures





USDA NRCS National Water & Climate Center  
 \* - DATA CURRENT AS OF: May 03, 2018 10:05:16 AM  
 - Based on May 01, 2018 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	109	127	126	116	102	92	86
	MAY-SEP	125	124	144	133	118	106	101
St. Mary R at Intl Boundary (2)	MAY-JUL	515	129	610	555	480	420	400
	MAY-SEP	595	127	695	635	550	490	470
Lima Reservoir Inflow (2)	MAY-JUL	49	98	73	59	40	26	50
	MAY-SEP	55	98	81	66	45	30	56
Clark Canyon Reservoir Inflow (2)	MAY-JUL	61	95	106	79	43	16.1	64
	MAY-SEP	81	98	136	103	59	26	83
Jefferson R nr Three Forks (2)	MAY-JUL	850	148	1120	960	740	575	575
	MAY-SEP	905	143	1220	1030	775	585	635
Hebgen Lake Inflow (2)	MAY-JUL	355	116	420	380	330	290	305
	MAY-SEP	465	115	550	500	430	380	405
Ennis Lake Inflow (2)	MAY-JUL	630	119	740	675	585	520	530
	MAY-SEP	790	116	930	845	735	650	680
Missouri R at Toston (2)	MAY-JUL	2020	136	2470	2200	1840	1580	1480
	MAY-SEP	2330	132	2890	2550	2100	1770	1760
Smith R bl Eagle Ck (2)	MAY-JUL	133	149	179	152	114	87	89
	MAY-SEP	146	147	200	169	123	90	99
Gibson Reservoir Inflow (2)	MAY-JUL	585	165	655	615	560	520	355
	MAY-SEP	640	162	715	670	610	565	395
Marias R nr Shelby (2)	MAY-JUL	445	148	560	490	400	330	300
	MAY-SEP	465	148	590	515	415	340	315

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)	MAY-JUL	75	132	82	78	72	68	57
	MAY-SEP	97	135	106	101	93	88	72
Wind R ab Bull Lake Ck	MAY-JUL	585	136	690	625	545	480	430
	MAY-SEP	635	137	750	680	590	520	465
Bull Lake Ck nr Lenore (2)	MAY-JUL	130	96	152	139	121	108	135
	MAY-SEP	159	96	185	170	148	133	166
Boysen Reservoir Inflow (2)	MAY-JUL	615	110	835	705	520	390	560
	MAY-SEP	660	107	895	755	565	425	615
Greybull R at Meeteetse	MAY-JUL	128	103	175	147	109	81	124
	MAY-SEP	175	103	230	198	153	119	170
Shell Ck nr Shell	MAY-JUL	63	121	77	69	57	49	52
	MAY-SEP	75	119	91	81	69	59	63
Bighorn R at Kane (2)	MAY-JUL	880	114	1250	1030	735	515	770
	MAY-SEP	935	113	1320	1090	780	550	830
NF Shoshone R at Wapiti	MAY-JUL	685	159	770	720	655	605	430
	MAY-SEP	765	158	860	805	730	675	485
SF Shoshone R nr Valley	MAY-JUL	320	160	360	340	305	285	200
	MAY-SEP	375	160	420	390	355	330	235
Buffalo Bill Reservoir Inflow	MAY-JUL	1040	165	1170	1090	985	905	630
	MAY-SEP	1160	166	1300	1220	1100	1010	700
Bighorn R nr St. Xavier (2)	MAY-JUL	1760	140	2210	1940	1570	1300	1260
	MAY-SEP	1870	140	2370	2070	1670	1380	1340
Little Bighorn R nr Hardin	MAY-JUL	69	81	112	86	52	26	85
	MAY-SEP	80	82	129	100	60	31	97

Tongue R nr Dayton (2)	MAY-JUL	65	81	90	75	55	40	80
	MAY-SEP	77	84	104	88	65	49	92
Tongue River Reservoir Inflow (2)	MAY-JUL	141	81	230	177	105	53	175
	MAY-SEP	164	83	260	200	126	70	198
NF Powder R nr Hazelton	MAY-JUL	11.5	139	14.6	12.8	10.2	8.4	8.3
	MAY-SEP	12.3	137	15.6	13.7	11.0	9.1	9.0
Powder R at Moorhead	MAY-JUL	193	128	315	245	143	70	151
	MAY-SEP	215	126	335	265	163	89	170
Powder R nr Locate	MAY-JUL	210	128	350	270	155	72	164
	MAY-SEP	235	127	380	295	177	91	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	3.8	97	6.3	4.8	2.8	1.36	3.9
Pactola Reservoir Inflow (2)	MAY-JUL	17.1	98	28	22	12.5	5.7	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	155	83	250	193	117	62	187
	MAY-SEP	173	82	280	215	130	68	210
Encampment R nr Encampment (2)	MAY-JUL	60	51	101	76	43	18.3	118
	MAY-SEP	65	51	108	83	48	22	127
Rock Ck ab King Canyon Cnl nr Arlington	MAY-JUL	47	98	59	52	42	35	48
	MAY-SEP	49	98	62	54	44	37	50
Seminole Reservoir Inflow (2)	MAY-JUL	445	72	685	540	350	210	615
	MAY-SEP	480	72	735	585	380	230	670
Sweetwater R nr Alcova	MAY-JUL	17.5	38	41	27	11.0	4.1	46
	MAY-SEP	20	40	45	30	12.6	4.7	50
La Prele Ck nr Douglas	MAY-JUL	2.1	14	10.0	5.3	1.00	0.140	14.9
	MAY-SEP	2.1	14	10.0	5.3	1.10	0.20	14.8
North Platte R bl Glendo Reservoir (2)	MAY-JUL	425	63	750	555	290	95	670
	MAY-SEP	435	62	775	570	300	98	700
North Platte R bl Guernsey Reservoir (2)	MAY-JUL	415	62	760	555	280	75	670
	MAY-SEP	425	61	775	570	285	75	700
Laramie R and Pioneer Cnl nr Woods Lg (2)	MAY-JUL	88	81	126	104	72	50	108
	MAY-SEP	95	80	137	112	78	53	119
Little Laramie R nr Filmore	MAY-JUL	50	104	65	56	44	35	48
	MAY-SEP	53	102	70	60	46	36	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 2018 Calendar Year Runoff Forecast  
June 8, 2018**

**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**

May runoff was 7.1 MAF, more than two times the long-term average for the Missouri River Basin above Sioux City. Runoff was above average due to all three major runoff components – plains and mountain snowmelt and rainfall runoff. At the end of April, the remaining plains snowpack melted and contributed to early May runoff in Fort Peck and Garrison. Secondly, mountain snowpack, which peaked in mid-April, began melting rapidly. Finally, rainfall in areas of Montana and Wyoming was well above average.

Runoff was well-above average in the Fort Peck, Garrison, and Sioux City reaches. During the last 120 years, the May 2018 runoff volume into Fort Peck (2,460 kAF) ranks as the highest runoff volume on record, behind 2,647 kAF in 1975. The May runoff volume into Garrison (3,196 kAF) ranks as the second highest May runoff volume only behind 3,887 kAF in 2011.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on June 1, is **34.6 MAF (136% of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **30.8 MAF (134% of average)**.

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 40.7 MAF upper basic forecast to the 29.3 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 7 months are being forecast for this June 1 forecast (5 months observed/7 months forecast), the range of wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is attributed to all 6 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 June 5, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows drought conditions in North Dakota and South Dakota, as well as Kansas, southeastern Nebraska and northern Missouri. Moderate Drought (D1) conditions dominate western portions of the Dakotas, and there are Severe Drought (D2) conditions in north central North Dakota and a small area of northeastern South Dakota. Abnormally Dry (D0) conditions are present in northeastern Montana. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of August, indicates drought conditions are likely to persist in northeastern Montana and North Dakota. Drought removal is likely in most drought-affected areas of South Dakota. In Missouri, drought removal is likely; however, drought is expected to persist with some improvement in Kansas.

# U.S. Drought Monitor

June 5, 2018  
 (Released Thursday, Jun. 7, 2018)  
 Valid 8 a.m. EDT

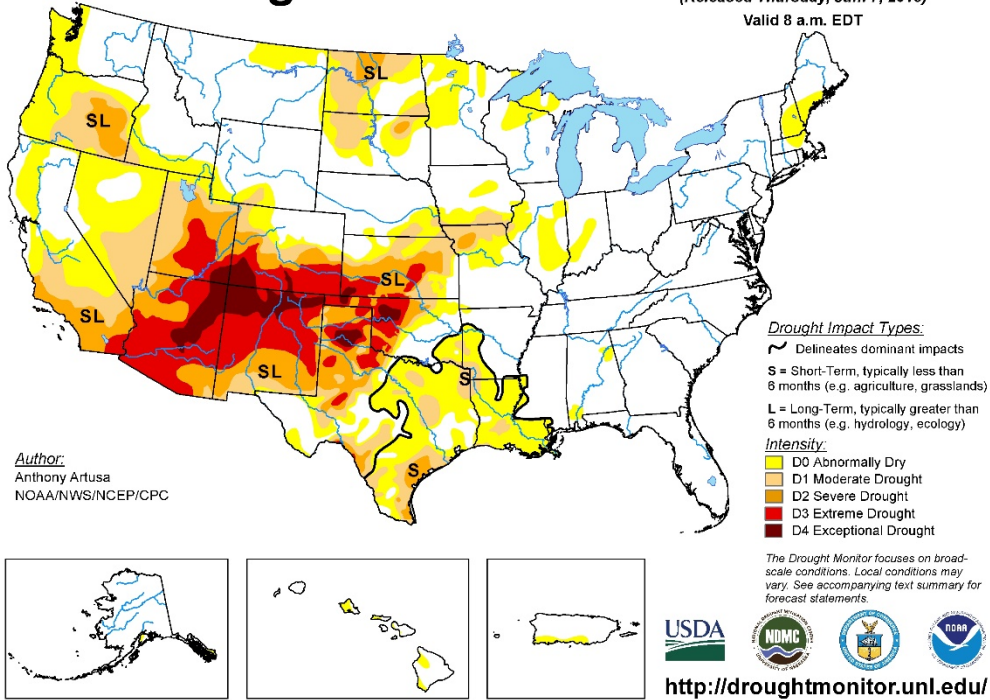


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for June 5, 2018.

# U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid for May 17 - August 31, 2018  
 Released May 17, 2018

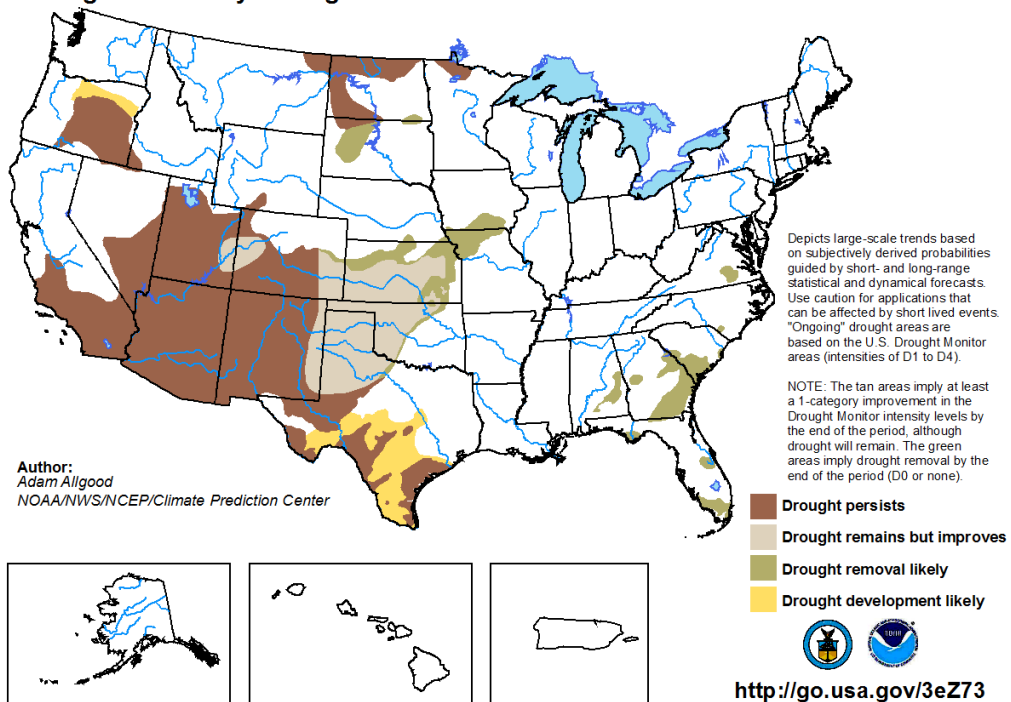
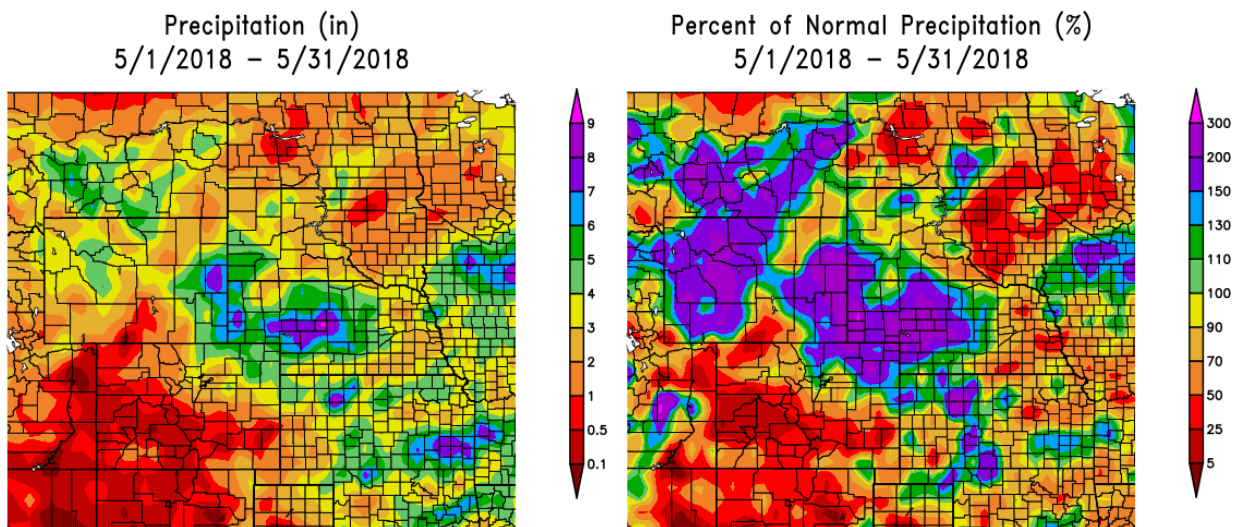


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

## Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at <http://www.hprcc.unl.edu/>. The May precipitation accumulations are shown in **Figure 3** as inches of precipitation (left) and percent of normal precipitation (right). May precipitation, particularly in Montana and Wyoming, had a significant influence on the above-average volumes of runoff in the Fort Peck and Garrison reaches. As a percent of normal, precipitation was more than 150 percent of normal in much of southern and central Montana and significant areas of Wyoming and western Nebraska (right image of **Figure 3**). In contrast, precipitation was less than 70 percent of normal in northern Montana, central North Dakota, eastern South Dakota, and many areas of the lower Basin. Some significant precipitation amounts and departures from normal are listed in **Table 1**. Billings, MT, which was one of the wetter locations in the upper Basin, recorded 5.22 inches in May 2018, the fourth wettest May out of 84 years of record. The record wettest May for Billings was 9.54 inches in 2011, 4.32 inches greater than in 2018.

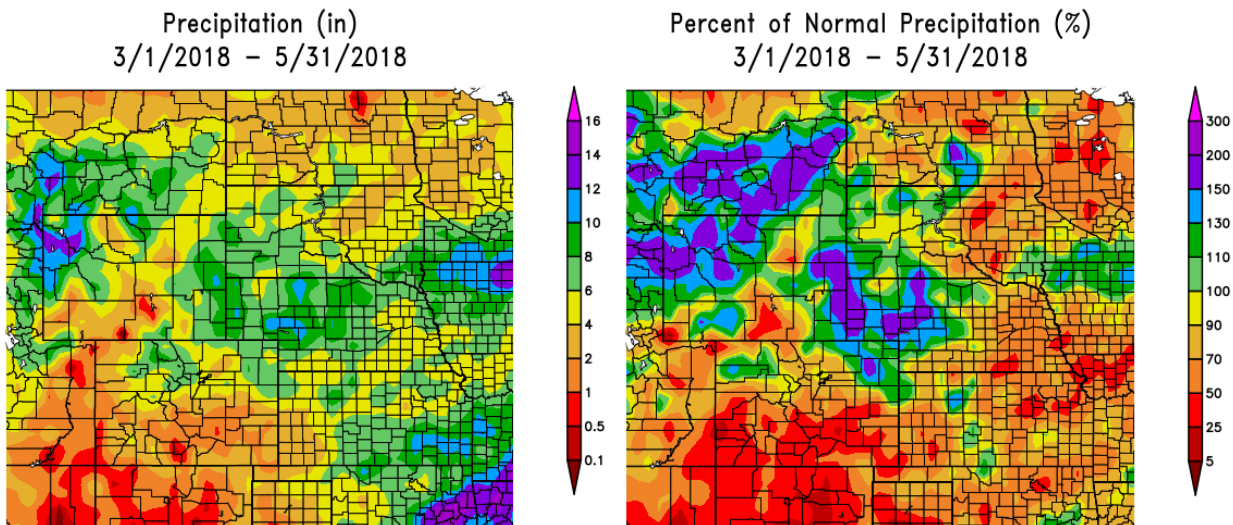


**Figure 3.** May 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

**Table 1.** May 2018 significant precipitation and departure from normal.

Location	Precipitation, inches	Departure from Normal, inches
Helena, MT	3.26	1.39
Great Falls, MT	3.52	1.10
Lewistown, MT	5.10	2.25
Livingston, MT	3.45	0.79
Billings, MT	5.22	3.04
Miles City, MT	4.19	2.01
Sheridan, WY	3.57	1.22
Lander, WY	4.07	1.87
Cheyenne, WY	4.10	1.76
Scottsbluff, NE	7.51	5.03

March-April-May precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the above-normal precipitation pattern in Montana, Wyoming and Nebraska due to the influence of May precipitation. Similarly, below-normal precipitation in May has also led to a similar below-normal precipitation pattern over the March-April-May three-month period in the Dakotas, eastern Nebraska, Iowa, Kansas and Missouri.

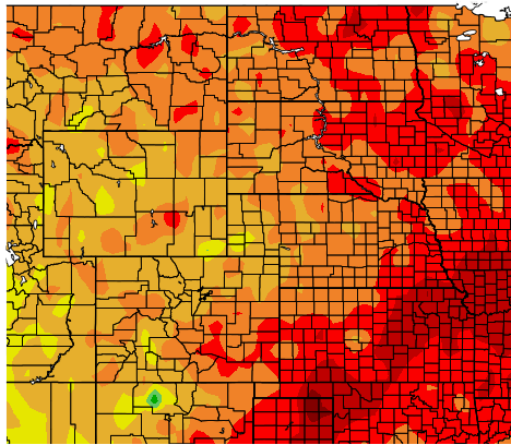


**Figure 4. March-April-May 2018 Precipitation (inches) and Percent of Normal Precipitation.** Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

May temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** were well-above normal in all of the Missouri Basin, leading to rapid snowmelt in the Rocky Mountains. Temperatures ranged from 2 to 4 deg F above normal in much of the upper Missouri and upper Yellowstone Basins in Montana and Wyoming, and 4 to 8 deg F above normal in northern and eastern Montana. Temperatures were even warmer in the Dakotas and all lower Basin states. Despite the above-normal May temperatures, March-April-May temperature departures, in the right image of **Figure 5**, reflect the overall colder-than-normal pattern that dominated the early spring season in the upper Basin. Colder-than-normal temperatures occurred over Montana and the Dakotas, while warmer-than-normal temperatures have occurred over Wyoming, Colorado and Kansas. Compared to long-term records maintained by the NOAA National Center for Environmental Information (NCEI), all Missouri Basin states ranked in the top 10 warmest Mays. Montana May temperatures were 6<sup>th</sup> warmest out of 124 years of record, while Nebraska was 4<sup>th</sup> warmest. Kansas experienced the 2<sup>nd</sup> warmest May, while Missouri experienced the warmest May on record.

Departure from Normal Temperature (F)  
5/1/2018 – 5/31/2018



Departure from Normal Temperature (F)  
3/1/2018 – 5/31/2018

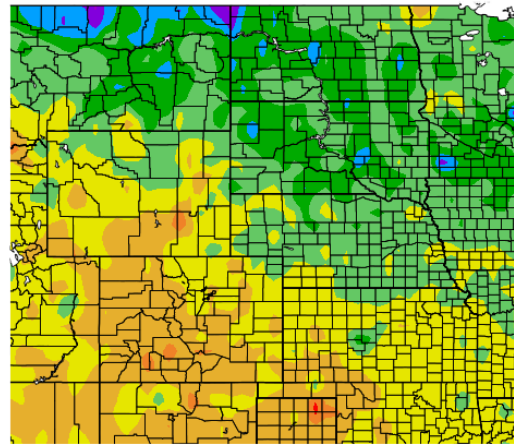


Figure 5. May 2018 and March-April-May 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

### 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. The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on June 3, 2018.

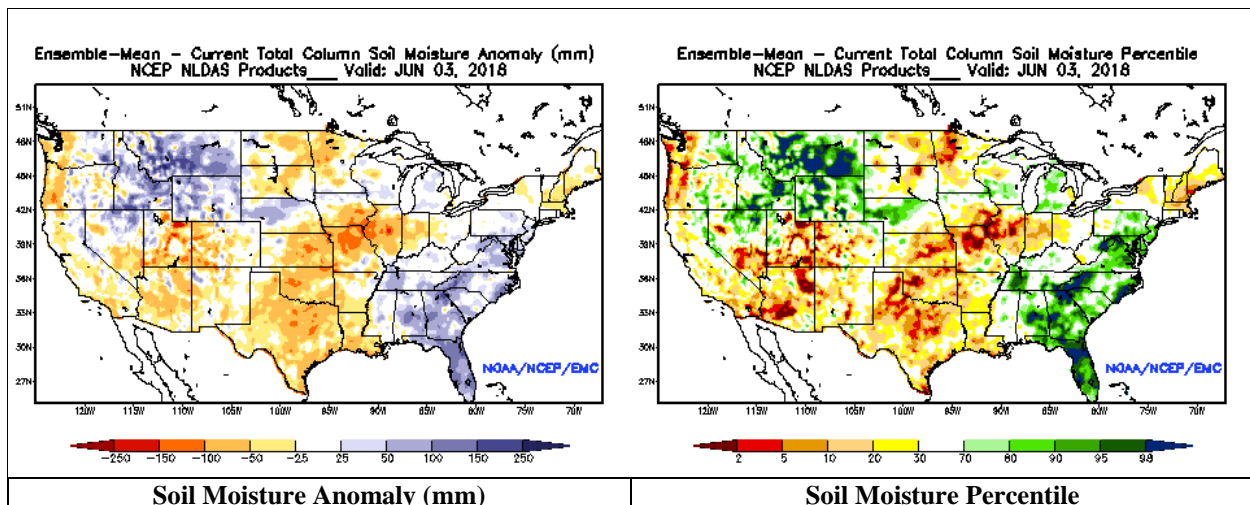


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

Soil moisture anomalies are well-above normal in Montana, Wyoming and western Nebraska due to wet antecedent moisture conditions during the winter and spring 2018, and due to the May

2018 precipitation in these areas. In contrast, soil moisture anomalies are below normal in the Dakotas, southeastern Nebraska, southern Iowa, Kansas and Missouri.

### **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. The remaining plains snowpack in northern Montana melted during mid-April 2018. Snowmelt runoff from the Milk River Basin in northern Montana entered Garrison Reservoir during early May, and it contributed to the above-average May runoff. No plains snowpack accumulated during May.

### **Mountain Snowpack**

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. By May 1, mountain snowpack is a good indicator of the total May-June-July runoff. In addition to mountain SWE, the volumes of May runoff into Fort Peck and Garrison can also be used to predict June-July runoff for the June 1 forecast. A third parameter that may be used to predict June-July runoff is total accumulated May-June-July precipitation at specific observation locations in the upper Basin. On June 1, the sum of observed May precipitation and an estimate of future June-July precipitation are used to predict June-July runoff.

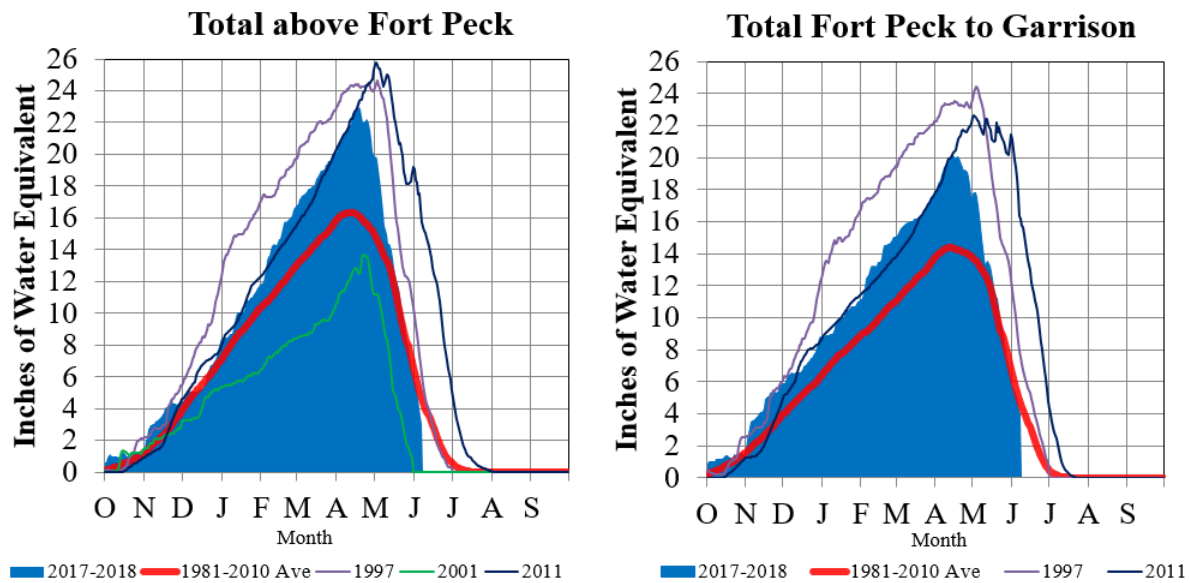
**Figure 7** includes time series plots of the average mountain SWE beginning on October 1, 2017 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 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).

The mountain snowpack accumulation peaked in both reaches: on April 19<sup>th</sup> at 23.0" (141% of the normal April 15 peak) for the reach above Fort Peck Dam, and on April 15<sup>th</sup> at 20.1" (137% of the normal April 15 peak) for the reach between Fort Peck and Garrison Dams.

On June 7, the mountain snowpack was 3.0 inches (66% of average) in the reach above Fort Peck Dam. The June 7, 2018 snowpack was about 12.8 inches lower than June 7, 2011. On June 7, 2018 the mountain snowpack in the reach between Fort Peck and Garrison was 4.0 inches (81% of average). The June 7, 2018 snowpack was about 12.3 inches lower than on June 7, 2011. **In other words, most of the mountain snowpack has melted, it is below the seasonal average, and it is much less than the snowpack at this time in 2011. The chance of having high runoff volumes similar to 2011 into Fort Peck and Garrison is much less due to the lower existing snowpack.** Based on the warm temperature outlook for the northern Rocky Mountains over the next couple weeks, we expect mountain snowpack to continue melting at a fairly rapid pace.

# Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

June 7, 2018



On June 7, 2018 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 3.0” 66% of average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 4.0”, 81% of average. The “Total above Fort Peck” reach peaked on April 19 at 23.0”, 141% of the normal April 15 peak. The “Total Fort Peck to Garrison” reach peaked on April 15 at 20.1”, 137% of the normal April 15 peak.

\*Generally considered the high and low year of the last 30-year period, respectively.

Provisional data. Subject to revision.

Figure 7. Mountain snowpack water content on June 7, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

## 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 ENSO and its implications on temperature and precipitation outlooks.

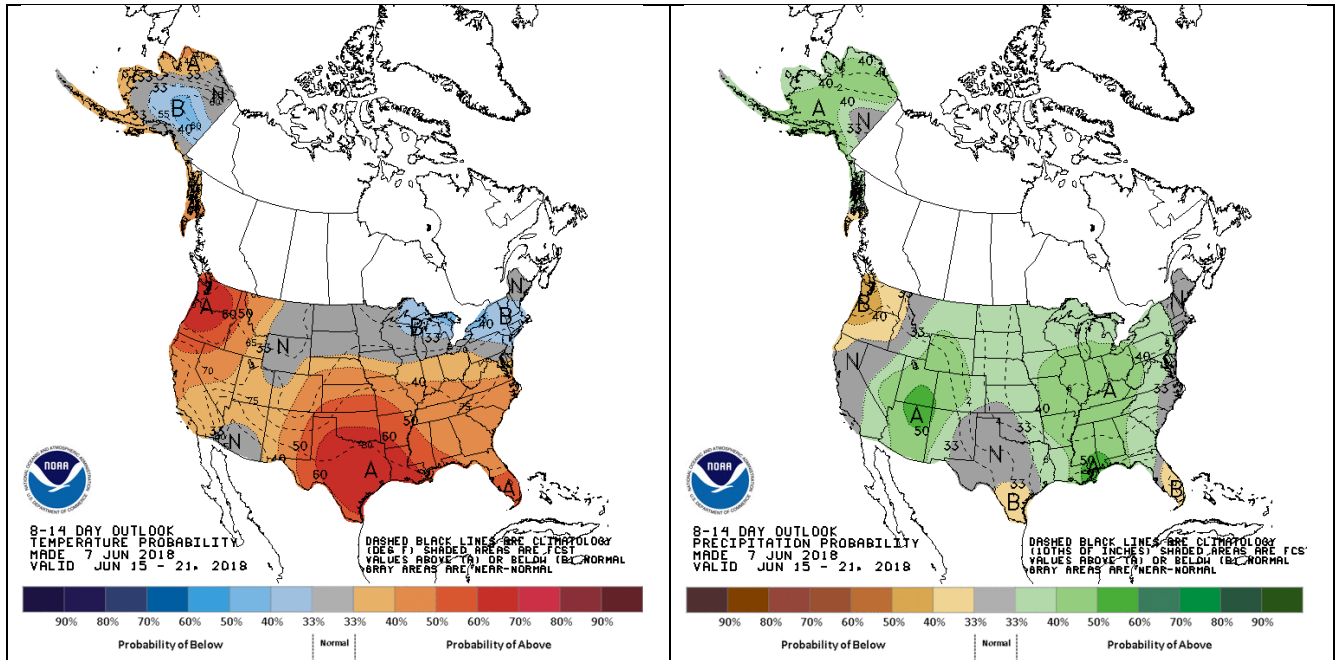
### ENSO (El Niño Southern Oscillation)

ENSO-neutral conditions are present in the equatorial Pacific and typically do not influence the chances for spring and early summer precipitation and temperatures.

### 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 21 in **Figure 8** indicates equal chances for temperatures in the upper Basin, while there is an increase in the chances for above-normal temperatures in western Montana, Nebraska, Colorado, Kansas, southern Iowa and Missouri. The precipitation outlook indicates a slight increase in the chances for precipitation across the Missouri Basin, with slightly greater chances for precipitation in the central Rocky Mountains and Missouri.



**Figure 8. CPC 8-14 Day temperature and precipitation outlooks through April 16, 2018.**

The June CPC temperature outlook in **Figure 9** indicates significantly increased chances for above-normal temperatures over the entire Basin, particularly in the southern region. With regard to precipitation, there are increased chances for below-normal precipitation extending from western Montana into Wyoming, Colorado and Kansas. There are equal chances for precipitation in much of the central Basin, and a slight increase in the chances for above-normal precipitation in North Dakota.

During the July-August-September 2018 period in **Figure 10**, the CPC outlooks indicate equal chances for temperature and precipitation across much of the central and southern Missouri Basin, and increased chances for above-normal temperatures in Montana, Wyoming and Colorado. With regard to precipitation, there is an increased chance for below-normal precipitation in northwestern Montana, an increased chance for above-normal precipitation in southern Wyoming, and equal chances in all other regions of the Missouri Basin.

During the October-November-December period in **Figure 11**, CPC outlooks indicate increased chances for above-normal temperatures over the Basin. There are equal chances for above-normal, normal and below-normal precipitation in the upper Basin; however, there are increased chances for above-normal precipitation in Nebraska, Kansas and Colorado.

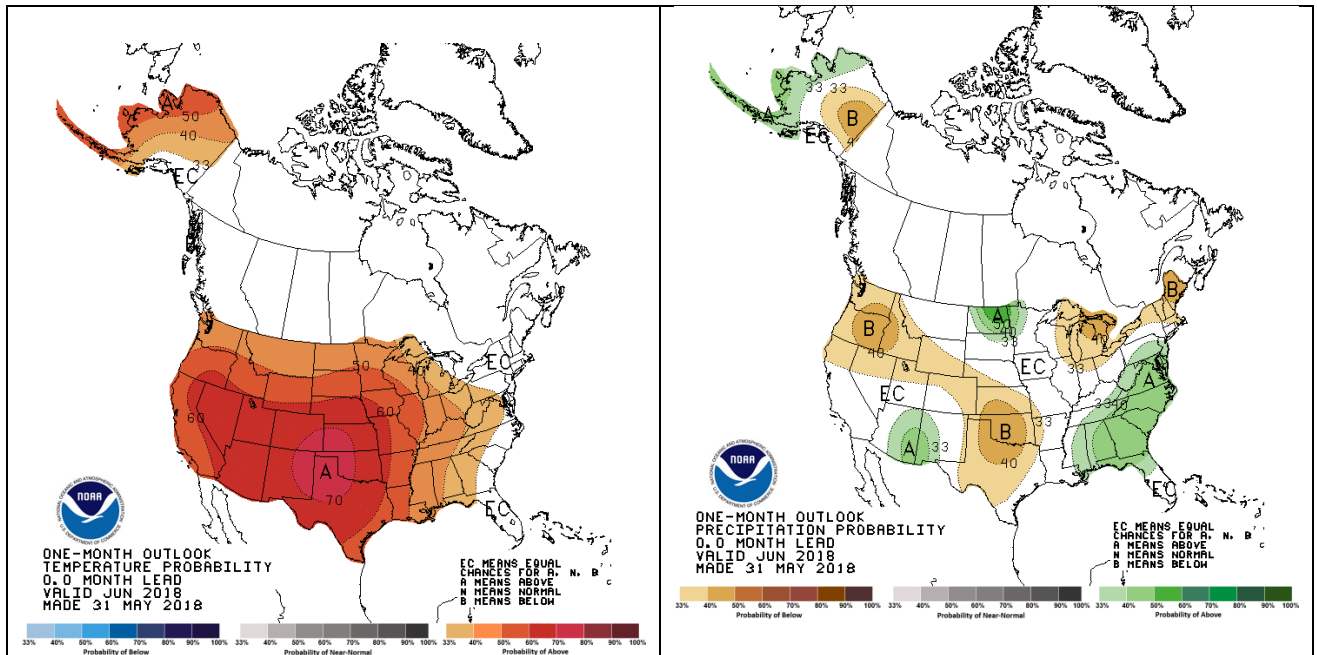


Figure 9. CPC June 2018 temperature and precipitation outlooks.

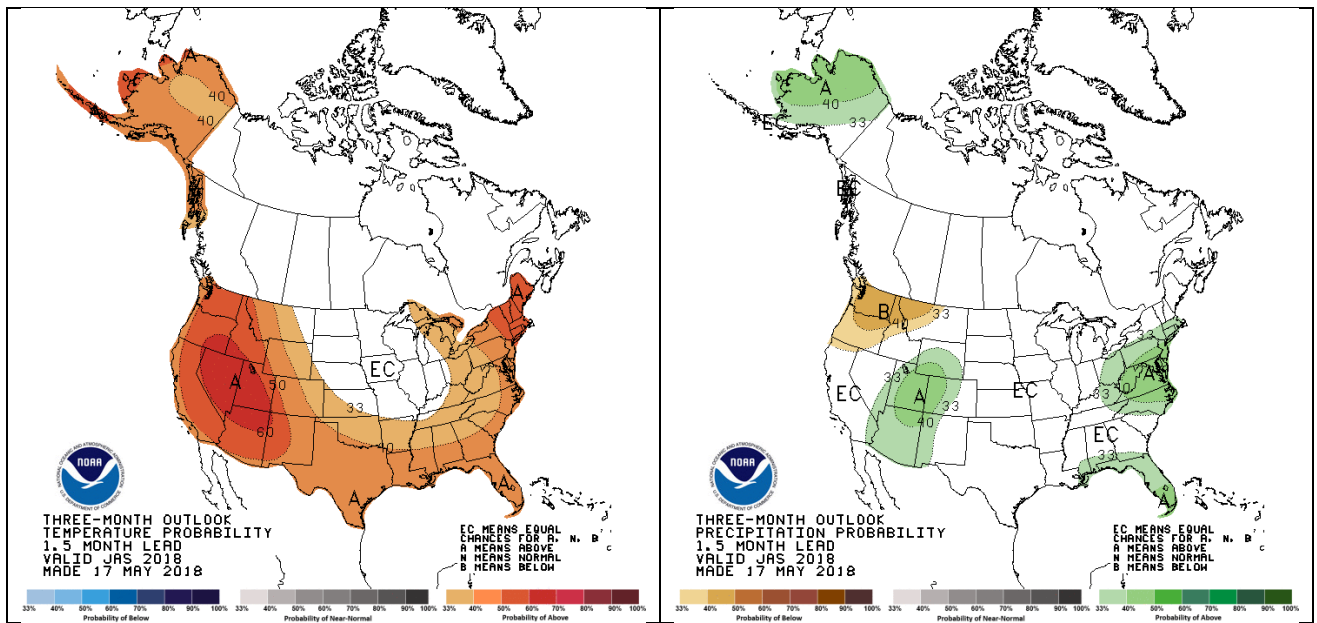


Figure 10. CPC July-August-September 2018 temperature and precipitation outlooks.

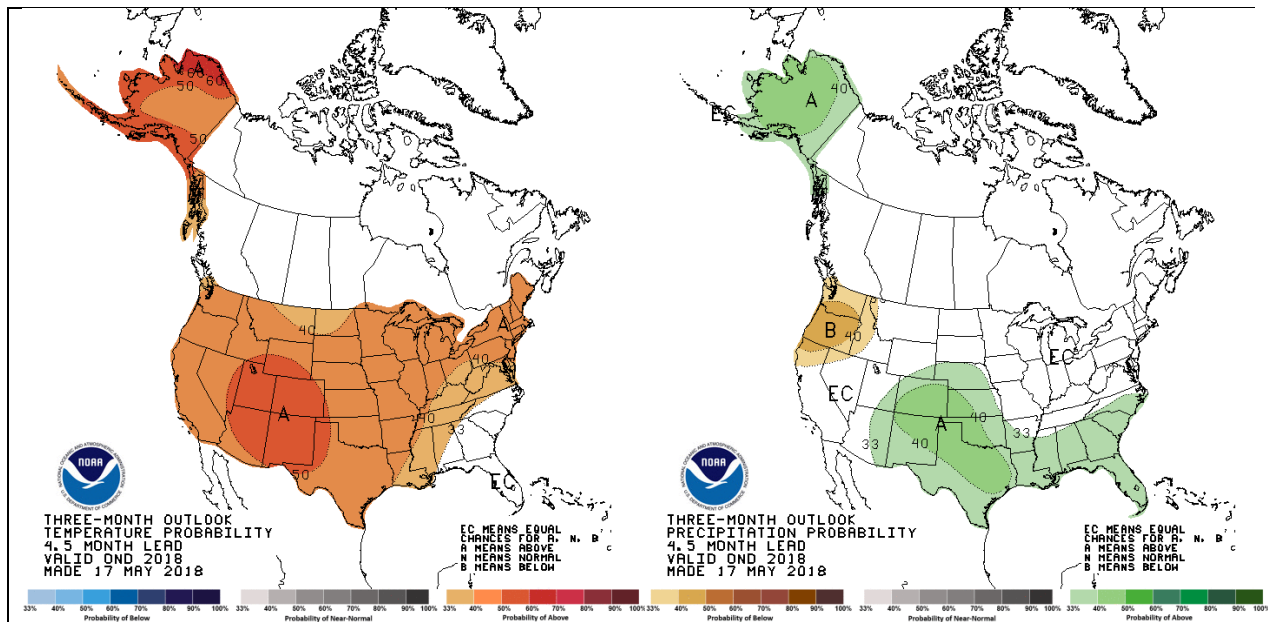
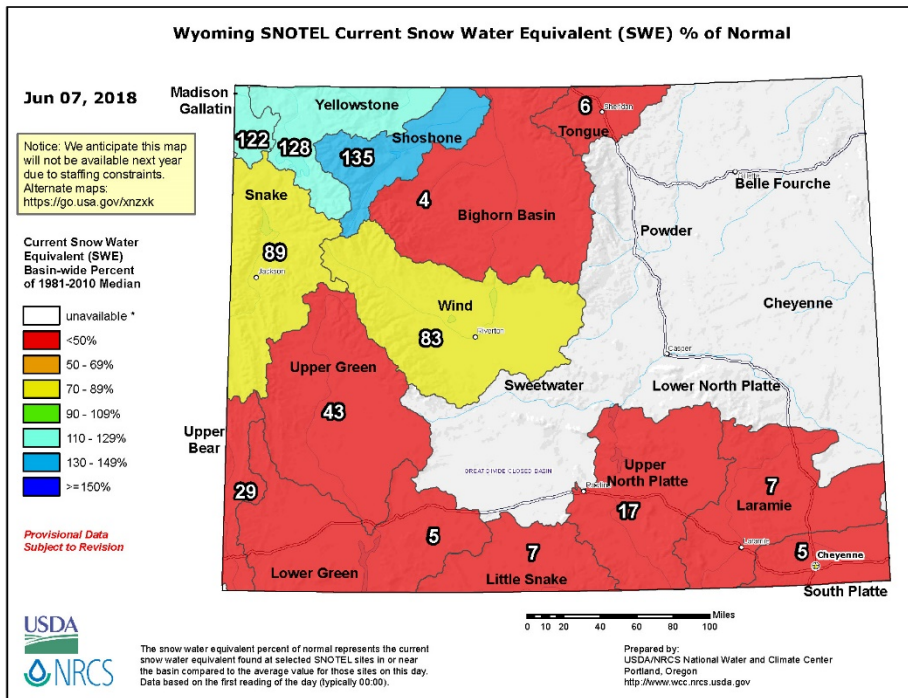
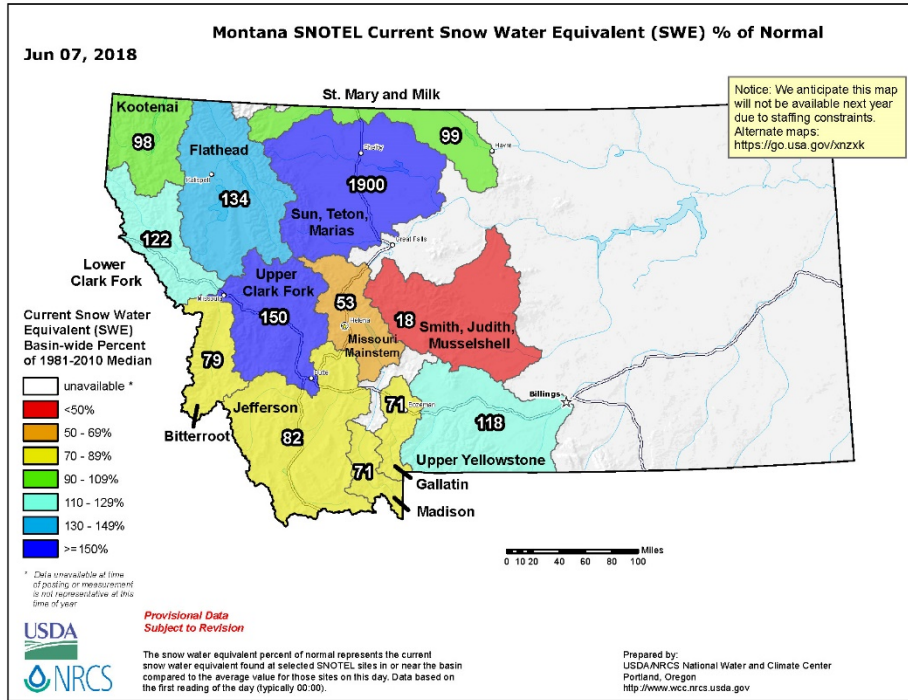


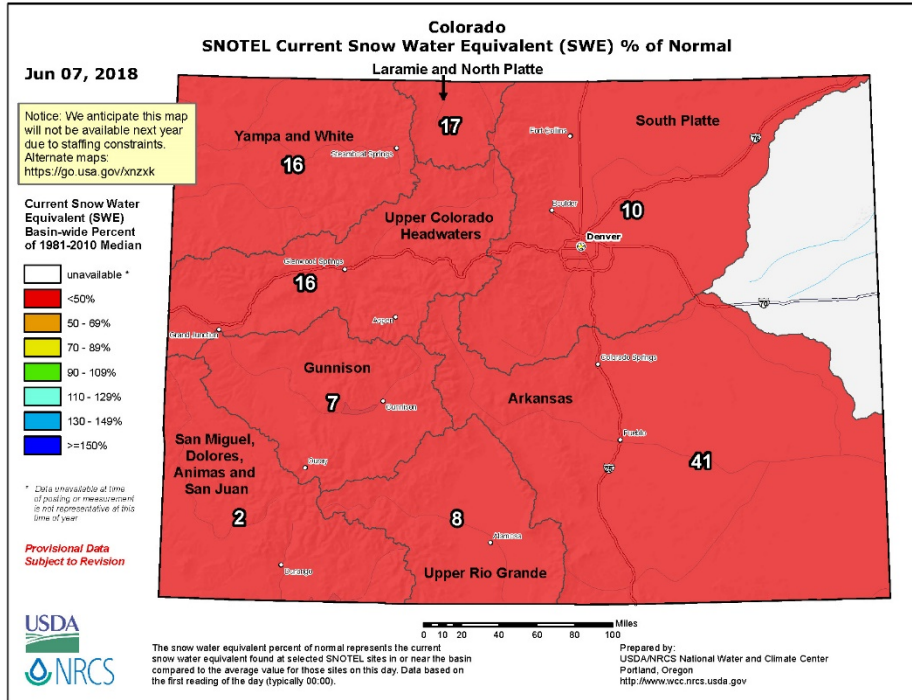
Figure 11. CPC October-November-December 2018 temperature and precipitation outlooks.

## Summary

In summary, the annual runoff forecast for the Missouri Basin above Sioux City, IA is **34.6 MAF, 136% of average**. Looking short-term, we're expecting runoff in June to be above average for the Fort Peck and Garrison reaches as the remaining mountain snowpack melts, and reservoir inflows peak within the next week. For the lower four reaches - Oahe to Sioux City - we're forecasting near-to below-average runoff for the June – July period, based on existing drought conditions, precipitation outlooks and current runoff trends. Looking further out – September through December – we're forecasting about average runoff throughout the entire upper basin.

# Additional Figures





USDA NRCS National Water & Climate Center  
 \* - DATA CURRENT AS OF: June 07, 2018 03:17:41 PM  
 - Based on June 01, 2018 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	62	111	77	68	55	46	56
	JUN-SEP	77	108	95	84	69	59	71
St. Mary R at Intl Boundary (2)	JUN-JUL	305	111	395	340	265	210	275
	JUN-SEP	375	109	475	415	330	270	345
Lima Reservoir Inflow (2)	JUN-JUL	27	100	39	32	22	15.2	27
	JUN-SEP	33	100	48	39	27	18.4	33
Clark Canyon Reservoir Inflow (2)	JUN-JUL	33	94	64	46	20	1.97	35
	JUN-SEP	54	98	96	71	37	11.8	55
Jefferson R nr Three Forks (2)	JUN-JUL	560	158	705	575	405	280	355
	JUN-SEP	620	149	805	645	430	275	415
Hebgen Lake Inflow (2)	JUN-JUL	184	103	225	200	168	144	178
	JUN-SEP	285	102	345	310	260	225	280
Ennis Lake Inflow (2)	JUN-JUL	340	103	415	370	310	265	330
	JUN-SEP	490	101	590	530	450	385	485
Missouri R at Toston (2)	JUN-JUL	1200	128	1560	1350	1060	845	940
	JUN-SEP	1490	122	1970	1690	1300	1010	1220
Smith R bl Eagle Ck (2)	JUN-JUL	70	130	104	84	56	36	54
	JUN-SEP	81	125	127	99	63	35	65
Gibson Reservoir Inflow (2)	JUN-JUL	250	119	295	270	230	205	210
	JUN-SEP	295	118	345	315	275	240	250
Marias R nr Shelby (2)	JUN-JUL	140	90	225	174	106	55	156
	JUN-SEP	153	89	255	194	112	52	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	58	123	65	61	55	51	47
	JUN-SEP	77	122	87	81	73	67	63
Wind R ab Bull Lake Ck	JUN-JUL	455	138	540	490	420	370	330
	JUN-SEP	505	138	610	545	460	395	365
Bull Lake Ck nr Lenore (2)	JUN-JUL	102	94	119	109	95	85	108
	JUN-SEP	131	94	153	140	122	108	139
Boysen Reservoir Inflow (2)	JUN-JUL	485	114	625	540	430	345	425
	JUN-SEP	540	111	715	610	470	365	485
Greybull R at Meeteetse	JUN-JUL	102	106	138	117	88	67	96
	JUN-SEP	150	106	194	168	132	106	142
Shell Ck nr Shell	JUN-JUL	35	100	44	39	31	25	35
	JUN-SEP	46	100	57	51	41	35	46
Bighorn R at Kane (2)	JUN-JUL	640	112	890	740	540	390	570
	JUN-SEP	705	112	1010	825	585	405	630
NF Shoshone R at Wapiti	JUN-JUL	440	144	505	465	415	375	305
	JUN-SEP	510	142	585	540	480	435	360
SF Shoshone R nr Valley	JUN-JUL	225	143	260	240	215	196	157
	JUN-SEP	270	143	310	285	255	230	189
Buffalo Bill Reservoir Inflow	JUN-JUL	680	146	790	725	635	570	465
	JUN-SEP	780	146	900	830	730	655	535
Bighorn R nr St. Xavier (2)	JUN-JUL	1180	128	1520	1320	1040	840	920
	JUN-SEP	1290	128	1700	1460	1120	880	1010
Little Bighorn R nr Hardin	JUN-JUL	48	91	76	60	37	20	53
	JUN-SEP	60	91	94	74	47	27	66

Tongue R nr Dayton (2)	JUN-JUL	39	80	55	45	33	23	49
	JUN-SEP	50	81	69	58	43	32	62
Tongue River Reservoir Inflow (2)	JUN-JUL	84	76	132	104	65	37	110
	JUN-SEP	104	78	162	127	81	47	134
NF Powder R nr Hazelton	JUN-JUL	5.9	131	7.9	6.7	5.0	3.8	4.5
	JUN-SEP	6.6	127	8.9	7.5	5.7	4.3	5.2
Powder R at Moorhead	JUN-JUL	114	124	171	137	91	57	92
	JUN-SEP	132	120	198	159	105	66	110
Powder R nr Locate	JUN-JUL	125	124	200	155	95	50	101
	JUN-SEP	148	121	235	184	113	61	122

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 2018 Calendar Year Runoff Forecast  
July 6, 2018**

**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**

June runoff was 10.0 MAF, almost two times the long-term average for the Missouri River Basin above Sioux City. Runoff was above average due to mountain snowmelt and above-average rainfall runoff throughout much of the Basin. The remaining mountain snowpack, which peaked in mid-April, melted out during June. Rainfall in areas of Montana and Wyoming was well above average for the second month in a row. In addition, June rainfall was also well-above average in areas of the Dakotas, Nebraska, Iowa, and Kansas.

Runoff was well-above average in all reaches during June. June runoff in the Sioux City reach was 327% of average, and the Garrison reach was 190% of average.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on July 1, is **39.8 MAF (157% of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **35.2 MAF (153% of average)**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 6 months, expected inflow could range from the 43.8 MAF upper basic forecast to the 36.3 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 6 months are being forecast for this July 1 forecast (6 months observed/6 months forecast), the range of wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is attributed to all 6 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 July 3, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows drought conditions in portions of every state in the Basin except Nebraska. Moderate Drought (D1) and Severe Drought (D2) conditions are present in small areas of Montana and the Dakotas, within larger areas of Abnormally Dry (D0) conditions. Central Kansas has Extreme Drought (D3) conditions. Northern Missouri and southern Iowa are effected by D0 to D2 conditions. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of September, indicates drought conditions are likely to persist in northeastern Montana and the Dakotas. Drought improvement is likely in Kansas, Iowa, and Missouri.

# U.S. Drought Monitor

July 3, 2018  
 (Released Thursday, Jul. 5, 2018)  
 Valid 8 a.m. EDT

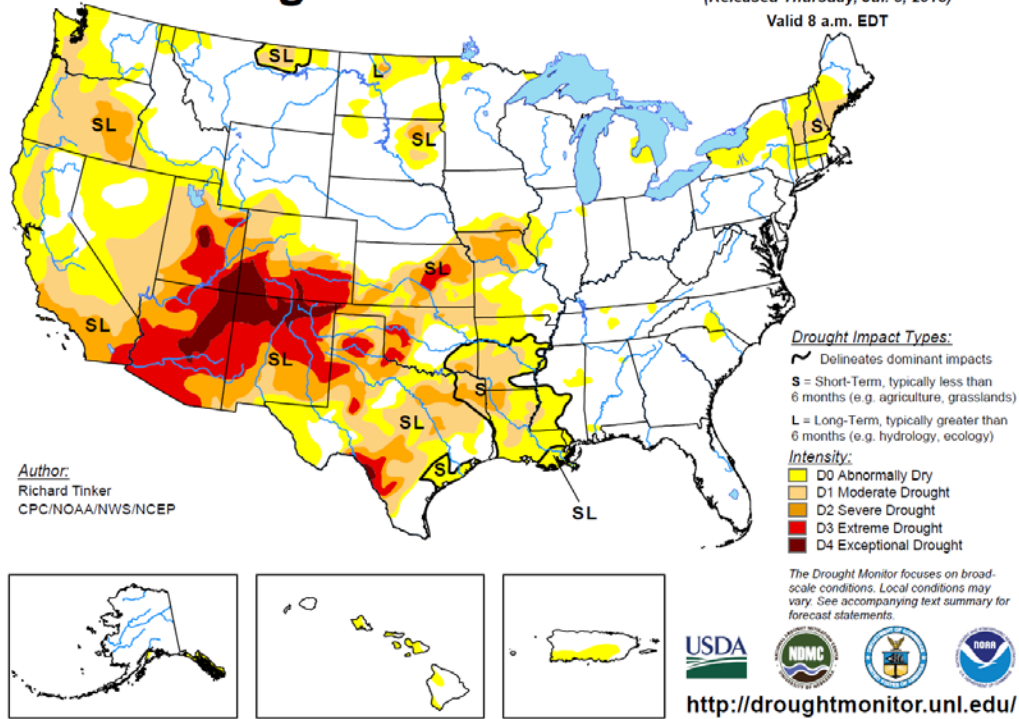


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for July 3, 2018.

# U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid for June 21 - September 30, 2018  
 Released June 21, 2018

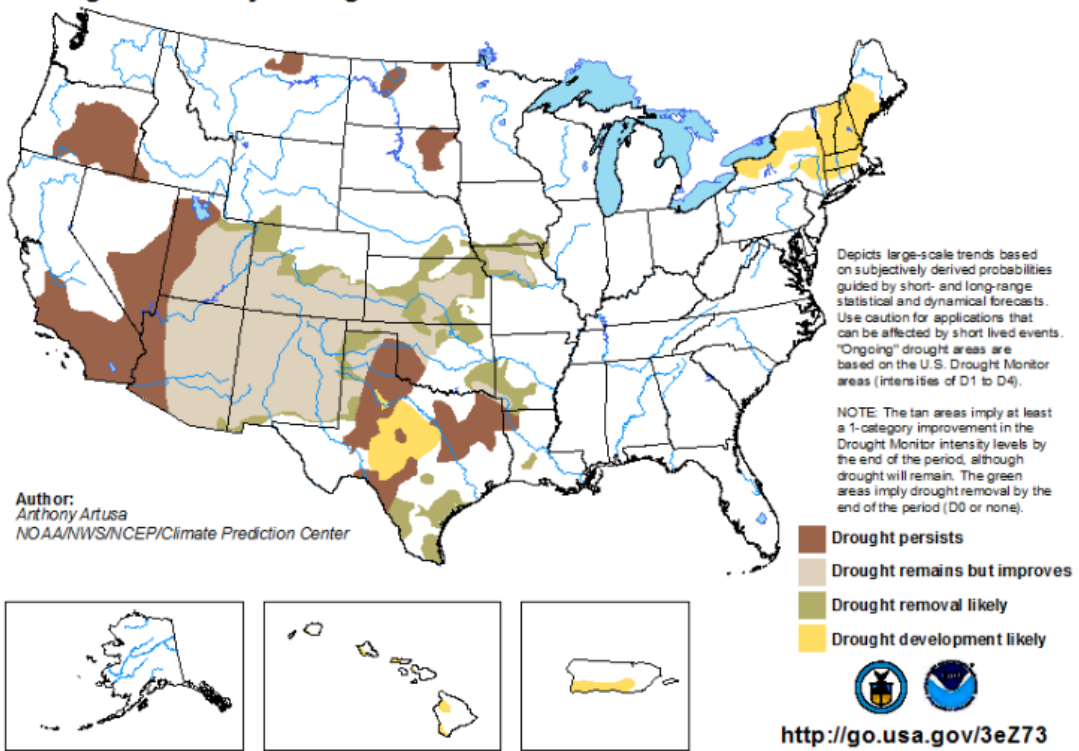
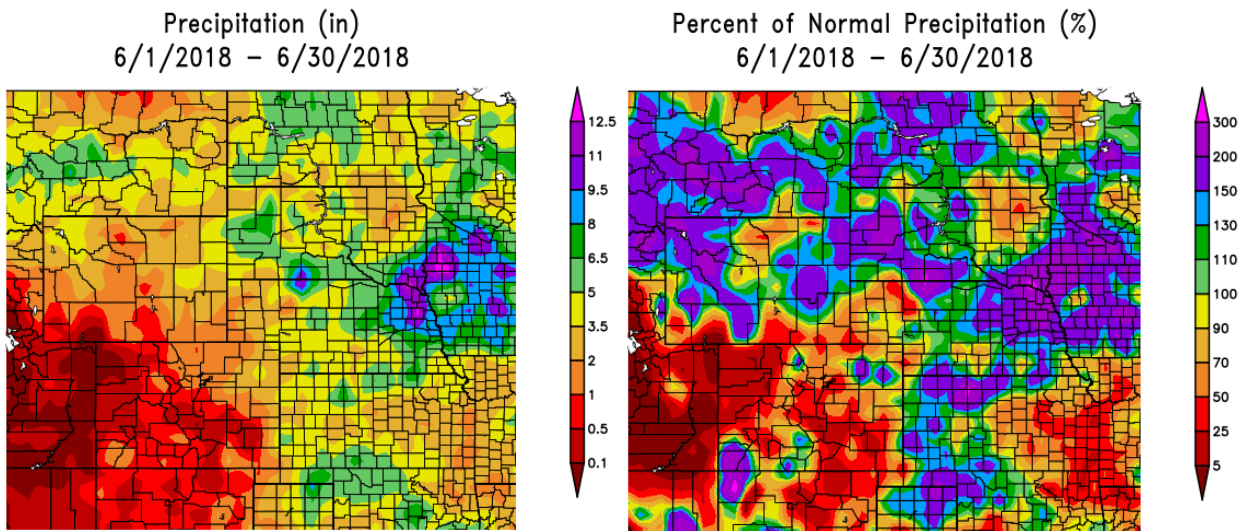


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

## Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at <http://www.hprcc.unl.edu/>. The June precipitation accumulations are shown in **Figure 3** as inches of precipitation (left) and percent of normal precipitation (right). June precipitation had a significant influence on the above-average volumes of runoff for all reaches. As a percent of normal, precipitation was more than 150 percent of normal in much of southern and central Montana, areas of Wyoming, the western Dakotas, northeastern Nebraska, western Iowa, and northern Kansas (right image of **Figure 3**). Some notable June rainfall totals (**Table 1**) included 5.63 inches at Lewistown, MT; 7.29 inches at Sioux Falls, SD; 8.65 inches at Sioux City, IA; 10.75 inches at Norfolk, NE; and 6.89 inches at Omaha, NE. In contrast, precipitation was less than 70 percent of normal in northern Montana, eastern South Dakota, and areas of Missouri and Kansas.



**Figure 3. June 2018 Precipitation (inches) and Percent of Normal Precipitation.** Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

April-May-June precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the above-normal precipitation pattern in Montana, Wyoming and Nebraska due to the influence of May and June precipitation. Similarly, below-normal precipitation in June has also led to a similar below-normal precipitation pattern over the April-May-June three-month period in the eastern Dakotas, Kansas, and Missouri. **Table 4** lists April-May-June precipitation totals and departures from normal. Montana and northwestern Wyoming experienced large precipitation departures during this time period at locations such as Helena, Lewistown, Billings, Miles City, and Lake Yellowstone, WY. Also, June rainfall in the lower basin increased precipitation totals and departures to above-normal levels at locations such as Scottsbluff, NE; Sioux Falls, SD; and Sioux City, IA.

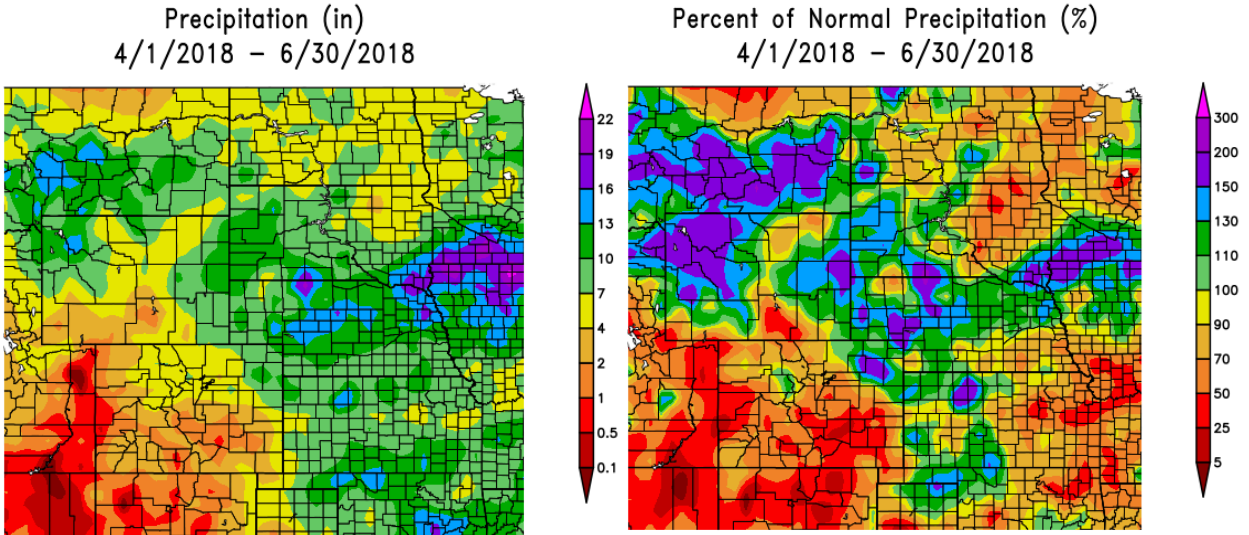


Figure 4. April-May-June 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

Table 1. May-June-July 2018 precipitation totals and departures from normal (units in inches).

Location	April Total	April Departure	May Total	May Departure	June Total	June Departure	April-May-June-Total	April-May-June-Departure
Helena, MT	1.61	0.63	3.26	1.39	3.36	1.30	8.23	3.32
Great Falls, MT	1.48	0.06	3.52	1.10	3.30	0.77	8.30	1.93
Livingston, MT	2.22	0.45	3.45	0.79	3.76	1.37	9.43	2.61
Lewistown, MT	1.75	0.34	5.10	2.25	5.63	2.55	12.48	5.14
Billings, MT	2.16	0.50	5.22	3.04	3.94	1.82	11.32	5.36
Miles City, MT	3.09	1.72	4.19	2.01	4.46	1.95	11.74	5.68
Sheridan, WY	1.83	0.23	3.57	1.22	1.43	-0.69	6.83	0.76
Lake Yellowstone, WY	3.95	1.87	2.48	0.21	4.02	2.02	10.45	4.10
Lander, WY	1.49	-0.38	4.07	1.87	1.66	0.39	7.22	1.88
Scottsbluff, NE	1.59	-0.24	7.51	5.03	2.99	0.14	12.09	4.93
Sioux Falls, SD	3.34	0.33	2.48	-0.92	7.29	3.37	13.11	2.78
Sioux City, IA	1.14	-1.81	3.71	-0.03	8.65	4.76	13.50	2.92
Norfolk, NE	1.32	-1.33	1.62	-2.31	10.75	6.49	13.69	2.85
Omaha, NE	0.27	-2.69	1.97	-2.79	6.89	2.71	9.13	-2.77

## Temperature

June temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** were slightly- to well-above normal in all of the Missouri Basin. Temperatures ranged from 2 to 6 deg F above normal in most of the plains region of the Basin. Central to western Montana was the exception, where temperatures were 0 to 2 degrees below-normal. Despite the above-normal May and June temperatures, April-May-June temperature departures, in the right image of **Figure 5**, still reflect areas of the overall colder-than-normal pattern that dominated the early

spring season in the upper Basin. Colder-than-normal temperatures occurred over Montana and the Dakotas, while warmer-than-normal temperatures have occurred over Wyoming, Colorado and Kansas.

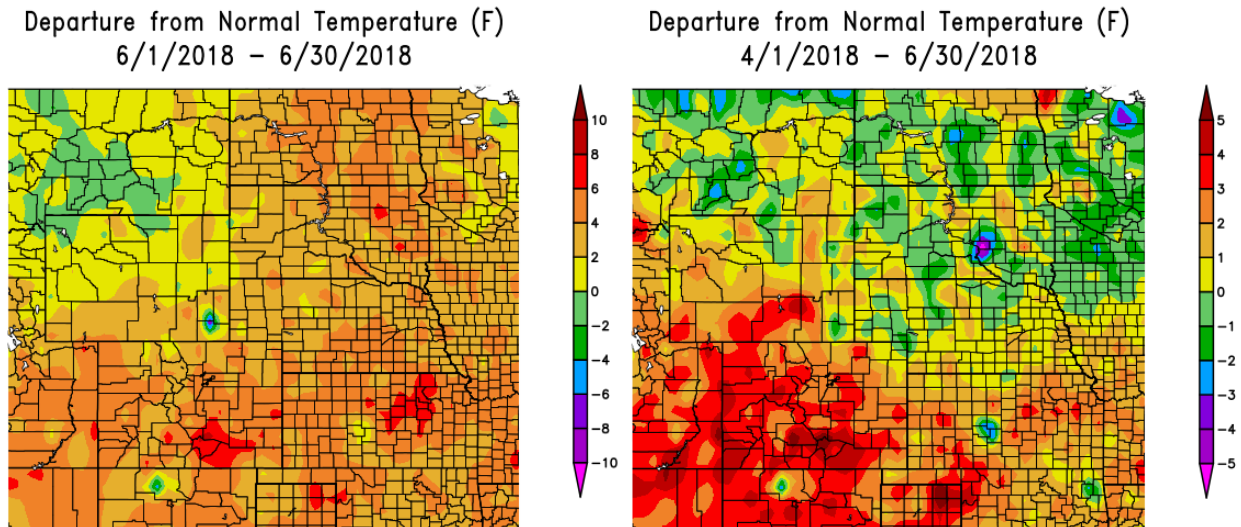
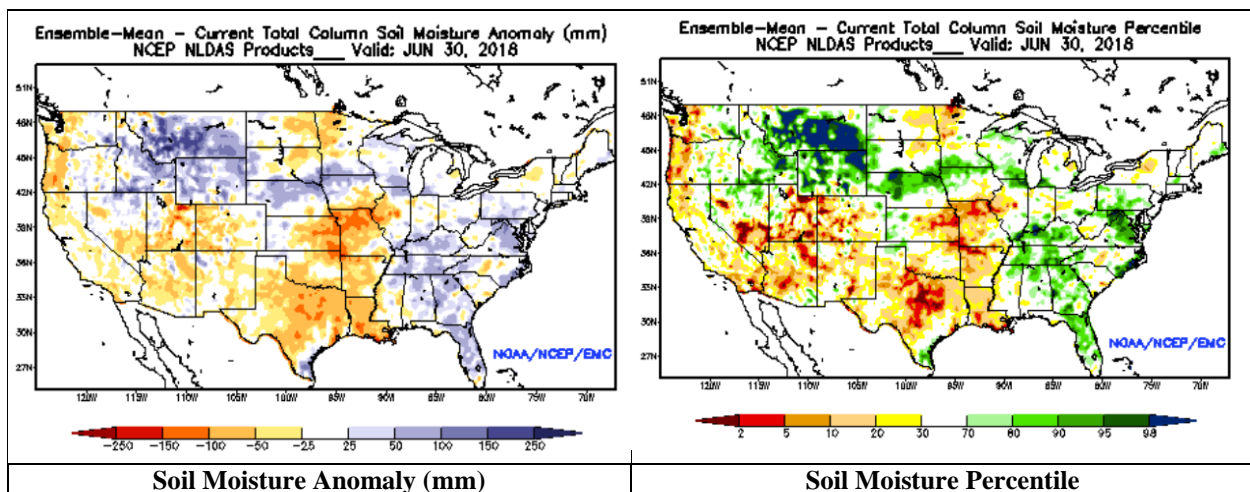


Figure 5. June 2018 and April-May-June 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

### 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. The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on June 30, 2018.



**Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>**

Soil moisture anomalies are well-above normal in Montana, Wyoming, Nebraska, and Iowa due to the May and June 2018 precipitation in these areas. In contrast, soil moisture anomalies are below normal in the eastern Dakotas, eastern Kansas and Missouri.

### **Mountain Snowpack**

Mountain snowpack is the primary factor used to predict May-June-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. By May 1, mountain snowpack is a good indicator of the total May-June-July runoff. In addition to mountain SWE, the volumes of May and June runoff into Fort Peck and Garrison can also be used to predict July runoff for the July 1 forecast. A third parameter that may be used to predict July runoff is total accumulated May-June-July precipitation at specific observation locations in the upper Basin. On July 1, the sum of observed May and June precipitation and an estimate of future July precipitation are used to predict July runoff.

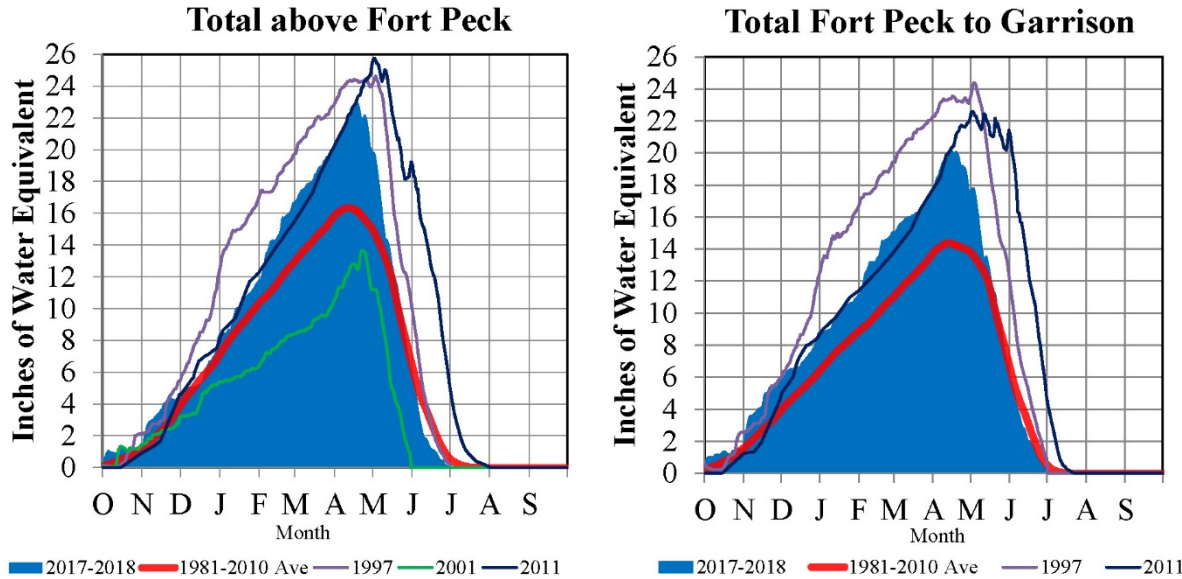
**Figure 7** includes time series plots of the average mountain SWE beginning on October 1, 2017 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 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).

The mountain snowpack accumulation peaked in both reaches: on April 19<sup>th</sup> at 23.0” (141% of the normal April 15 peak) for the reach above Fort Peck Dam, and on April 15<sup>th</sup> at 20.1” (137% of the normal April 15 peak) for the reach between Fort Peck and Garrison Dams.

On July 2, the mountain snowpack was 0.03 inches (6% of average) in the reach above Fort Peck Dam. On July 2, 2018 the mountain snowpack in the reach between Fort Peck and Garrison was 0.1 inches (29% of average). **In other words, most of the mountain snowpack has melted, it is below the seasonal average, and it is much less than the snowpack at this time in 2011.**

# Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

July 2, 2018



On July 2, 2018 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 0.03” 6% of average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 0.1”, 29% of average. The “Total above Fort Peck” reach peaked on April 19 at 23.0”, 141% of the normal April 15 peak. The “Total Fort Peck to Garrison” reach peaked on April 15 at 20.1”, 137% of the normal April 15 peak.

\*Generally considered the high and low year of the last 30-year period, respectively.

Provisional data. Subject to revision.

**Figure 7. Mountain snowpack water content on July 2, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.**

## 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 ENSO and its implications on temperature and precipitation outlooks.

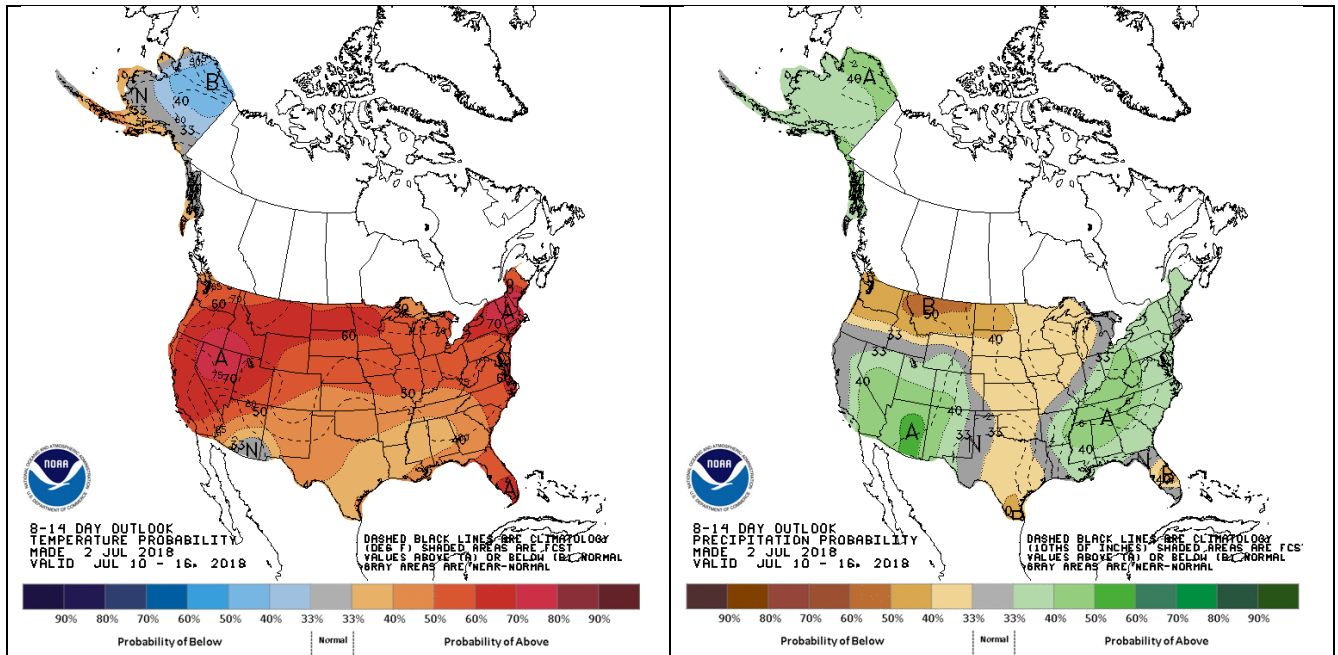
## **ENSO (El Niño Southern Oscillation)**

ENSO-neutral conditions are present in the equatorial Pacific and typically do not influence the chances for spring and early summer precipitation and temperatures. ENSO-neutral conditions are favored throughout the Northern Hemisphere summer 2018; however, an El Niño Watch has been issued by CPC. The chance for El Niño to develop has increased to 50% during the fall and about 65% during the winter 2018-19. El Niño conditions favor warmer-than-normal temperatures during the winter in the Northern Rocky Mountains and Northern Plains.

## 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 July 16 in **Figure 8** indicates an increase in the chances for above-normal temperatures throughout the Basin. The precipitation outlook indicates a slight increase in the chances for below-normal precipitation across the Missouri Basin.



**Figure 8.** CPC 8-14 Day temperature and precipitation outlooks through July 16, 2018.

The July CPC temperature outlook in **Figure 9** indicates slightly increased chances for above-normal temperatures over the lower Basin, with slightly increased chances for below-normal temperatures in Montana and northwestern Wyoming. With regard to precipitation, there are increased chances for above-normal precipitation extending from Wyoming into southern Montana. There are equal chances for precipitation in most of the central Basin, and a slight increase in the chances for below-normal precipitation in Kansas.

During the August-September-October 2018 period in **Figure 10**, the CPC outlooks indicate equal chances for precipitation across the entire Basin, with the exception of a slight increase in the chance for above-normal precipitation in Wyoming. The temperature outlook indicates a slight increase in the chances for above-normal temperatures throughout the Basin.

During the November-December 2018-January 2019 period in **Figure 11**, CPC outlooks indicate increased chances for above-normal temperatures over the Basin. There are equal chances for

above-normal, normal and below-normal precipitation in the upper Basin; however, there are increased chances for above-normal precipitation in Nebraska, Kansas and Colorado.

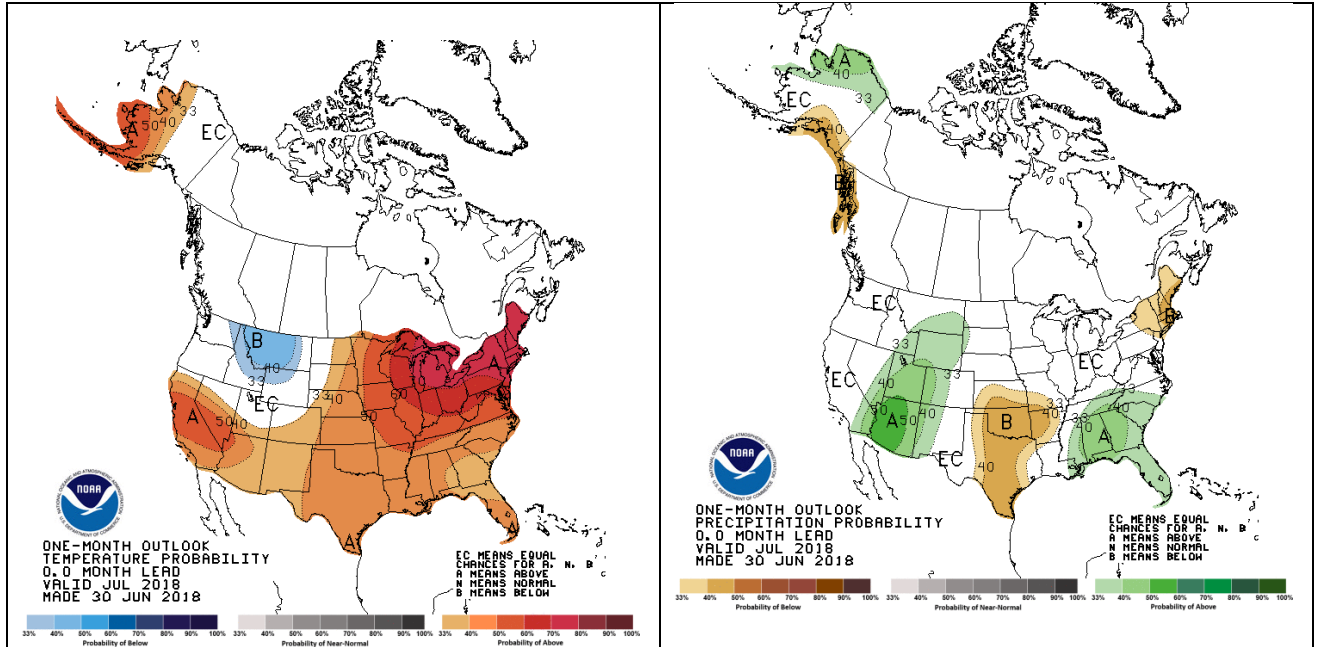


Figure 9. CPC July 2018 temperature and precipitation outlooks.

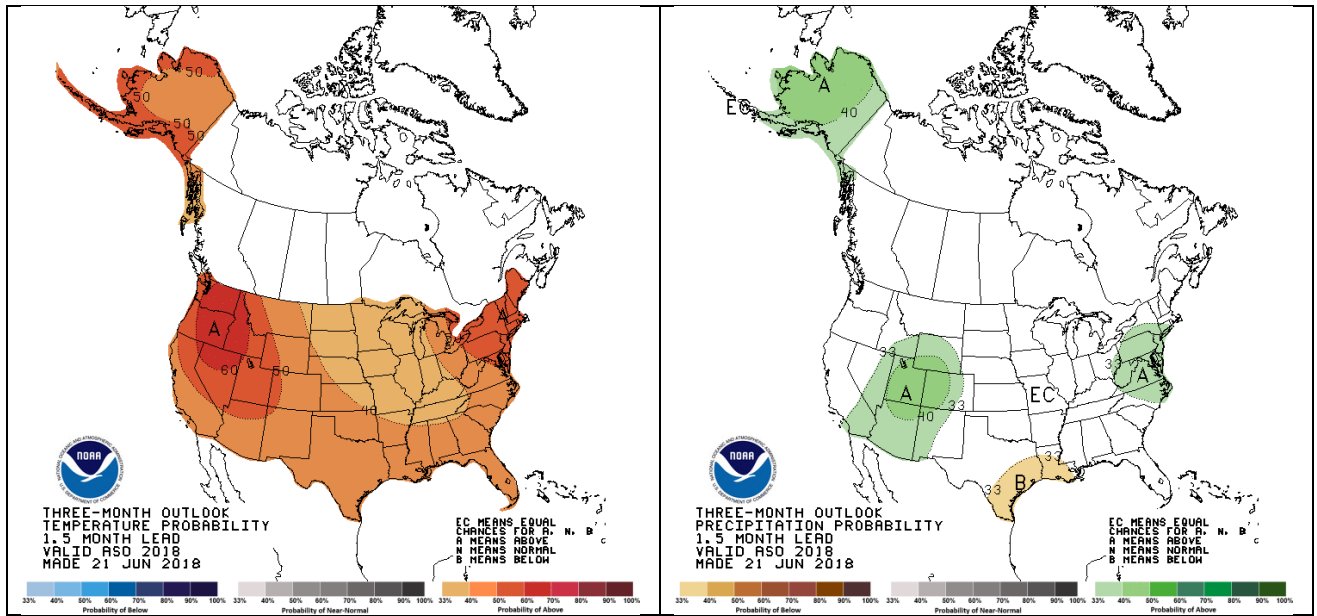


Figure 10. CPC August-September-October 2018 temperature and precipitation outlooks.

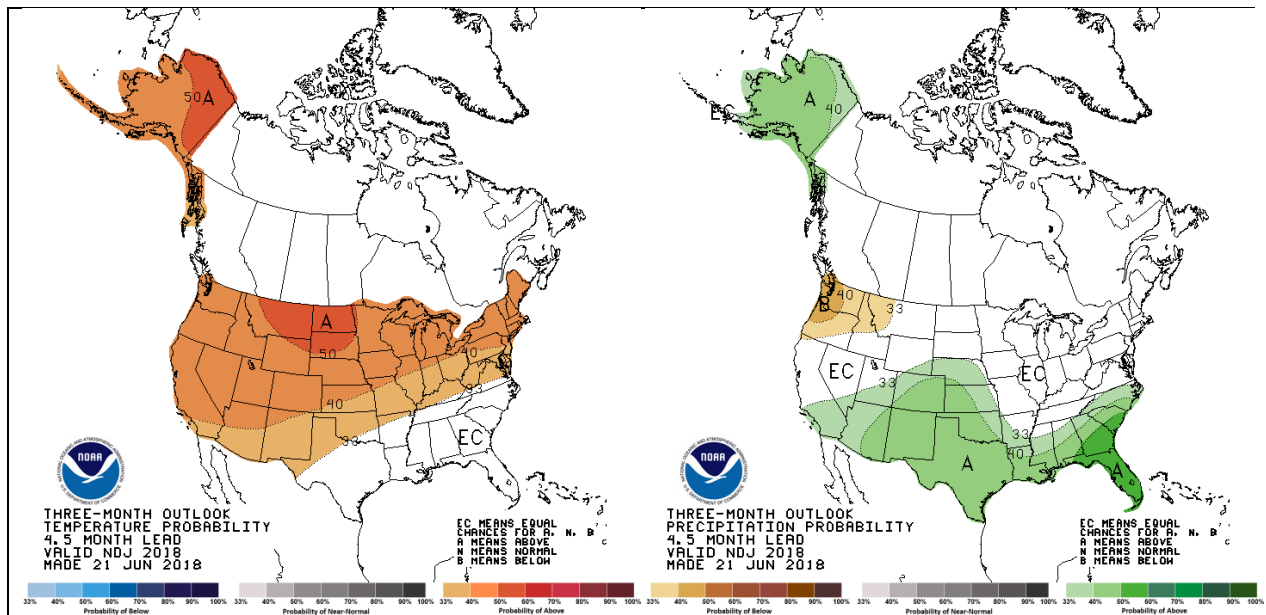
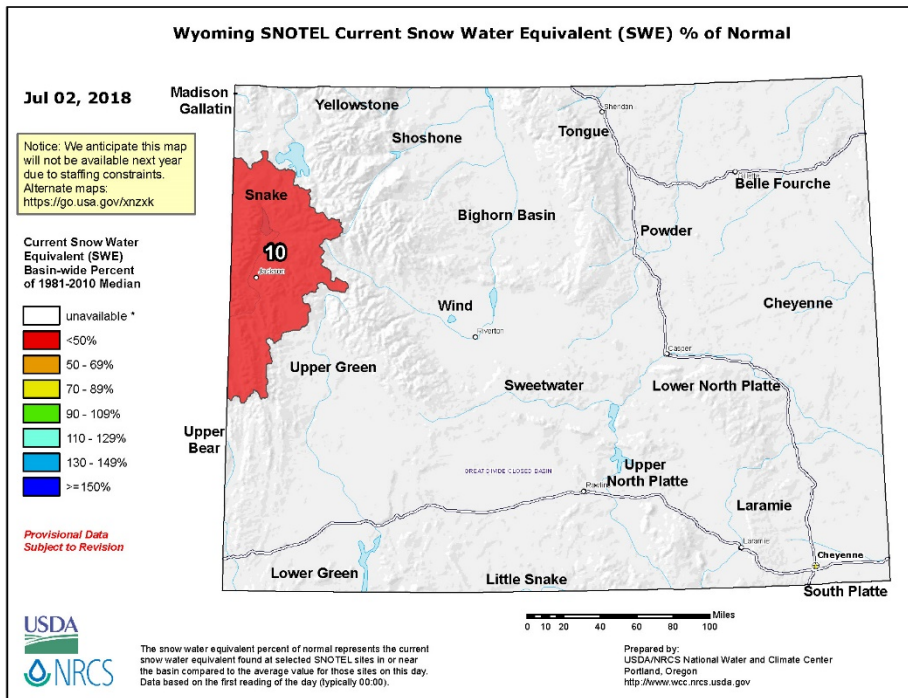
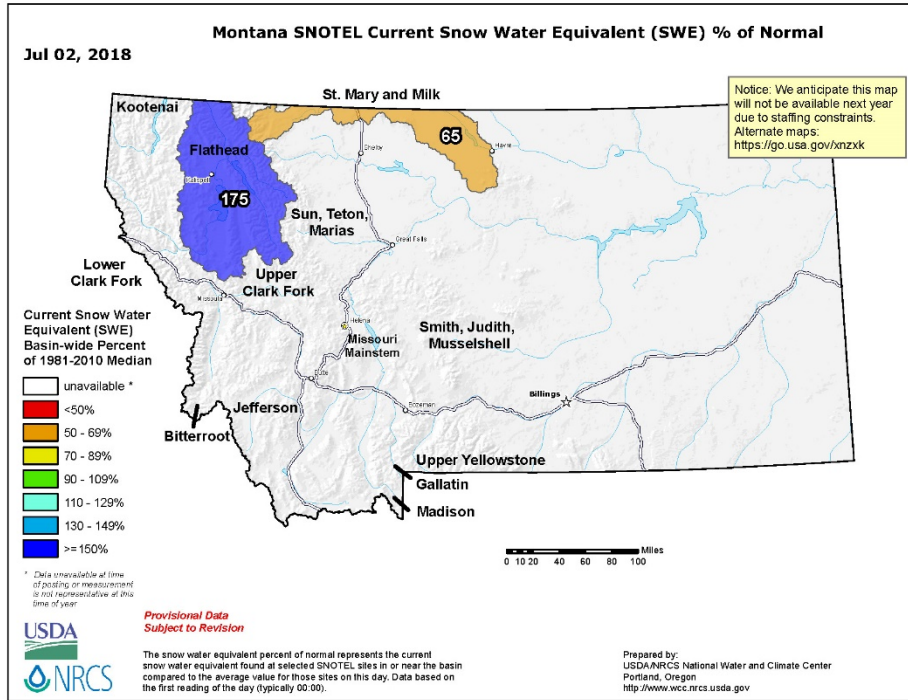


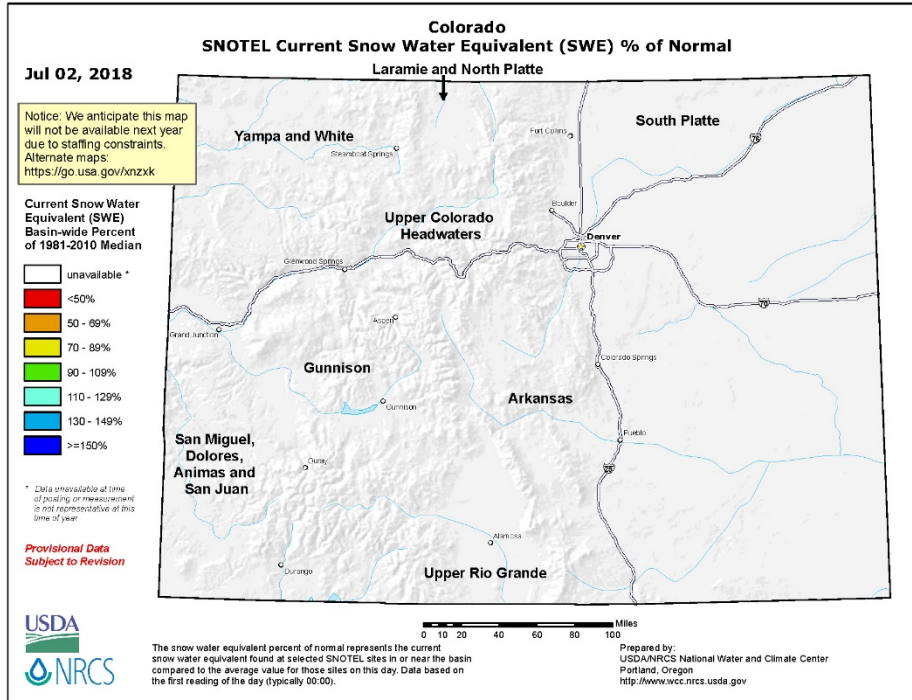
Figure 11. CPC November-December 2018-January 2019 temperature and precipitation outlooks.

## Summary

In summary, the annual runoff forecast for the Missouri Basin above Sioux City, IA is **39.8 MAF, 157% of average**. This forecast is bracketed by the lower basic forecast of 36.3 MAF and the upper basic forecast of 43.8 MAF. Looking short-term, we're expecting runoff in July to follow the trend from June and be above average for all reaches, based on existing soil moisture conditions, precipitation outlooks and current runoff trends. For August and September, we're forecasting slightly above-average runoff. Looking further out – October through December – we're forecasting about average runoff throughout the entire upper basin.

# Additional Figures





**Upper Missouri River Basin  
August 2018 Calendar Year Runoff Forecast  
August 7, 2018**

**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**

July runoff was 5.1 MAF (155% of average) in the upper Missouri River Basin above Sioux City, IA. Runoff in the Fort Peck and Garrison reaches was above average due to high streamflow caused by this year's above-average mountain snowpack and above-normal June precipitation. Runoff in the Gavins Point to Sioux City reach was much greater than average due to well-above normal July precipitation in much of eastern South Dakota and northern Nebraska. Runoff was also above average in the Oahe reach due to locally heavy rainfall. In contrast, precipitation was well-below normal in Montana, western Wyoming, eastern Kansas, southern Iowa and Missouri. During the latter half of July, Missouri River stages from Nebraska City to St. Joseph receded below flood stage due to these drier conditions.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on August 1, is **39.8 MAF (157% of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **34.2 MAF (148% of average)**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 6 months, expected inflow could range from the 41.5 MAF upper basic forecast to the 38.2 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 5 months are being forecast for this August 1 forecast (7 months observed/5 months forecast), the range of wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is attributed to all 6 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 July 31, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows drought conditions in portions of every state in the Basin. Moderate Drought (D1) conditions are present in north central Montana and northeastern South Dakota. Extreme Drought (D3) and Exceptional Drought (D4) conditions are present in central and eastern Kansas. Northern Missouri and southern Iowa are effected by D1 to D3 conditions. The Seasonal Drought Outlook in **Figure 2**, indicates drought conditions are likely to develop and persist in northwestern Montana, Kansas and Missouri.

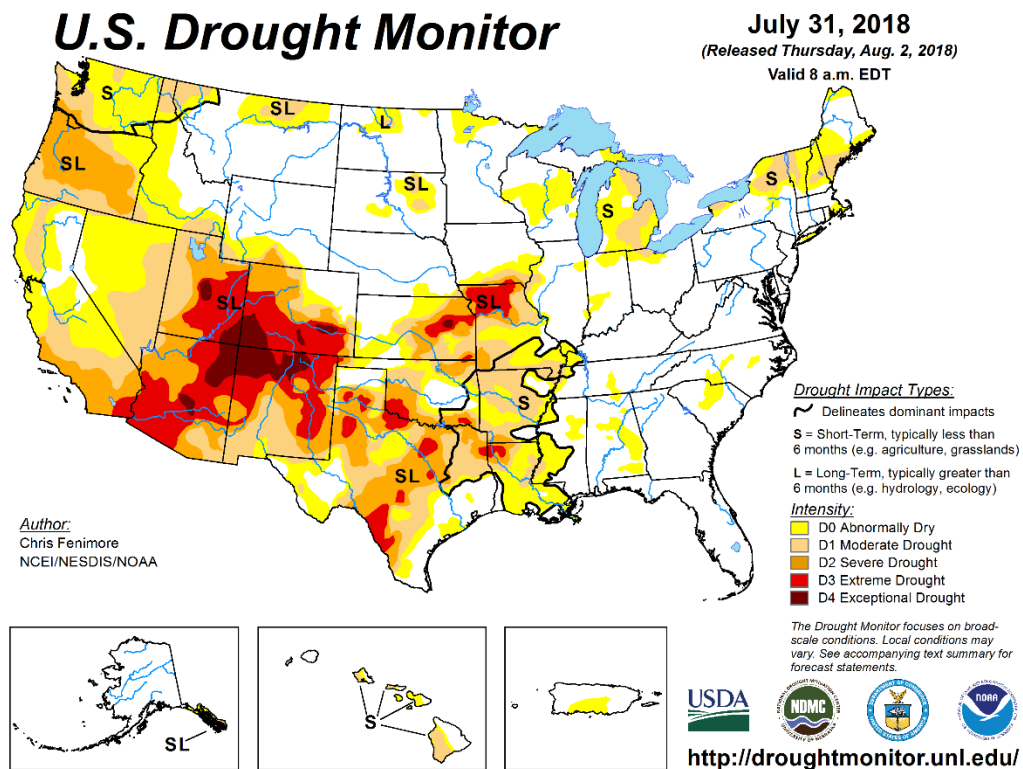


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for July 31, 2018.

**U.S. Seasonal Drought Outlook**  
**Drought Tendency During the Valid Period**

Valid for July 19 - October 31, 2018  
 Released July 19, 2018

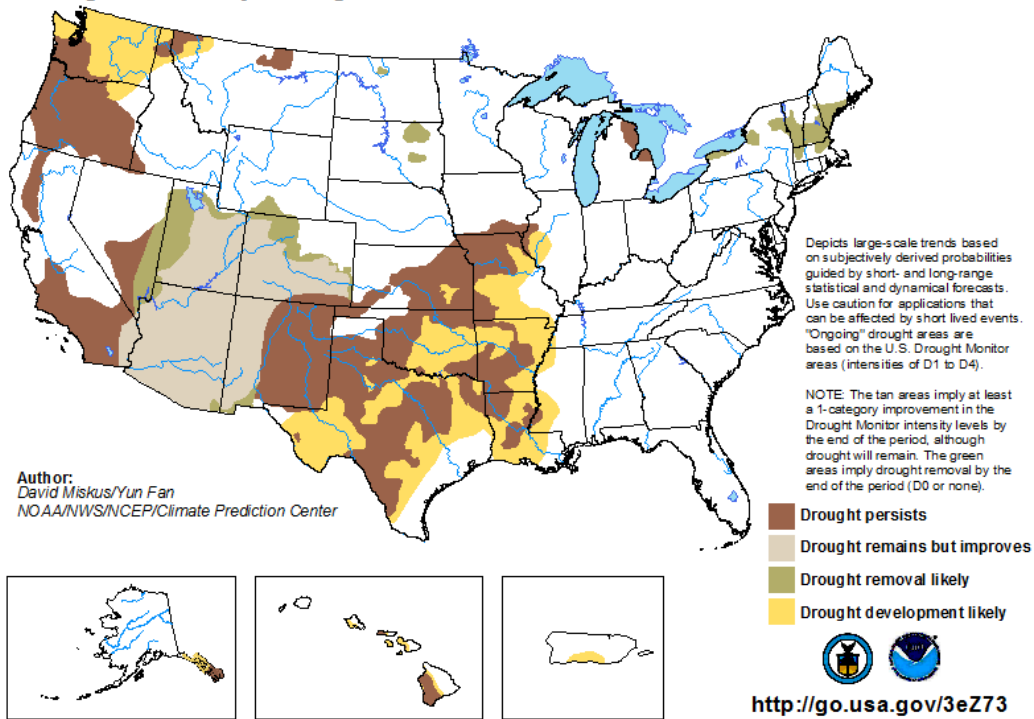


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

**Precipitation**

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at <http://www.hprcc.unl.edu/>. The July precipitation accumulations are shown in **Figure 3** as inches of precipitation (left) and percent of normal precipitation (right). July precipitation was much drier than normal in Montana and Wyoming, while a more normal to above-normal pattern occurred over the Dakotas and Nebraska. Above-normal precipitation occurred from northeastern Wyoming into western South Dakota, northern Nebraska and eastern South Dakota. Precipitation was also below normal in eastern Kansas and Missouri. Some notable July and May-June-July rainfall totals and departures are listed in **Table 1**. Negative July departures were prevalent in Montana, including a -1.18-inch departure in Helena, MT, which received only 0.01 inches of precipitation in July!

May-June-July precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the above-normal precipitation pattern in southern Montana, Wyoming, Nebraska and southeastern South Dakota and northwestern Iowa. **Table 4** lists May-June-July precipitation totals and departures from normal. May-June-July departures are mostly above normal, with the exception of below normal departures in Glasgow, MT and Omaha, NE. Accumulated precipitation measured near Glasgow, MT reflects the drought conditions being experienced in north central Montana.

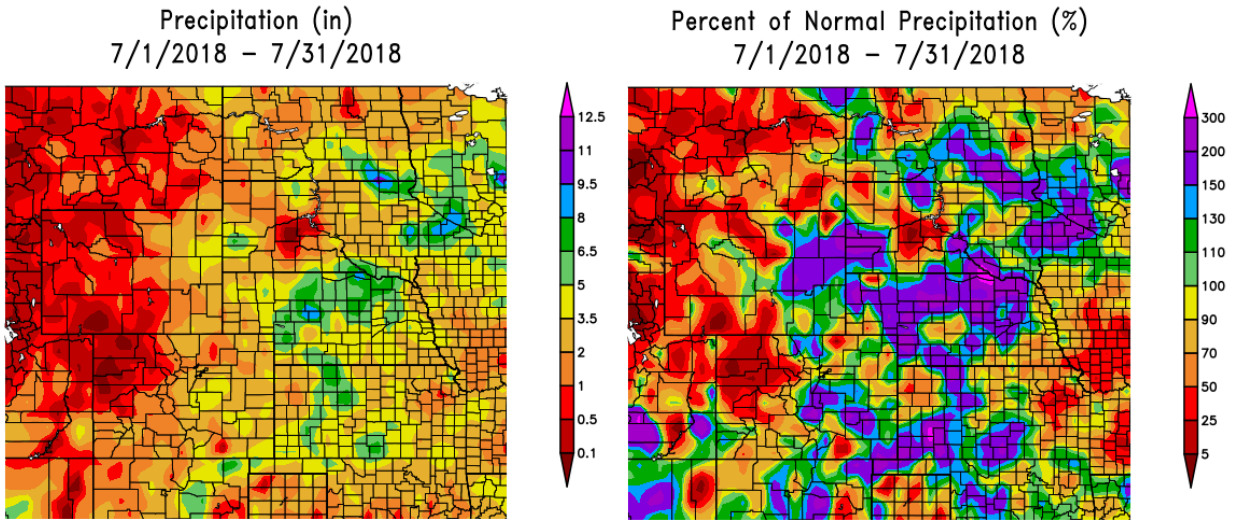


Figure 3. July 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

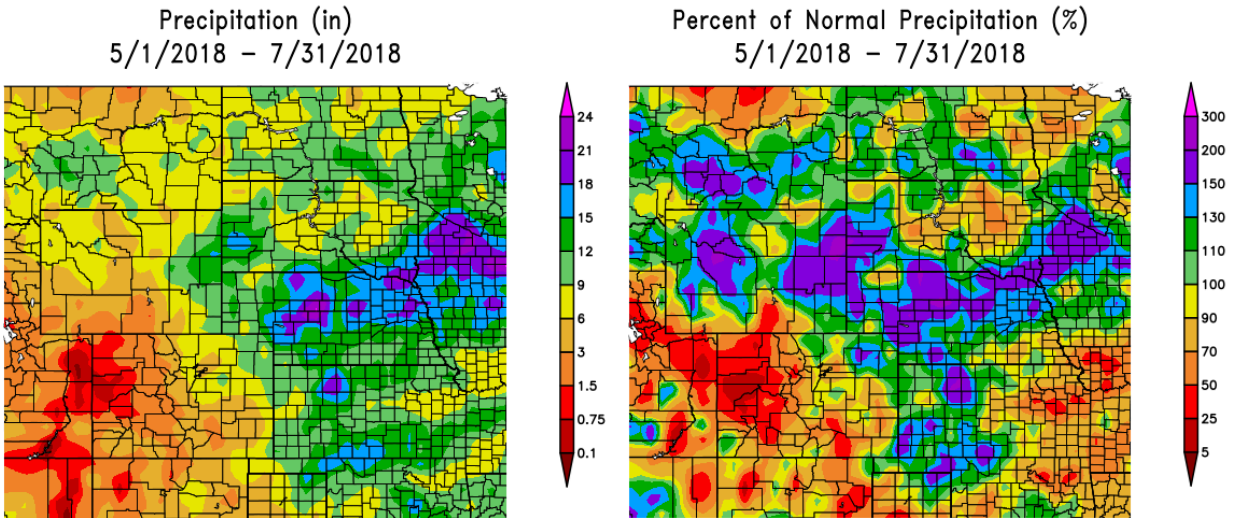


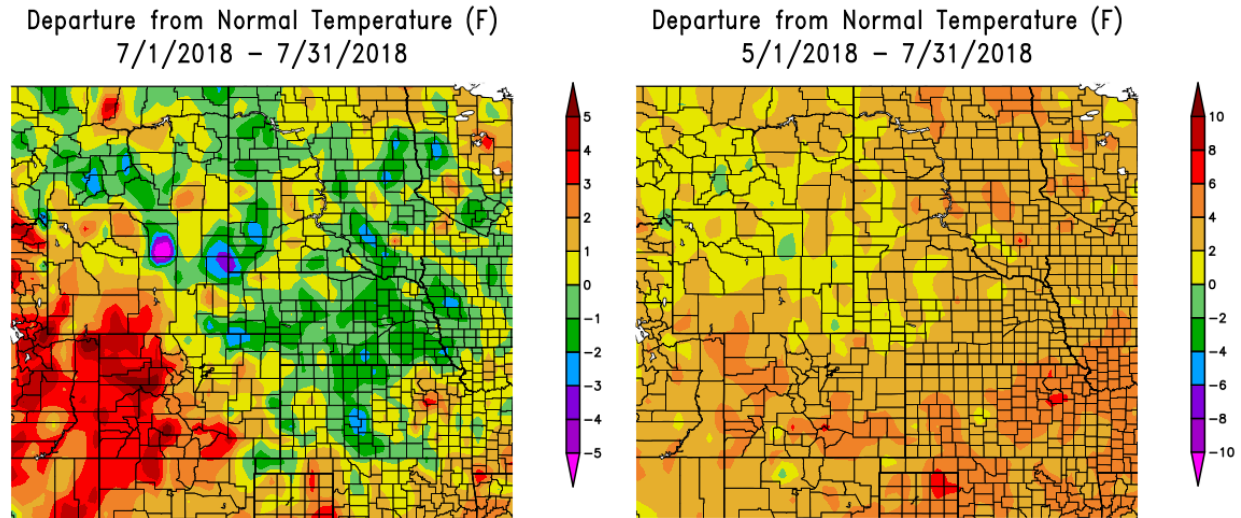
Figure 4. May-June-July 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

**Table 1. May-June-July 2018 precipitation totals and departures from normal (units in inches).**

Location	May Total	May Departure	June Total	June Departure	July Total	July Departure	May-July Total	May-July Departure
Helena, MT	3.26	1.39	3.36	1.30	0.01	-1.18	6.63	1.51
Great Falls, MT	3.52	1.10	3.30	0.77	0.12	-1.38	6.94	0.49
Lewistown, MT	5.10	2.25	5.63	2.55	0.62	-1.31	11.35	3.49
Glasgow, MT	1.47	-0.45	1.62	-0.71	0.92	-0.86	4.01	-2.02
Billings, MT	5.22	3.04	3.94	1.82	0.65	-0.67	9.81	4.19
Miles City, MT	4.19	2.01	4.46	1.95	0.99	-0.65	9.64	3.31
Sheridan, WY	3.57	1.22	1.43	-0.69	1.21	0.03	6.21	0.56
Lake Yellowstone, WY	2.48	0.21	4.02	2.02	0.88	-0.59	7.38	1.64
Lander, WY	4.07	1.87	1.66	0.39	0.67	-0.11	6.40	2.15
Sioux Falls, SD	2.48	-0.92	7.29	3.37	4.94	1.85	14.71	4.30
Sioux City, IA	3.71	-0.03	8.65	4.76	2.30	-1.14	14.66	3.59
Norfolk, NE	1.62	-2.31	10.75	6.49	4.81	1.49	17.18	5.67
Omaha, NE	1.97	-2.79	6.89	2.71	2.93	-0.90	11.79	-0.98

### Temperature

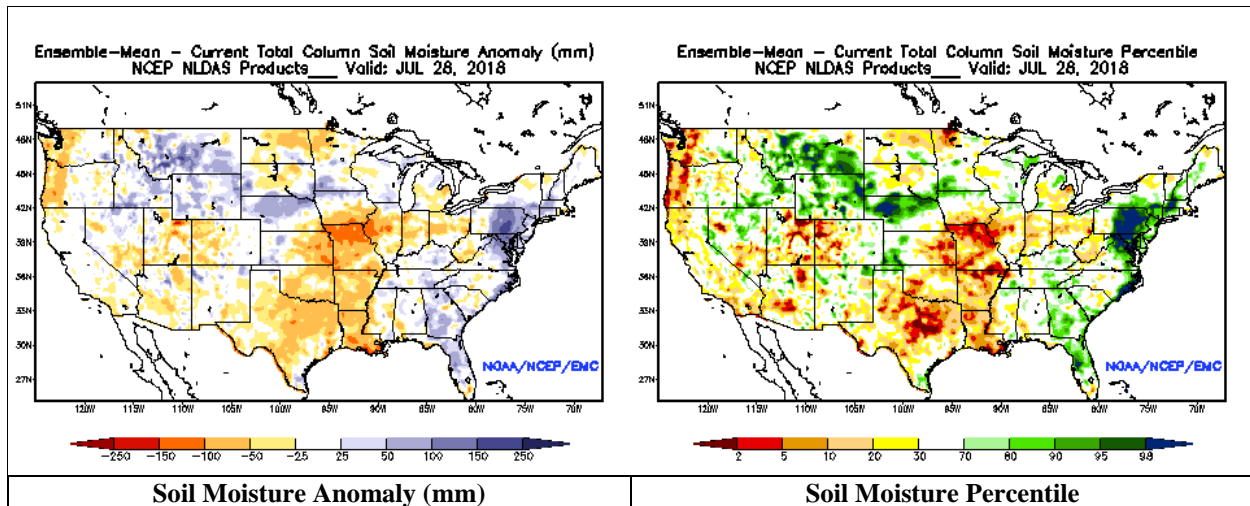
July temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** were near-normal with a slight tilt toward below-normal temperatures in South Dakota, Nebraska and western Iowa. These cooler temperatures are related to the frequent rain events that caused above-normal rainfall in these areas. May-June-July temperature departures, in the right image of **Figure 5**, reflect a slightly warmer-than-normal pattern in Montana and Wyoming, and an above-normal pattern (2 to 6 deg F above normal) in the Plains and lower Basin. The above normal-temperature in the lower Basin are related to the below-normal precipitation in the same region.



**Figure 5. July 2018 and May-June-July 2018 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. The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on July 28, 2018.



**Figure 6.** NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

Soil moisture anomalies are above normal in much of Montana, Wyoming, Nebraska, southeastern South Dakota and northern Iowa. In contrast, soil moisture anomalies are below normal in the Dakotas, eastern Kansas, southeastern Nebraska, southern Iowa and Missouri.

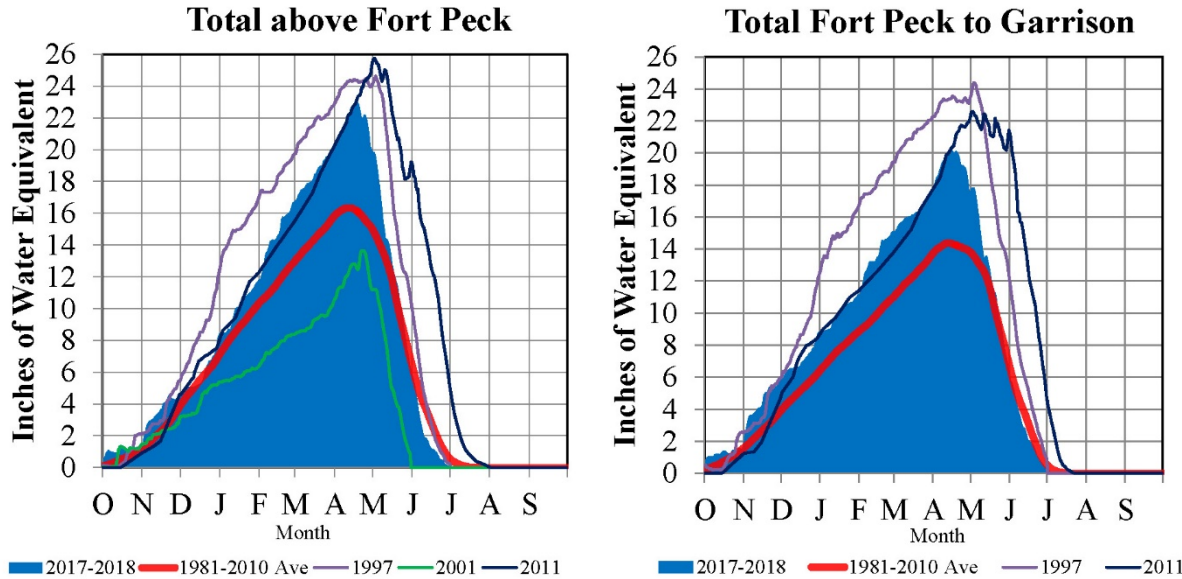
## Mountain Snowpack

**Figure 7** includes time series plots of the average mountain SWE beginning on October 1, 2017 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).

The mountain snowpack accumulation peaked in both reaches: on April 19<sup>th</sup> at 23.0” (141% of the normal April 15 peak) for the reach above Fort Peck Dam, and on April 15<sup>th</sup> at 20.1” (137% of the normal April 15 peak) for the reach between Fort Peck and Garrison Dams. **The mountain snowpack melted in early July 2018.**

# Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

July 2, 2018



On July 2, 2018 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 0.03” 6% of average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 0.1”, 29% of average. The “Total above Fort Peck” reach peaked on April 19 at 23.0”, 141% of the normal April 15 peak. The “Total Fort Peck to Garrison” reach peaked on April 15 at 20.1”, 137% of the normal April 15 peak.

\*Generally considered the high and low year of the last 30-year period, respectively.

Provisional data. Subject to revision.

Figure 7. Mountain snowpack water content on July 2, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

## 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 ENSO and its implications on temperature and precipitation outlooks.

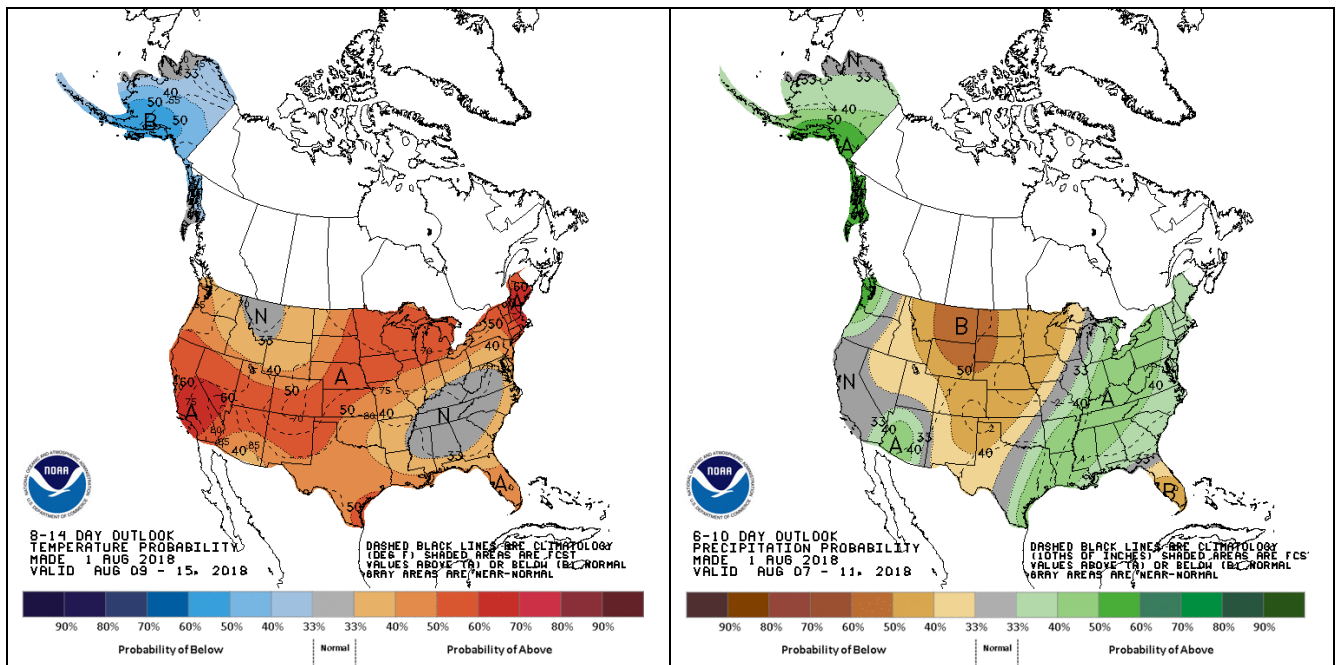
## **ENSO (El Niño Southern Oscillation)**

ENSO-neutral conditions are present in the equatorial Pacific and typically do not influence the chances for spring and early summer precipitation and temperatures. ENSO-neutral conditions are favored throughout the Northern Hemisphere summer 2018; however, an El Niño Watch has been issued by CPC. The chance for El Niño to develop has increased to over 65% during the fall and winter 2018-19. El Niño conditions favor warmer-than-normal temperatures during the winter in the Northern Rocky Mountains and Northern Plains.

## 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 August 15 in **Figure 8** indicates an increase in the chances for above-normal temperatures throughout the Basin. The precipitation outlook indicates an increase in the chances for below-normal precipitation across the Missouri Basin. The chance for below-normal precipitation is greater than 50 percent in Montana, Wyoming and the western Dakotas.



**Figure 8. CPC 8-14 Day temperature and precipitation outlooks through August 15, 2018.**

The August CPC temperature outlook in **Figure 9** indicates slightly increased chances for above-normal temperatures in western Montana and western Wyoming, with equal chances for below-normal, normal and above-normal temperatures in much of the Missouri Basin. With regard to precipitation, there are increased chances for below-normal precipitation in western Montana. There are equal chances for precipitation in all other regions of the Basin.

During the September-October-November 2018 period in **Figure 10**, the CPC temperature outlook indicates increased chances for above-normal temperatures throughout the Basin. With regard to precipitation there are equal chances for below-normal, normal and above-normal precipitation across the entire Basin.

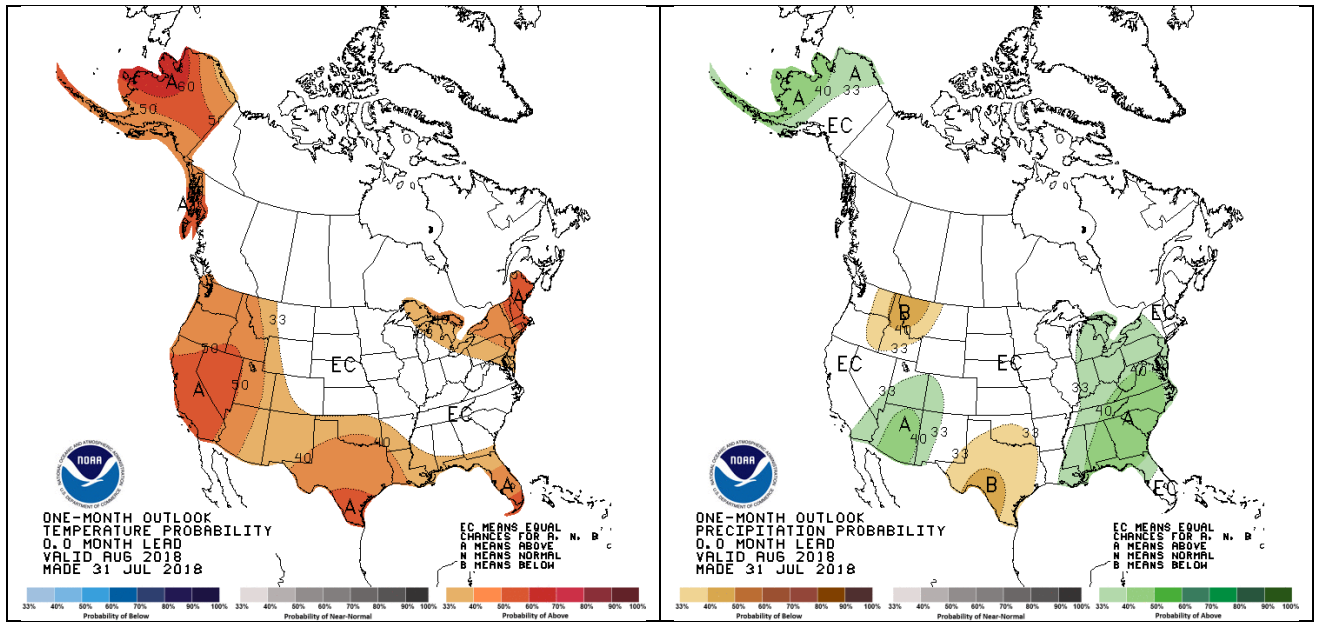


Figure 9. CPC August 2018 temperature and precipitation outlooks.

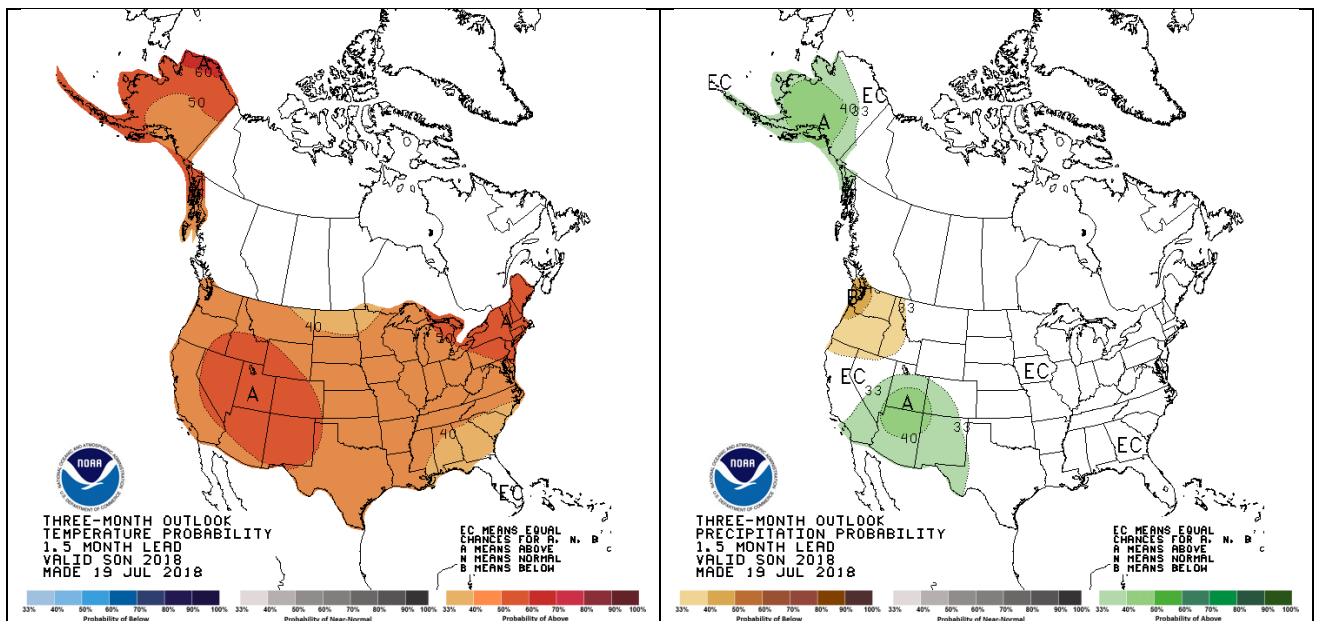


Figure 10. CPC September-October-November 2018 temperature and precipitation outlooks.

During the December 2018-January-February 2019 period in **Figure 11**, the CPC temperature outlook indicates increased chances for above-normal temperatures over the Basin. With regard to precipitation there are increase chances for below-normal precipitation in Montana, northern Wyoming and western North Dakota; and an increased chance for above-normal precipitation in portions of the lower Basin.

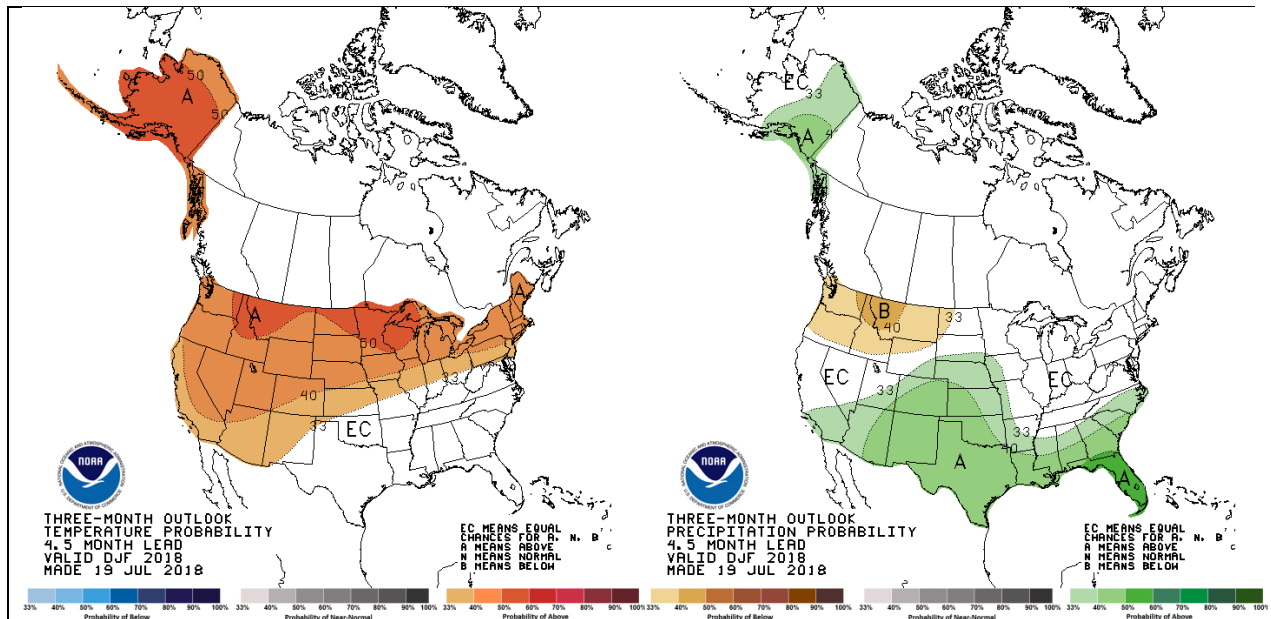


Figure 11. CPC December 2018-January-February 2019 temperature and precipitation outlooks.

## Summary

In summary, the annual runoff forecast for the Missouri Basin above Sioux City, IA is **39.8 MAF, 157% of average**. This forecast is bracketed by the lower basic forecast of 38.2 MAF and the upper basic forecast of 41.5 MAF. Looking short-term, streamflow has been declining in the upper basin, and in August we expect streamflow and runoff to continue declining to more normal levels for all reaches above Gavins Point. Above average runoff is expected to continue in the Sioux City reach due to the existing above-average streamflows. From September to December, we're forecasting about average runoff, based on current soil moisture, precipitation outlooks and current runoff trends.

**Upper Missouri River Basin  
September 2018 Calendar Year Runoff Forecast  
September 5, 2018**

**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**

August runoff was 1.9 MAF (138% of average) in the upper Missouri River Basin above Sioux City, IA. Runoff in the Fort Peck and Garrison reaches declined to near-average levels. Runoff was much higher than average in the Oahe reach (223% of average), Gavins Point reach (195% of average) and Sioux City reach (298% of average). Precipitation was very scattered during August, with areas of above-average and below-average precipitation in every state within the Basin.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on September 4, is **39.8 MAF (157% of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **34.2 MAF (148% of average)**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 4 months, expected inflow could range from the 40.9 MAF upper basic forecast to the 38.8 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 much wetter or drier conditions, respectively. Given that 4 months are being forecast for this September 1 forecast (8 months observed/4 months forecast), the range of wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is attributed to all 6 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 August 28, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows drought conditions in portions of every state in the Basin except Nebraska, which is only Abnormally Dry (D0) in a very small area. Severe Drought (D2) conditions are present in north central Montana, north central North Dakota, and northeastern South Dakota. Extreme Drought (D3) and Exceptional Drought (D4) conditions are present in eastern Kansas and northern Missouri. The Seasonal Drought Outlook in **Figure 2**, indicates drought conditions are likely to develop and persist in Montana and North Dakota, while drought conditions are likely to improve in South Dakota, Kansas, Missouri, and Iowa.

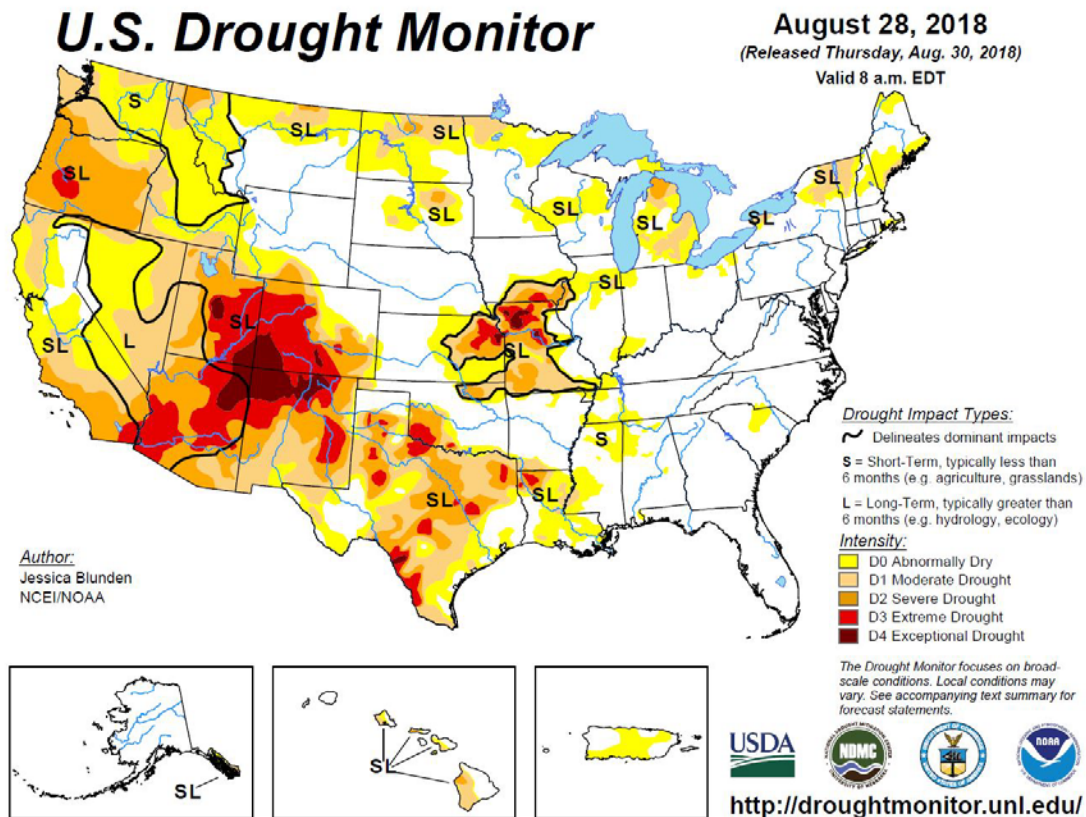


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for August 28, 2018.

**U.S. Seasonal Drought Outlook** Valid for August 16 - November 30, 2018  
**Drought Tendency During the Valid Period** Released August 16, 2018

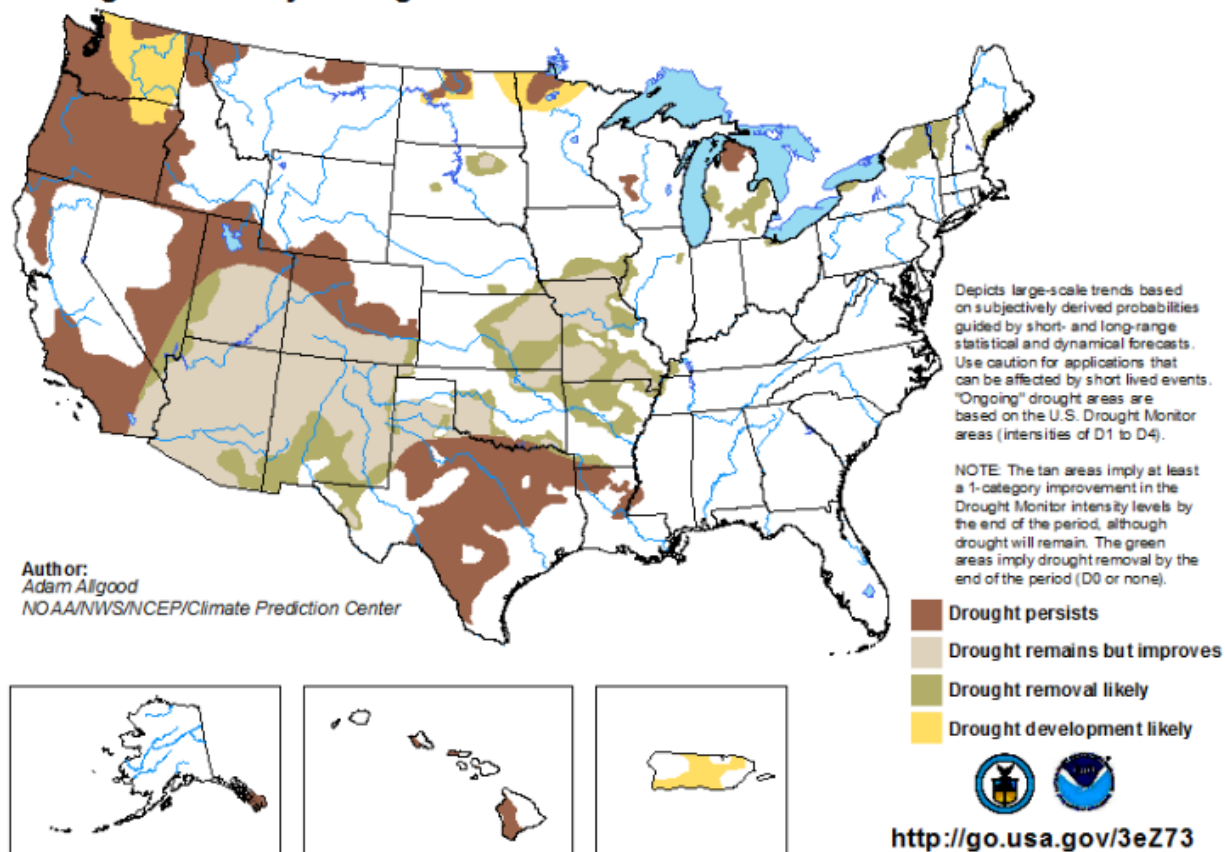


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

## Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at <http://www.hprcc.unl.edu/>. The August precipitation accumulations are shown in **Figure 3** as inches of precipitation (left) and percent of normal precipitation (right). August precipitation was scattered across the Basin, as shown in right image of **Figure 3**. All states in the Basin experienced areas of above-normal and below-normal precipitation, with southern Montana, western Iowa, and Kansas experiencing the most above-normal precipitation.

June-July-August precipitation accumulations are shown in **Figure 4**. The three-month accumulations reflect the above-normal precipitation pattern in southern Montana, Wyoming, Nebraska, southeastern South Dakota, northwestern Iowa, and western Kansas.

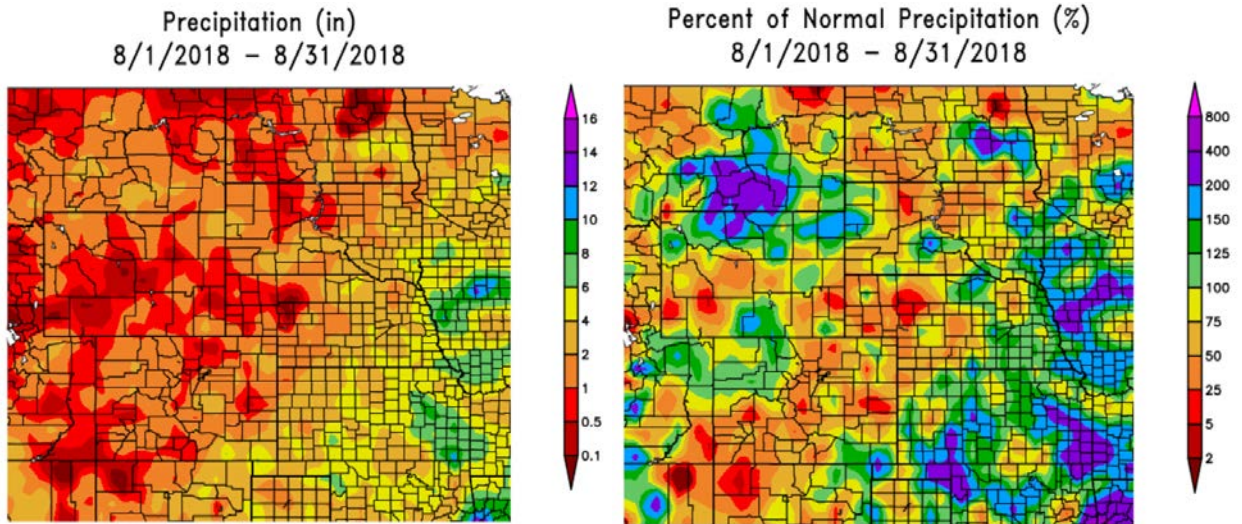


Figure 3. August 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

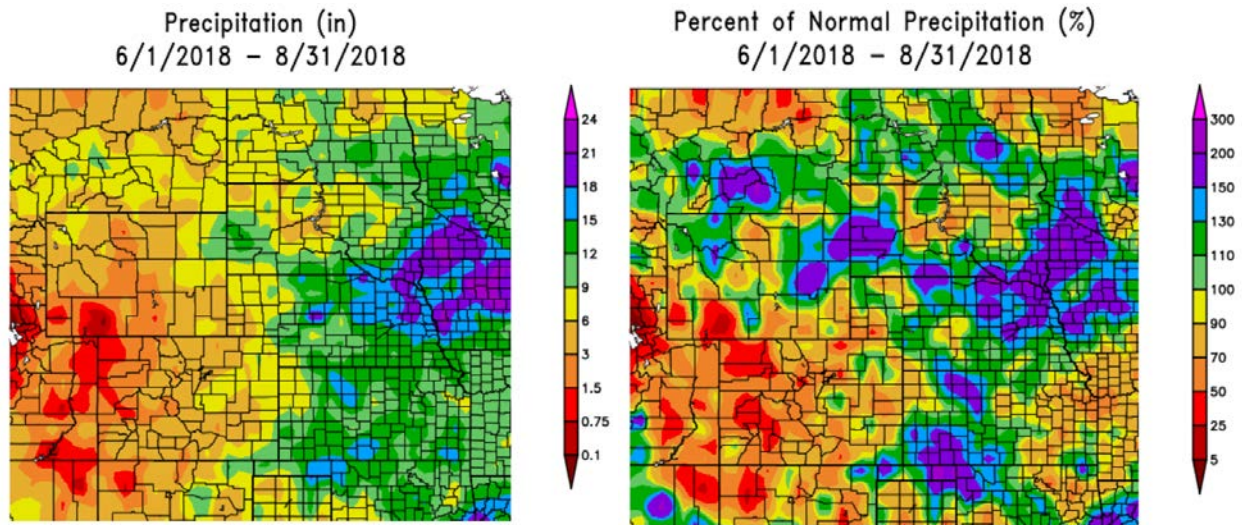


Figure 4. June-July-August 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

August temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5** were near-normal with a slight tilt toward below-normal temperatures across the Basin. These cooler temperatures are related to the frequent rain events. June-July-August temperature departures, in the right image of **Figure 5**, reflect a slightly warmer-than-normal pattern in North Dakota, South Dakota, Iowa, Kansas, and Missouri. Montana, Wyoming, the western Dakotas, and western Nebraska have been slightly cooler than normal over the past 3 months.

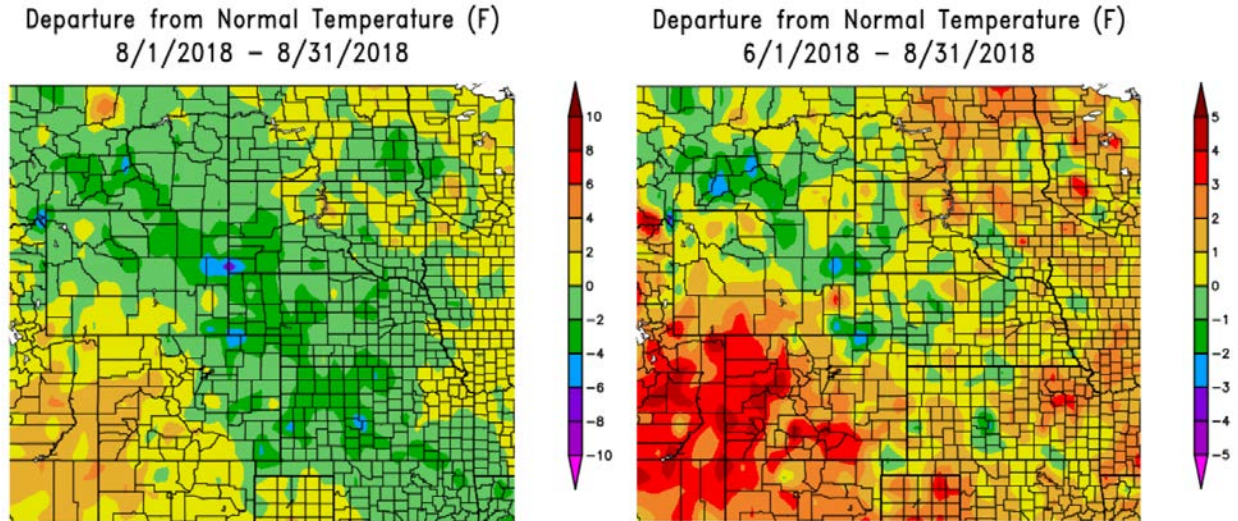


Figure 5. August 2018 and June-July-August 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## 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. The left image of **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly and the right image of **Figure 6** shows the soil moisture percentile on September 1, 2018.

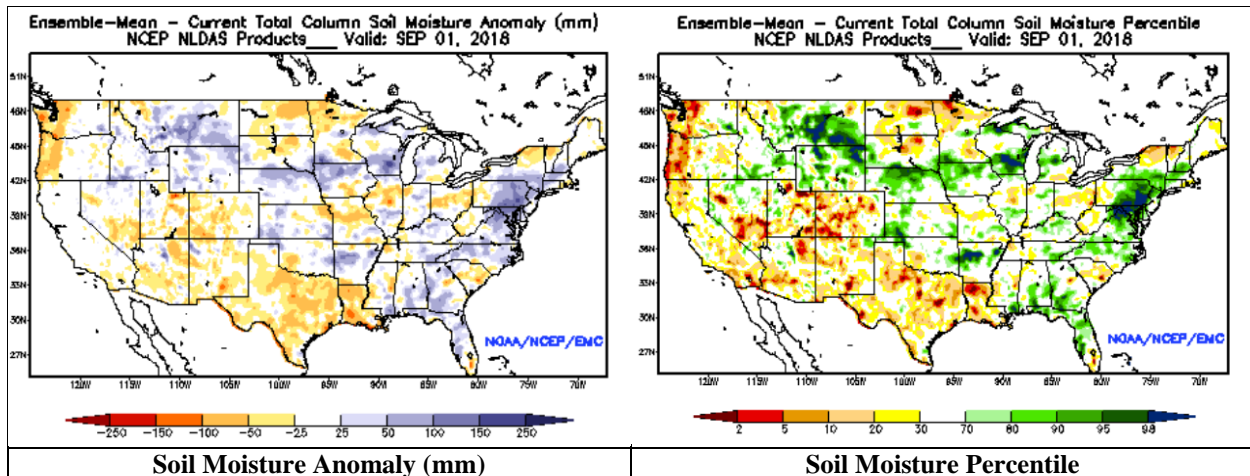


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

Soil moisture anomalies are above normal in much of Montana, Wyoming, Nebraska, southeastern South Dakota, Iowa, and Kansas. In contrast, soil moisture anomalies are below normal in the Dakotas, northeastern Kansas, and Missouri.

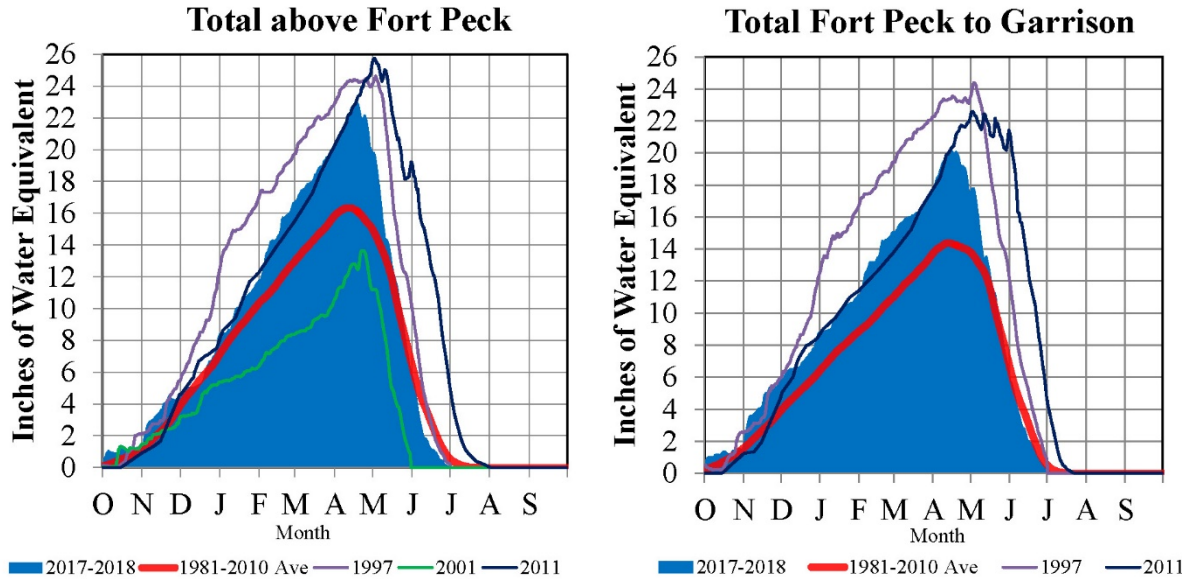
## Mountain Snowpack

**Figure 7** includes time series plots of the average mountain SWE beginning on October 1, 2017 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).

The mountain snowpack accumulation peaked in both reaches: on April 19 at 23.0” (141% of the normal April 15 peak) for the reach above Fort Peck Dam, and on April 15 at 20.1” (137% of the normal April 15 peak) for the reach between Fort Peck and Garrison Dams. **The mountain snowpack melted in early July 2018.**

# Missouri River Basin – Mountain Snowpack Water Content 2017-2018 with comparison plots from 1997\*, 2001\*, and 2011

July 2, 2018



On July 2, 2018 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 0.03” 6% of average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 0.1”, 29% of average. The “Total above Fort Peck” reach peaked on April 19 at 23.0”, 141% of the normal April 15 peak. The “Total Fort Peck to Garrison” reach peaked on April 15 at 20.1”, 137% of the normal April 15 peak.

\*Generally considered the high and low year of the last 30-year period, respectively.

Provisional data. Subject to revision.

Figure 7. Mountain snowpack water content on July 2, 2018 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

## 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 ENSO and its implications on temperature and precipitation outlooks.

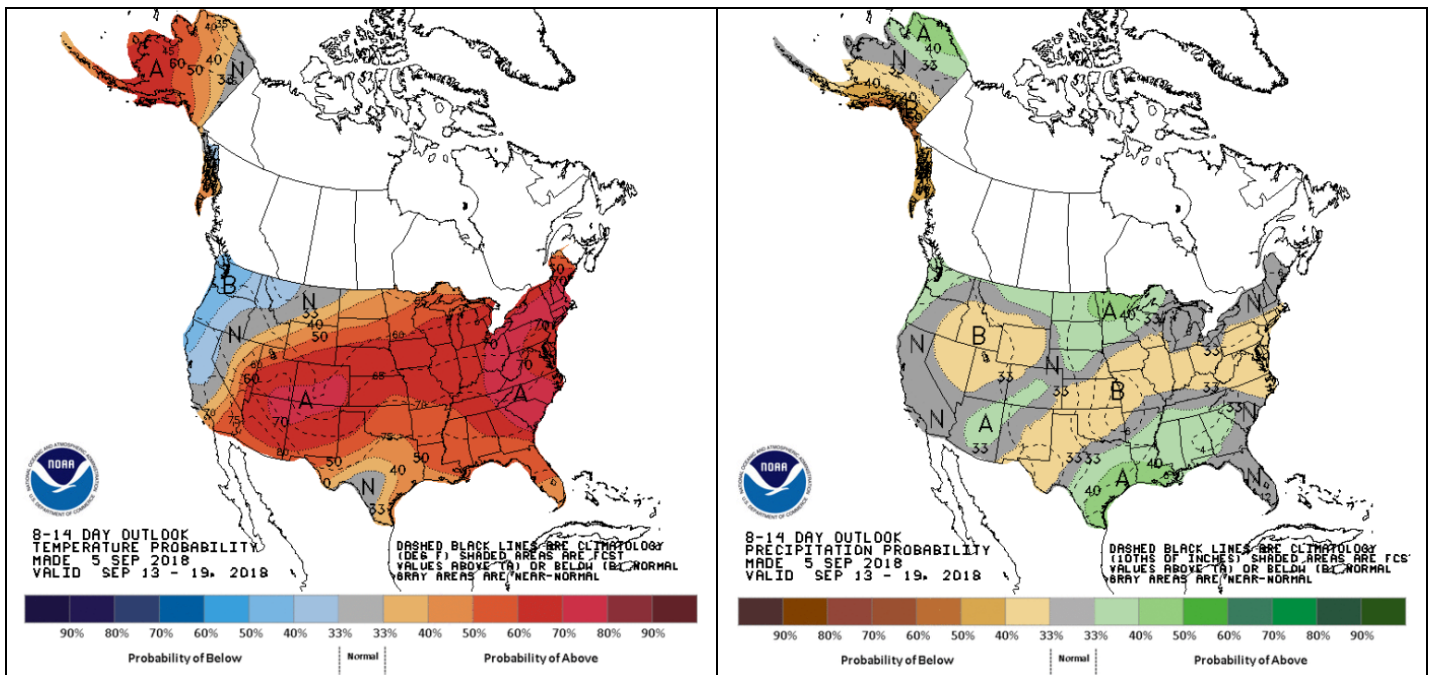
## **ENSO (El Niño Southern Oscillation)**

ENSO-neutral conditions are present in the equatorial Pacific and typically do not influence the chances for spring and early summer precipitation and temperatures. ENSO-neutral conditions are favored throughout the Northern Hemisphere summer 2018; however, an El Niño Watch has been issued by CPC. The chance for El Niño to develop in the fall of 2018 is about 60%, and that chance increases to about 70% by winter of 2018-2019. El Niño conditions favor warmer-than-normal temperatures during the winter in the Northern Rocky Mountains and Northern Plains.

## 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 September 19 in **Figure 8** indicates an increase in the chances for above-normal temperatures throughout most of the Basin. The precipitation outlook indicates an increase in the chances for below-normal precipitation in the lower Basin, Wyoming, and southern Montana. There is a chance for above-normal precipitation in northern Montana, the Dakotas, and north-central Nebraska.



**Figure 8.** CPC 8-14 Day temperature and precipitation outlooks through September 19, 2018.

The September CPC temperature outlook in **Figure 9** indicates slightly increased chances for above-normal temperatures in the lower Basin, with equal chances for below-normal, normal and above-normal temperatures in Montana, Wyoming, North Dakota, and western South Dakota. With regard to precipitation, there are increased chances for above-normal precipitation in Nebraska, eastern South Dakota, Iowa, Kansas, and Colorado. There are equal chances for precipitation in all other regions of the Basin.

During the October-November-December 2018 period in **Figure 10**, the CPC temperature outlook indicates increased chances for above-normal temperatures throughout the Basin. With regard to precipitation there are equal chances for below-normal, normal and above-normal precipitation in Wyoming, the Dakotas, Iowa, and Missouri. There are increased chances for below-normal precipitation in Montana, and increased chances for above-normal precipitation in Colorado, Nebraska, and Kansas.

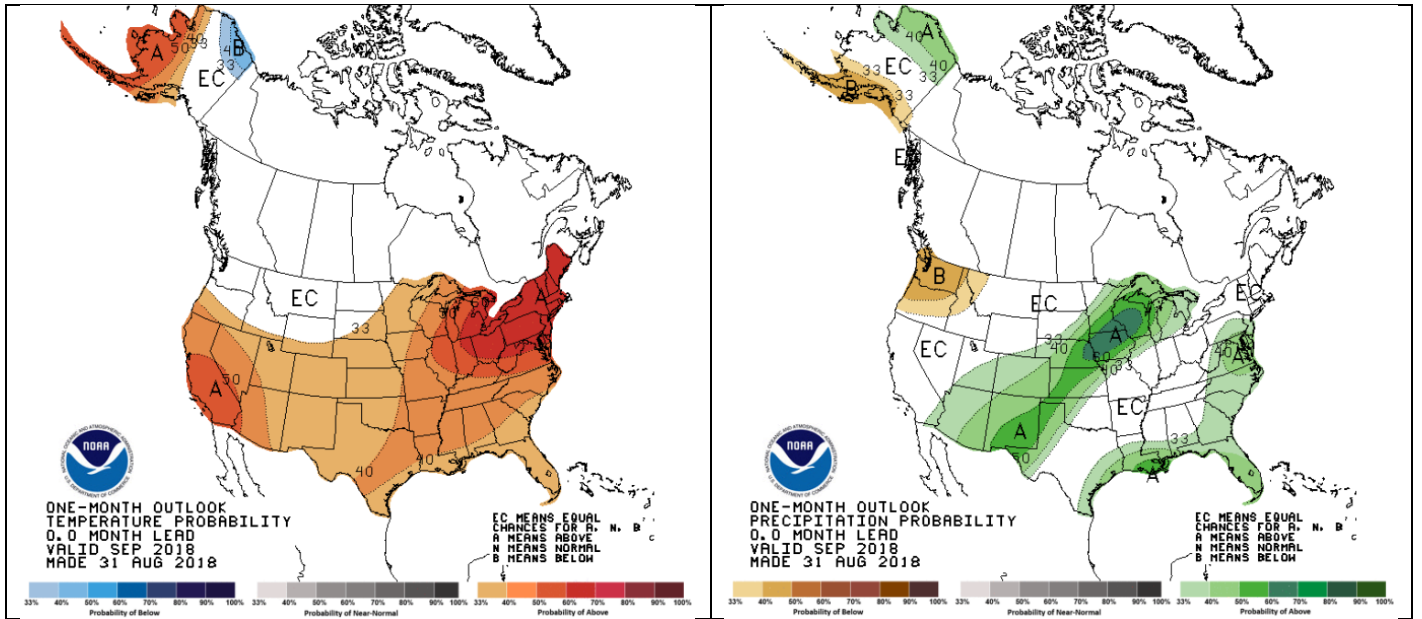


Figure 9. CPC September 2018 temperature and precipitation outlooks.

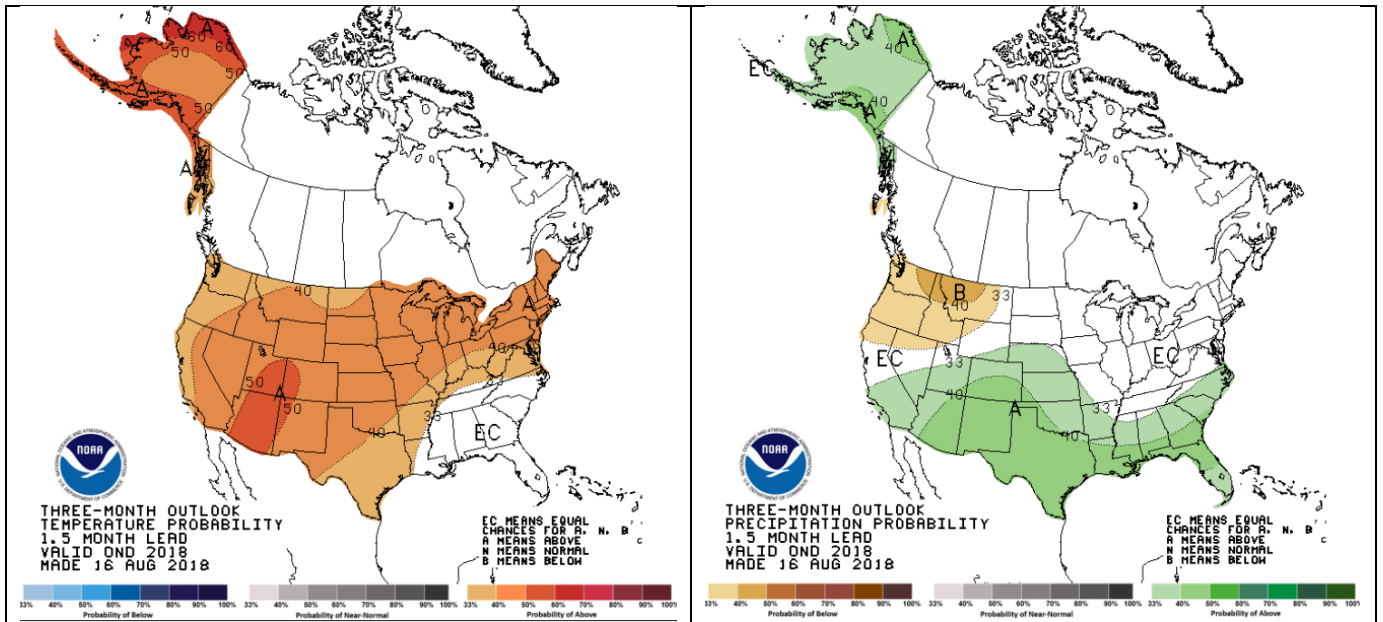


Figure 10. CPC October-November-December 2018 temperature and precipitation outlooks.

## **Summary**

In summary, the annual runoff forecast for the Missouri Basin above Sioux City, IA is **39.8 MAF, 157% of average**. This forecast is bracketed by the lower basic forecast of 38.8 MAF and the upper basic forecast of 40.9 MAF. Looking short-term, streamflow has declined to normal levels in the Fort Peck and Garrison reaches, and in September we expect streamflow and runoff to remain around normal levels. Above-average runoff is expected to continue in the Oahe, Gavins Point, and Sioux City reaches during September. From October to December, we are forecasting about average runoff, based on current soil moisture, precipitation outlooks and current runoff trends.

**Upper Missouri River Basin  
October 2018 Calendar Year Runoff Forecast  
October 2, 2018**

**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**

September runoff was 1.7 MAF (151 percent of average) in the upper Missouri River Basin above Sioux City, IA; however, the September runoff summation above Gavins Point Dam was 0.9 MAF (86 percent of average). The September Sioux City reach runoff was 848 kAF (757 percent of average), and greater than the previous high September runoff, which was 830 kAF in September 2010. Runoff was also above average in the Gavins Point reach (225 percent). Runoff was average in the Oahe reach and below average in the Fort Peck, Garrison and Fort Randall reaches. The calendar year runoff summation above Sioux City, IA as of October 1 is 37.1 MAF. This would rank as the sixth highest upper Basin runoff summation when compared to the calendar year runoff for the 120-year period of record.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on October 4, is **40.6 MAF (160 percent of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **33.6 MAF (146 percent of average)**. The 40.6 MAF of

runoff would be essentially tied with 1978 as the 3<sup>rd</sup> highest in 120 years of record-keeping, exceeded only in 1997 and 2011.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 3 months, expected inflow could range from the 41.5 MAF upper basic forecast to the 39.8 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 much wetter or drier conditions, respectively. Given that 3 months are being forecast for this October 1 forecast (9 months observed/3 months forecast), the range of wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is attributed to all 6 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 September 25, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows that Moderate (D1) to Severe (D2) drought conditions are present in northern Montana, northern North Dakota, and central South Dakota. In North Dakota, there are small pockets of Extreme (D3) drought conditions north of the Missouri Basin. Abnormally Dry (D0) conditions are also present in the larger areas surrounding the D1 and D2 conditions. In the lower Basin, D3 conditions continue to impact eastern Kansas, with some Exceptional (D4) drought conditions in the vicinity of the Kansas City metro area. D1 to D3 conditions are impacting western and central Missouri, where precipitation deficits are well-below normal for the 2018 calendar year. The Seasonal Drought Outlook in **Figure 2** indicates drought conditions are likely to persist in Montana, North Dakota and South Dakota, while drought conditions are likely to improve in eastern Kansas and northwestern Missouri.

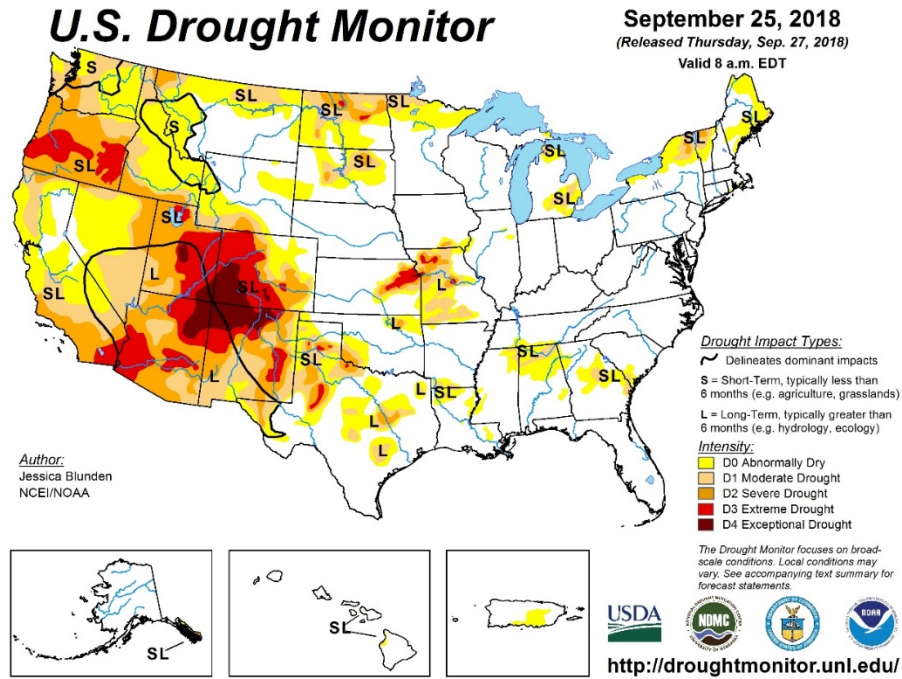


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for September 25, 2018.

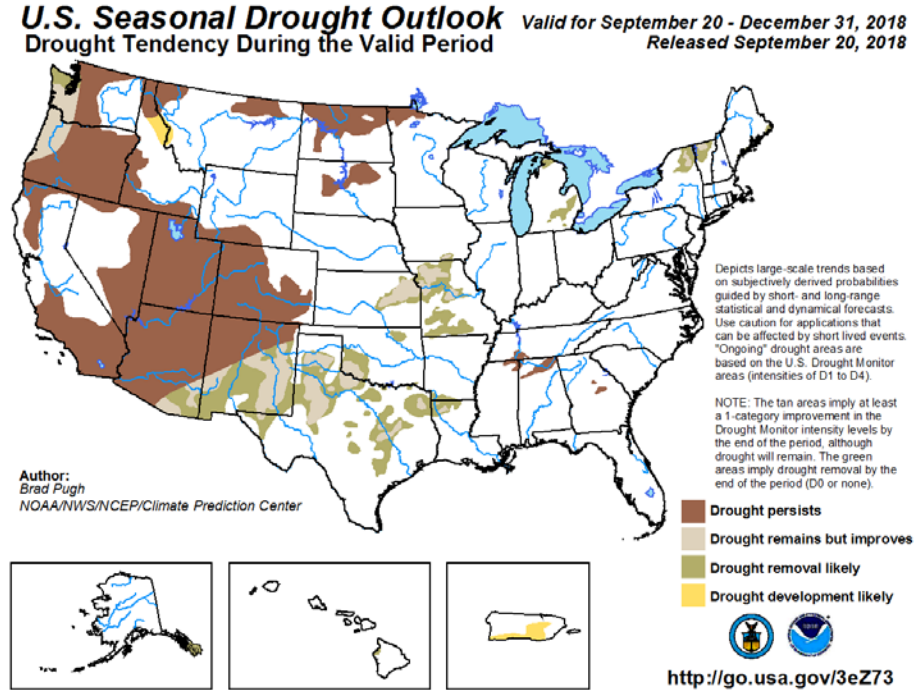
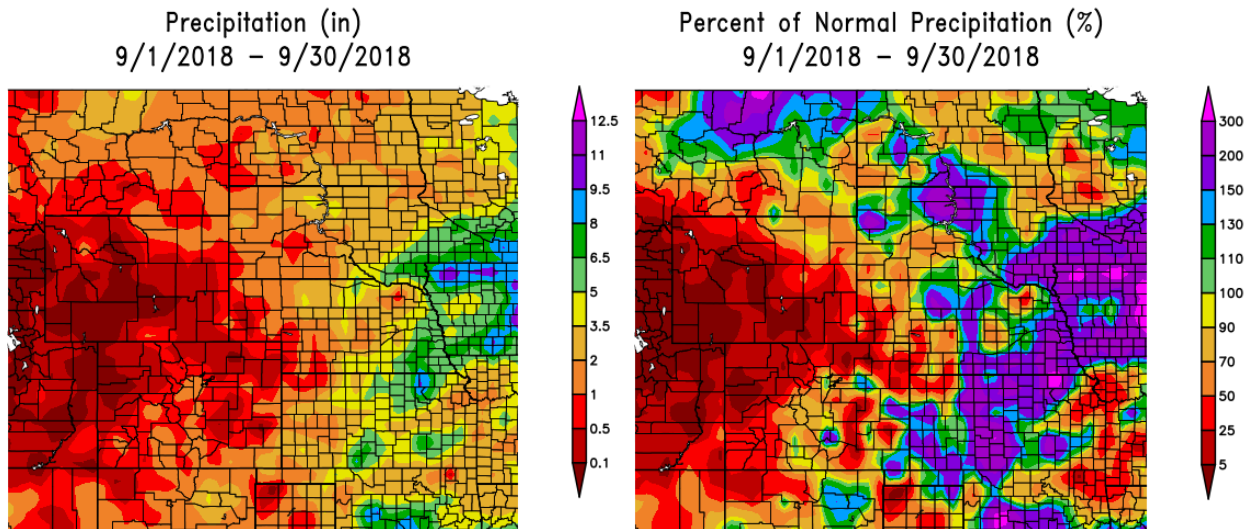


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

## Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at <http://www.hprcc.unl.edu/>. The September precipitation accumulations are shown in **Figure 3** as inches of precipitation (left) and percent of normal precipitation (right). September precipitation was less than 50 percent of normal in much of Wyoming, southern Montana, western Colorado and western Nebraska, as shown in right image of **Figure 3**. Precipitation was well-above normal in northern Montana, north central South Dakota, southeastern South Dakota, southern Minnesota, Iowa, eastern Nebraska and northern Kansas.



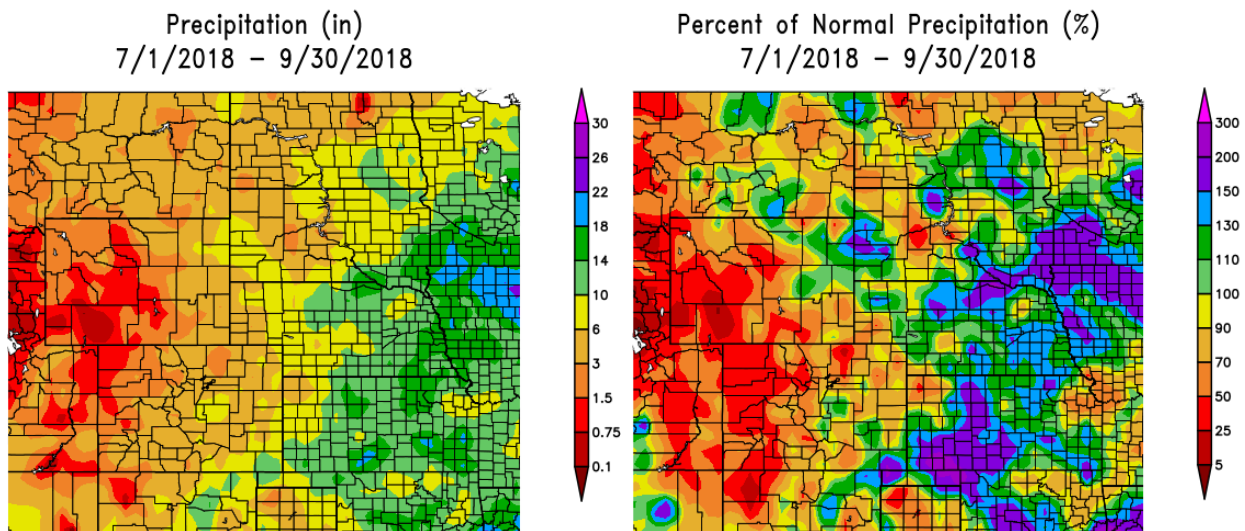
**Figure 3. September 2018 Precipitation (inches) and Percent of Normal Precipitation.** Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

**Table 1** lists some significant rainfall amounts for September 2018 and the September departures from normal. Sioux Falls, SD; Sioux City, IA; and Estherville, IA in northwestern Iowa received more than twice the normal September precipitation, much of which fell September 18 and 19. This heavy rainfall caused flooding on area rivers including the Vermillion River, Big Sioux River, Floyd River and Little Sioux River. The Missouri River entered flood stage from Nebraska City, NE to St. Joseph, MO. Lincoln, NE and Omaha, NE areas also received heavy September rainfall, much of which occurred from September 1 to 4.

**Table 1. Significant September 2018 rainfall amounts and departures in the Missouri Basin.**

City, State	September Rainfall (inches)	Departure from Normal (inches)
Mobridge, SD	3.33	1.79
Mitchell, SD	4.07	1.75
Sioux Falls, SD	7.34	4.57
Sioux City, IA	7.42	4.46
Estherville, IA	8.64	5.36
NWS Valley, NE	5.91	3.06
Lincoln, NE	7.13	4.11

July-August-September precipitation accumulations are shown in **Figure 4**. In general, more precipitation has occurred in the lower Basin than in the upper Basin (left image). The three-month accumulations reflect the recent above-normal precipitation pattern in eastern South Dakota, Nebraska, Iowa and central Kansas. During the three-month period, areas of southeastern South Dakota, southwestern Minnesota and northwestern Iowa have received more than 150 percent of normal precipitation. In contrast, western Montana and much of Wyoming have received below-normal precipitation since the beginning of July.



**Figure 4. July-August-September 2018 Precipitation (inches) and Percent of Normal Precipitation.** Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

September temperatures are portrayed by the image of temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5**. September temperatures were about 1 to 2 deg F below normal in Montana and North Dakota, while temperatures in all other areas of the Missouri Basin were near normal to 1 to 2 deg F above normal. During the July to September period (right image of **Figure 5**), temperatures have ranged from 1 to 3 deg F below normal in Montana and North Dakota, to about normal in South Dakota, Nebraska and Kansas. Three-month temperatures were 1 to 2 deg F above normal in Iowa, Missouri and eastern Kansas.

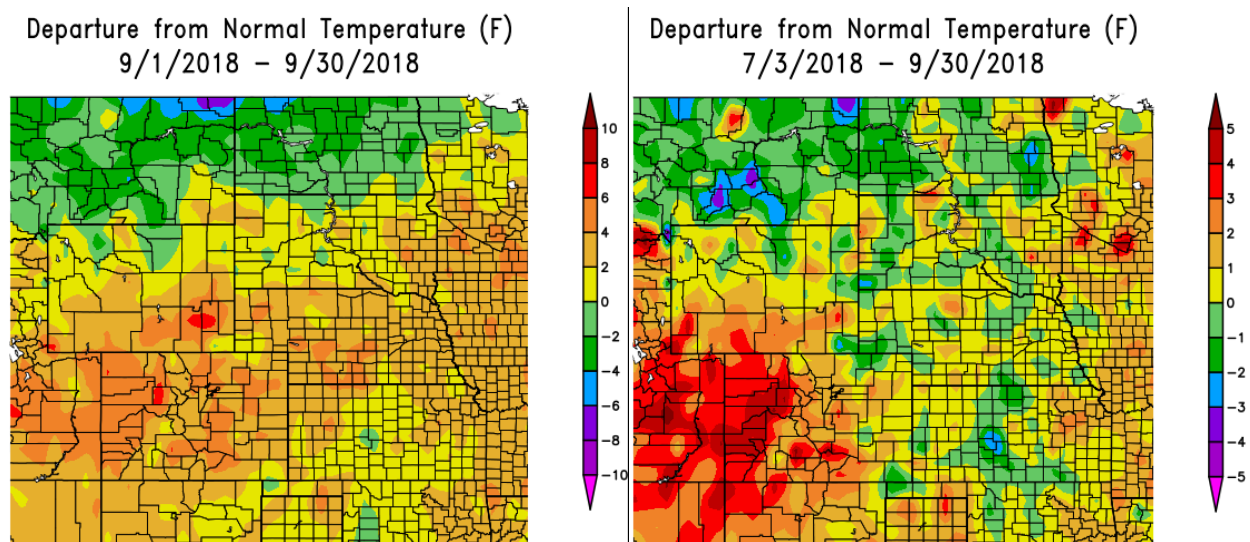


Figure 5. September 2018 and July-August-September 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## 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. **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly, and **Figure 7** shows the soil moisture percentile on September 26, 2018.

Soil moisture anomalies are 25 mm (about 1 inch) to 75 mm (about 3 inches) above normal in much of Montana, western southern and southeastern South Dakota, Iowa, portions of Nebraska and Kansas. The lack of precipitation in western Montana, western Wyoming, central South Dakota, North Dakota and Missouri has caused negative soil moisture anomalies (deficits). In terms of soil moisture severity, soils are very wet with a 98<sup>th</sup> percentile ranking in southeastern South Dakota, southwestern Minnesota and northwestern Iowa. The Musselshell River Basin in central Montana also has relatively wet soils with a percentile ranking ranging from the 95<sup>th</sup> to the 98<sup>th</sup> percentile ranking.

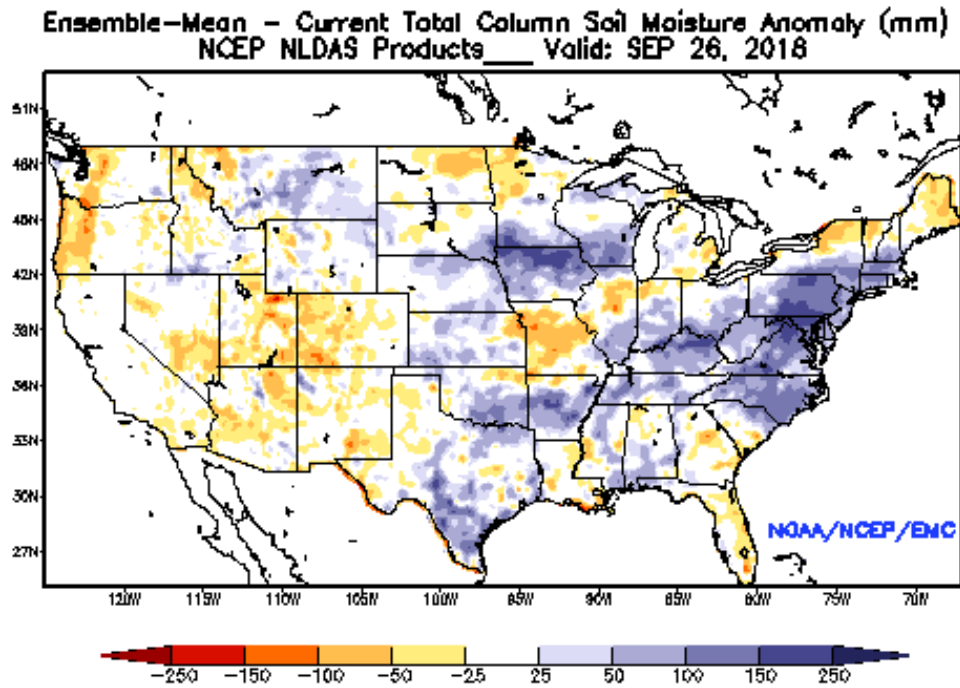


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm). Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

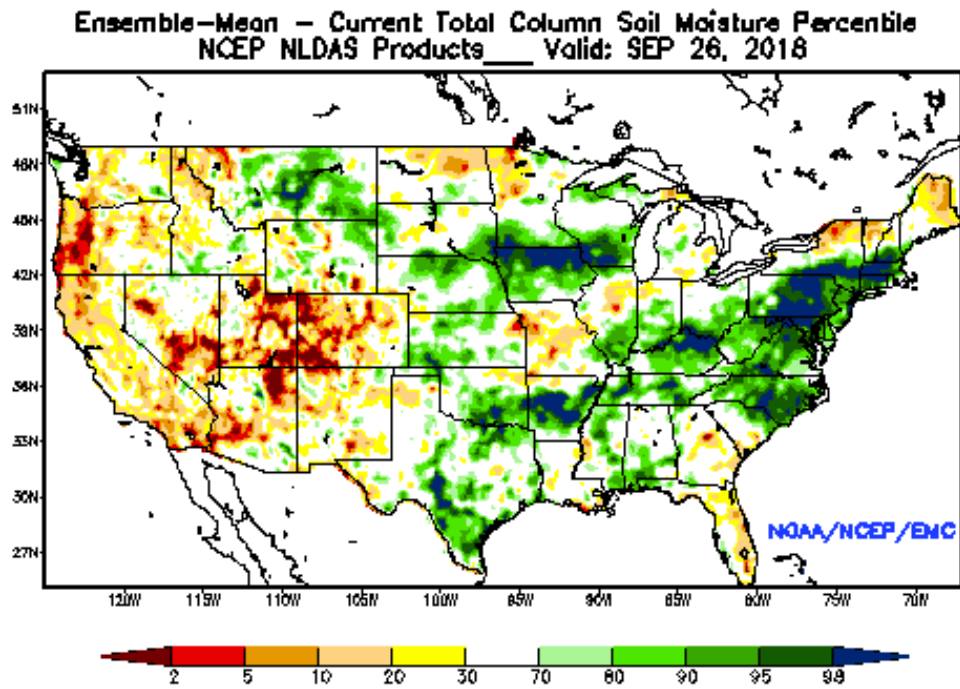


Figure 7. NOAA NLDAS Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

## 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 ENSO and its implications on temperature and precipitation outlooks.

### **ENSO (El Niño Southern Oscillation)**

ENSO-neutral conditions are present in the equatorial Pacific and typically do not influence the chances for spring and early summer precipitation and temperatures. The El Niño watch remains in effect. El Niño would favor increased chances for precipitation in the lower basin, but increased chances for above-normal temperatures in the upper Basin. This could lead to an increased chance for above-average runoff in the winter if temperatures at the beginning of winter are above normal. There is currently a 50-55 percent chance that El Niño will develop during the Northern Hemisphere fall (September-October-November), increasing to 65-70 percent during the winter (December-January-February).

### **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/>.

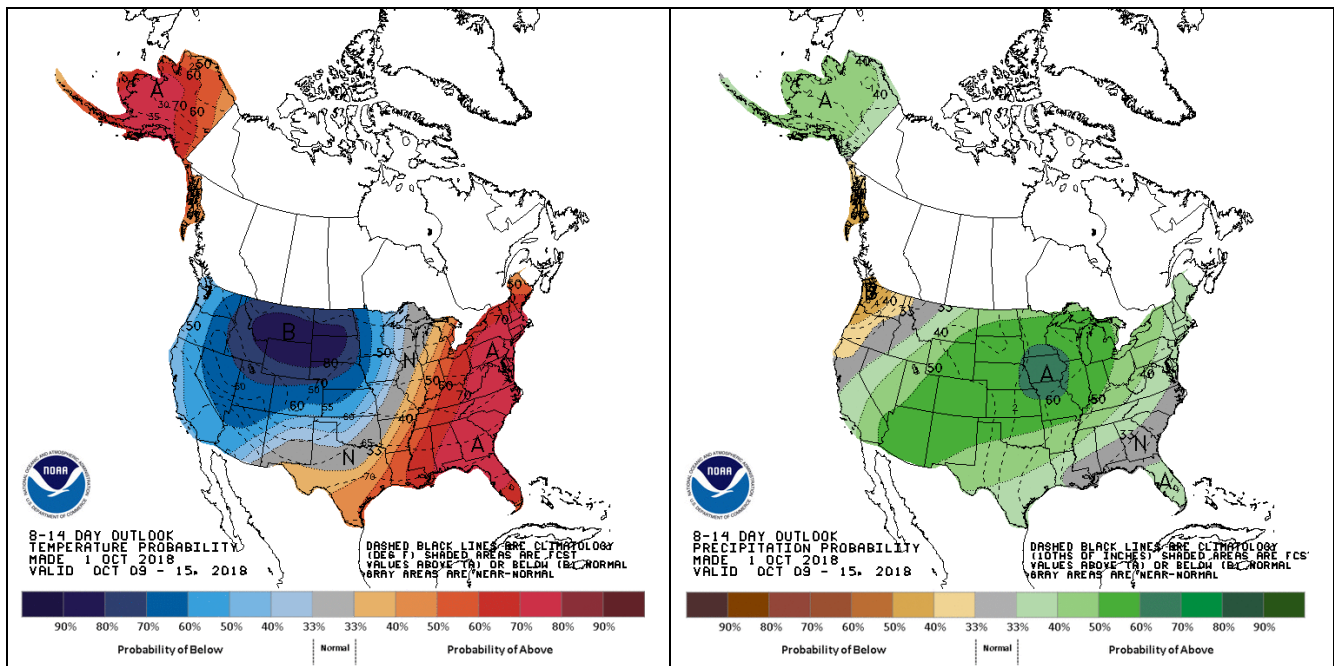
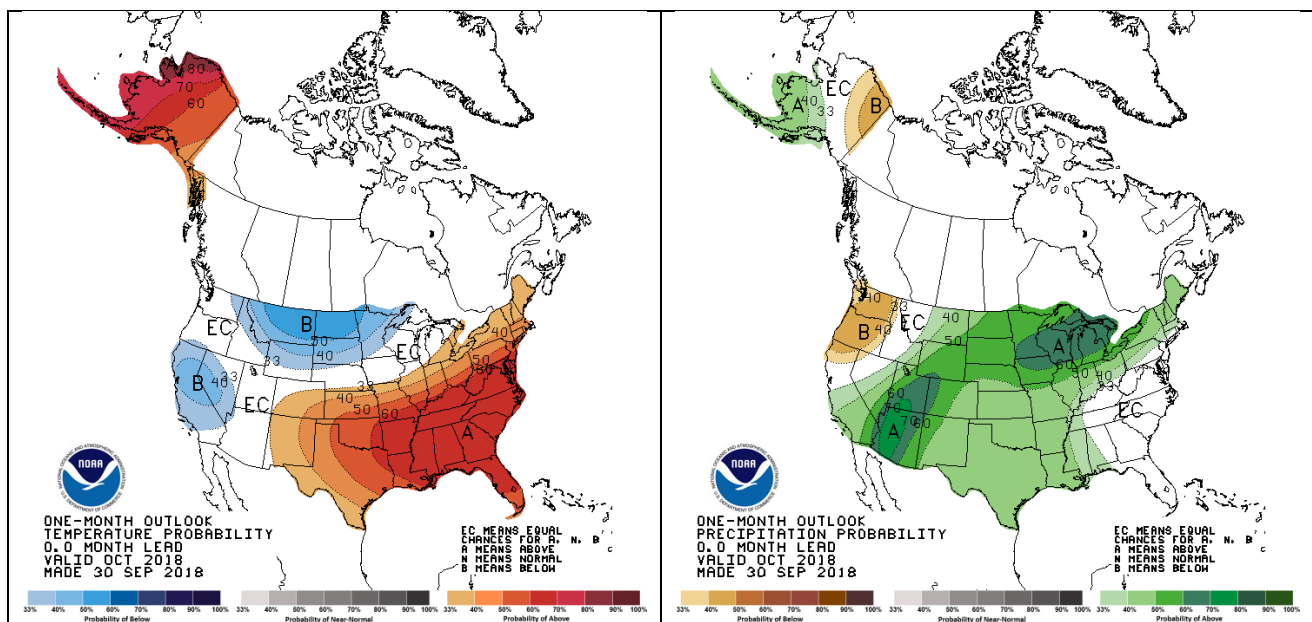


Figure 8. CPC 8-14 Day temperature and precipitation outlooks through October 14, 2018.

The CPC temperature outlook through October 15 in **Figure 8** indicates a significant increase in the chances for below-normal temperatures throughout most of the Basin, especially in the upper Basin. The precipitation outlook indicates an increase in the chances for above-normal precipitation in the entire Missouri Basin.

The October CPC temperature outlook in **Figure 9** indicates increased chances for below-normal temperatures in the upper Basin, with increased chances for above-normal temperatures in Kansas and Missouri. With regard to precipitation, there are increased chances for above-normal precipitation in much of the Missouri Basin with the greatest increase in precipitation chances extending from southern Wyoming and western Colorado to Minnesota and Iowa.



**Figure 9. CPC October 2018 temperature and precipitation outlooks.**

During the November-December 2018-January 2019 period in **Figure 10**, the CPC temperature outlook indicates increased chances for above-normal temperatures throughout the Basin. With regard to precipitation there are equal chances for below-normal, normal and above-normal precipitation in Wyoming, the Dakotas, Iowa, and Missouri. There are increased chances for below-normal precipitation in Montana, and increased chances for above-normal precipitation in Colorado, Nebraska, and Kansas.

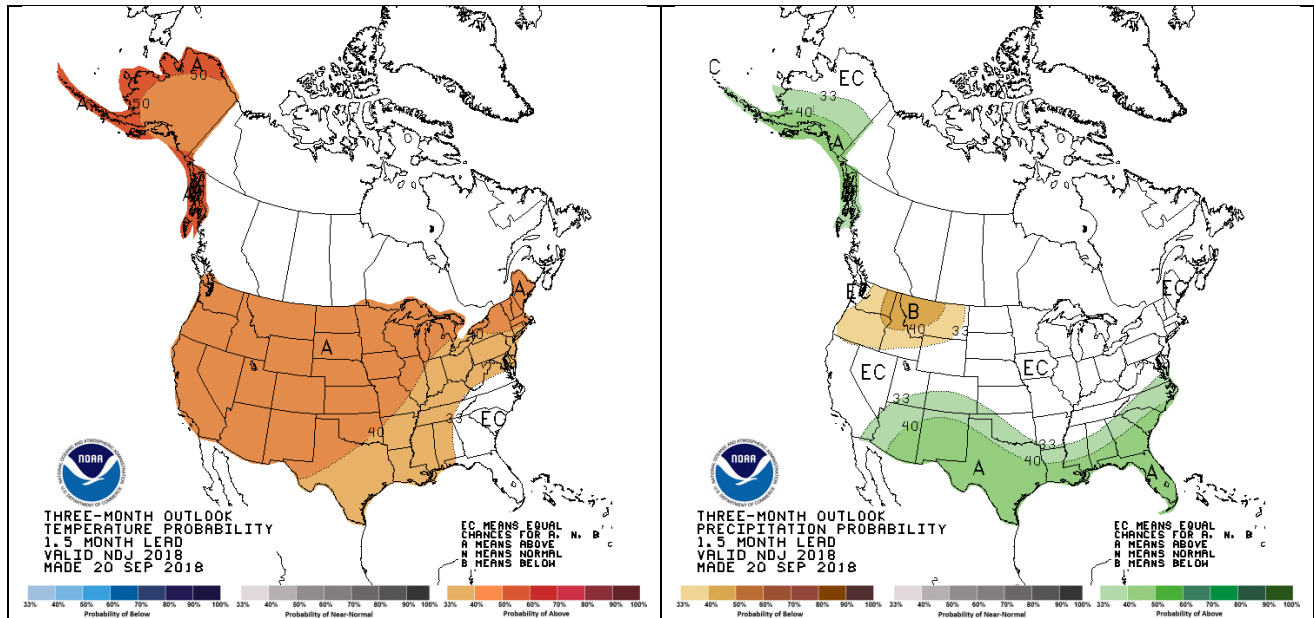


Figure 10. CPC November-December 2018-January 2019 temperature and precipitation outlooks.

## Summary

In summary, the annual runoff forecast for the Missouri Basin above Sioux City, IA is **40.6 MAF, 160 percent of average**. This forecast is bracketed by the lower basic forecast of 39.8 MAF and the upper basic forecast of 41.5 MAF. Looking short-term, streamflow has declined to below-normal levels in the Fort Peck and Garrison reaches, and in October we expect streamflow and runoff to remain below normal; however, chances for above-normal precipitation have increased. Runoff is forecast to be about average in the Oahe and Fort Randall reaches, while above-average runoff is forecast to continue in the Gavins Point and Sioux City reaches. Heavy rainfall is forecast to occur October 5-9 in Kansas, eastern Nebraska, western Iowa, and potentially southeastern South Dakota. This has been factored into our runoff forecast for the Gavins Point to Sioux City reach. We are forecasting the October runoff in the Sioux City reach to be more than five times average. Runoff is forecast to be well-above average in the Sioux City reach through the end of the calendar year.

**Upper Missouri River Basin  
November 2018 Calendar Year Runoff Forecast  
November 2, 2018**

**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**

October runoff was 1.9 MAF (160 percent of average) in the upper Missouri River Basin above Sioux City, IA; however, the October runoff summation above Gavins Point Dam was 1.1 MAF (99 percent of average). The Gavins Point to Sioux City reach runoff for October was almost 9 times average, and was the second highest October runoff in the 120 years of record, following record-high runoff in September. Runoff was also above average in the Gavins Point reach (207 percent). The calendar year runoff summation above Sioux City, IA as of November 1 is 39.1 MAF.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on November 1, is **41.4 MAF (163 percent of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **34.0 MAF (147 percent of average)**. The 41.4 MAF of runoff would be the 3<sup>rd</sup> highest in 120 years of record-keeping, exceeded only in 1997 and 2011.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 2 months, expected inflow could range from the 42.0 MAF upper basic forecast to the

40.9 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 much wetter or drier conditions, respectively. Given that 2 months are being forecast for this November 1 forecast (10 months observed/2 months forecast), the range of wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is attributed to all 6 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 October 30, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows that Moderate (D1) to Severe (D2) drought conditions are present in North Dakota, while Moderate (D1) drought conditions are present in north-central Montana and central South Dakota. Abnormally Dry (D0) conditions are also present in the larger areas surrounding the D1 and D2 conditions. In the lower Basin, D0 conditions continue to impact eastern Kansas and central Missouri. The Seasonal Drought Outlook in **Figure 2** indicates drought conditions are likely to persist in Montana, North Dakota and South Dakota, while drought removal is likely for Kansas and Missouri.

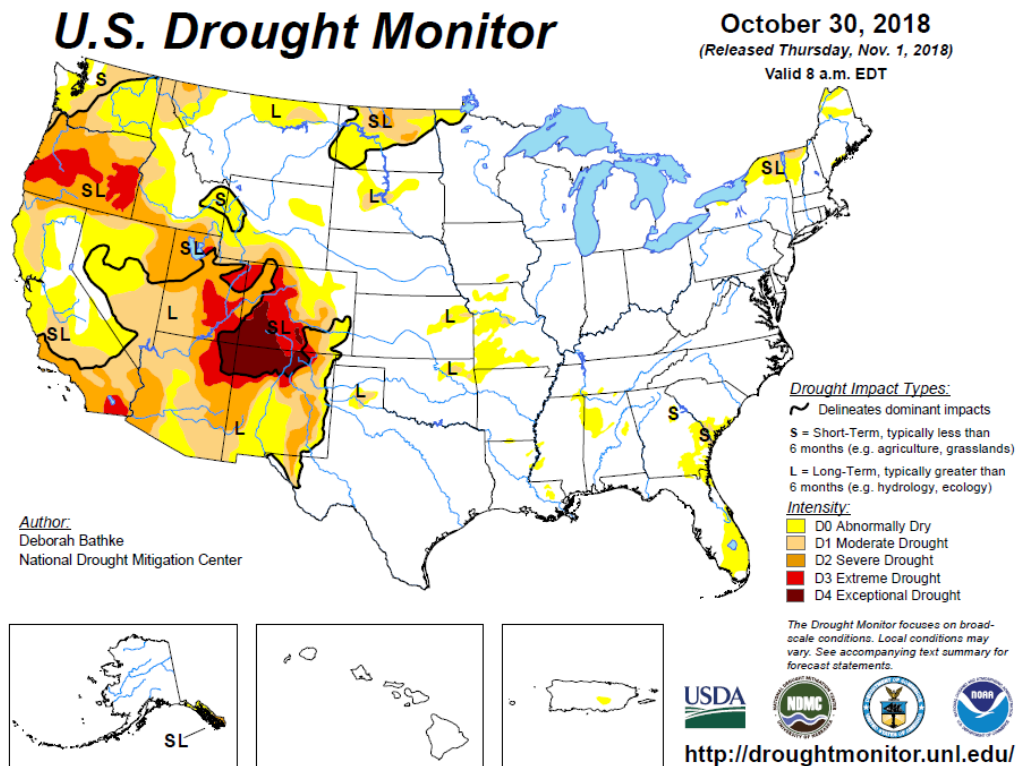


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for October 30, 2018.

**U.S. Seasonal Drought Outlook**  
Drought Tendency During the Valid Period

Valid for October 18 - January 31, 2019  
Released October 18, 2018

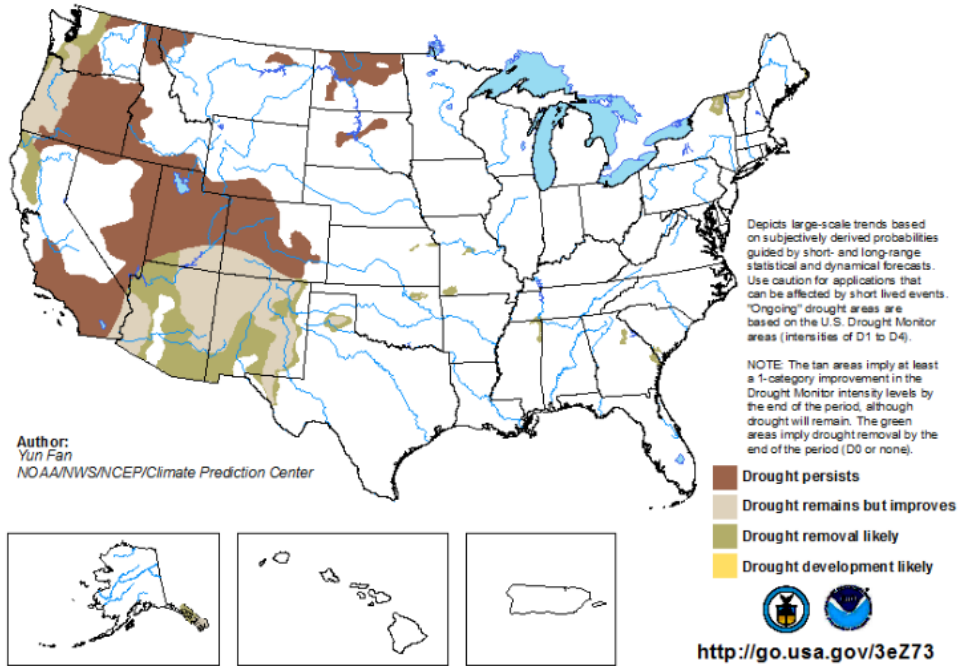
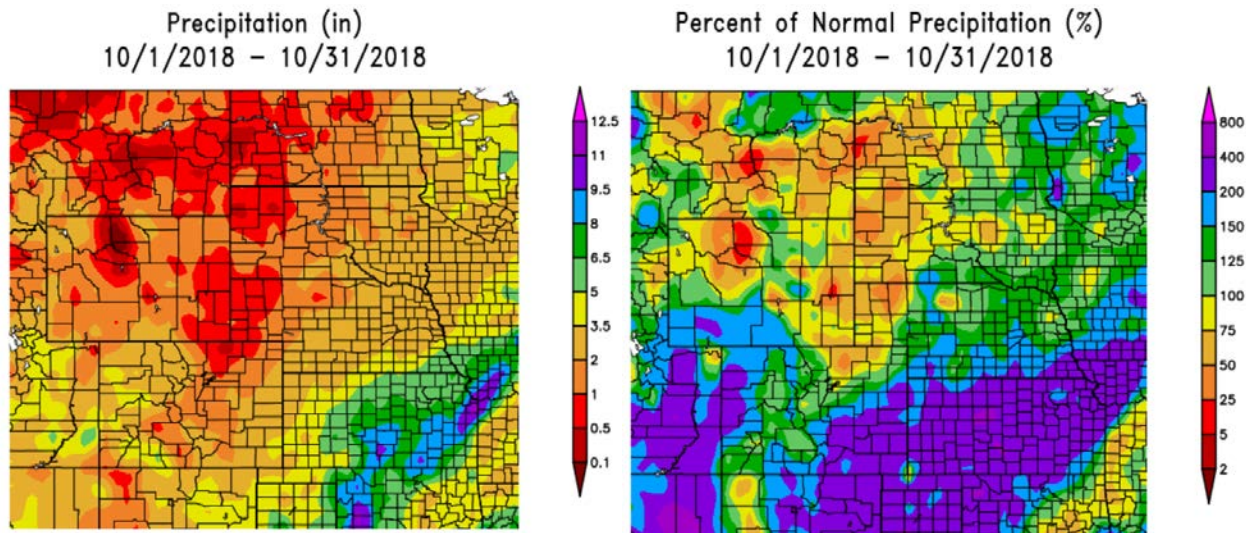


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

## Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at <http://www.hprcc.unl.edu/>. The October precipitation accumulations are shown in **Figure 3** as inches of precipitation (left) and percent of normal precipitation (right). October precipitation was less than 50 percent of normal in much of Wyoming, Montana, the western Dakotas and western Nebraska, as shown in right image of **Figure 3**. Precipitation was well-above normal in northern Montana, Iowa, southern Nebraska, Kansas, and northwestern Missouri.



**Figure 3. October 2018 Precipitation (inches) and Percent of Normal Precipitation.** Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

August-September-October precipitation accumulations are shown in **Figure 4**. In general, more precipitation has occurred in the lower Basin than in the upper Basin (left image). The three-month accumulations reflect the recent above-normal precipitation pattern in eastern South Dakota, Nebraska, Iowa and central Kansas. During the three-month period, areas of southeastern South Dakota, southwestern Minnesota and northwestern Iowa have received more than 150 percent of normal precipitation. In contrast, areas of North Dakota, Montana, Wyoming, and Colorado have received below-normal precipitation since the beginning of August.

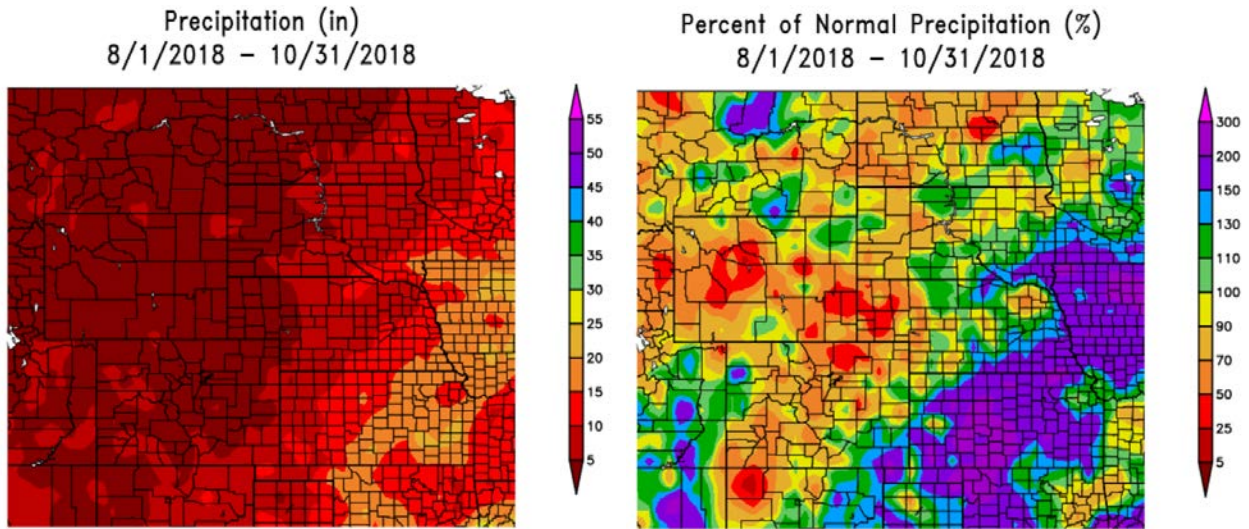


Figure 4. August-September-October 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

October temperatures are portrayed by the image of temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5**. October temperatures were about 1 to 6 deg F below normal throughout most of the Basin. During the August to October period (right image of **Figure 5**), temperatures have ranged from 1 to 4 deg F below normal over most of the Basin, with areas of 1 to 2 deg F above normal in portions of Colorado, Wyoming, eastern Kansas, central Iowa, and Missouri.

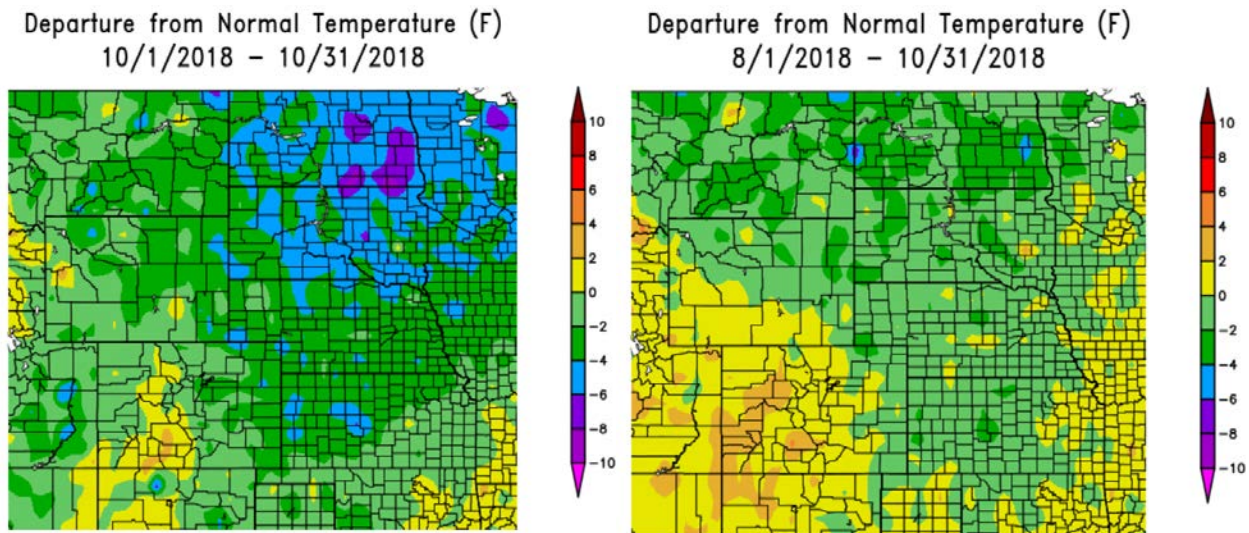


Figure 5. October 2018 and August-September-October 2018 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## 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. **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly, and **Figure 7** shows the soil moisture percentile on November 2, 2018.

Soil moisture anomalies are 25 mm (about 1 inch) to 150 mm (about 6 inches) above normal in areas of Montana, southeastern South Dakota, Iowa, Nebraska, and Kansas. The lack of precipitation in western Montana, central South Dakota, North Dakota and Missouri has caused negative soil moisture anomalies (deficits). In terms of soil moisture severity, soils are very wet with a 98<sup>th</sup> percentile ranking in southeastern South Dakota, southwestern Minnesota, northwestern Iowa, and western Kansas. The Musselshell River Basin in central Montana also has relatively wet soils with a percentile ranking ranging from the 95<sup>th</sup> to the 98<sup>th</sup> percentile ranking.

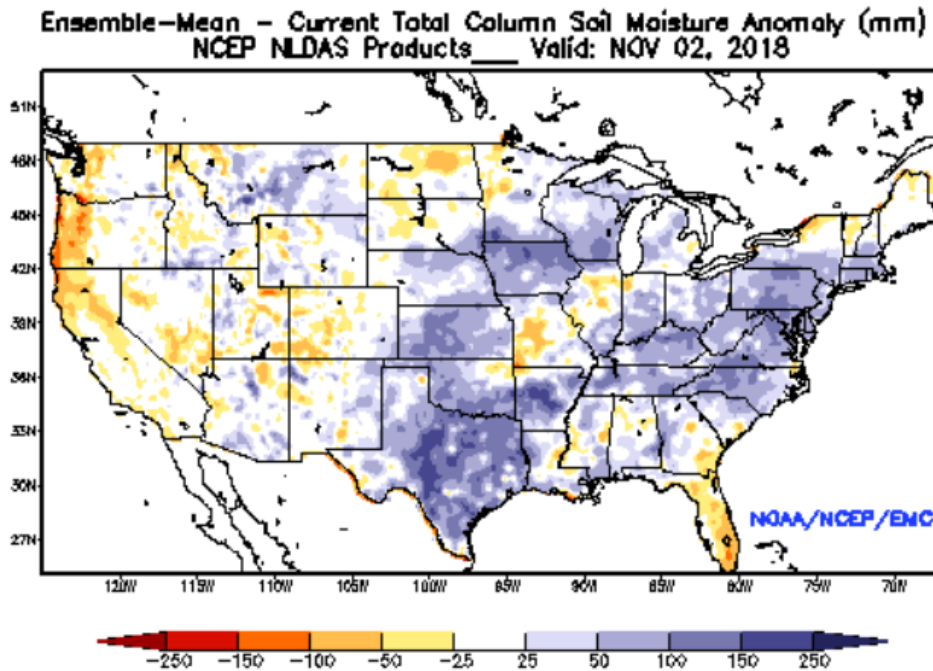


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm). Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

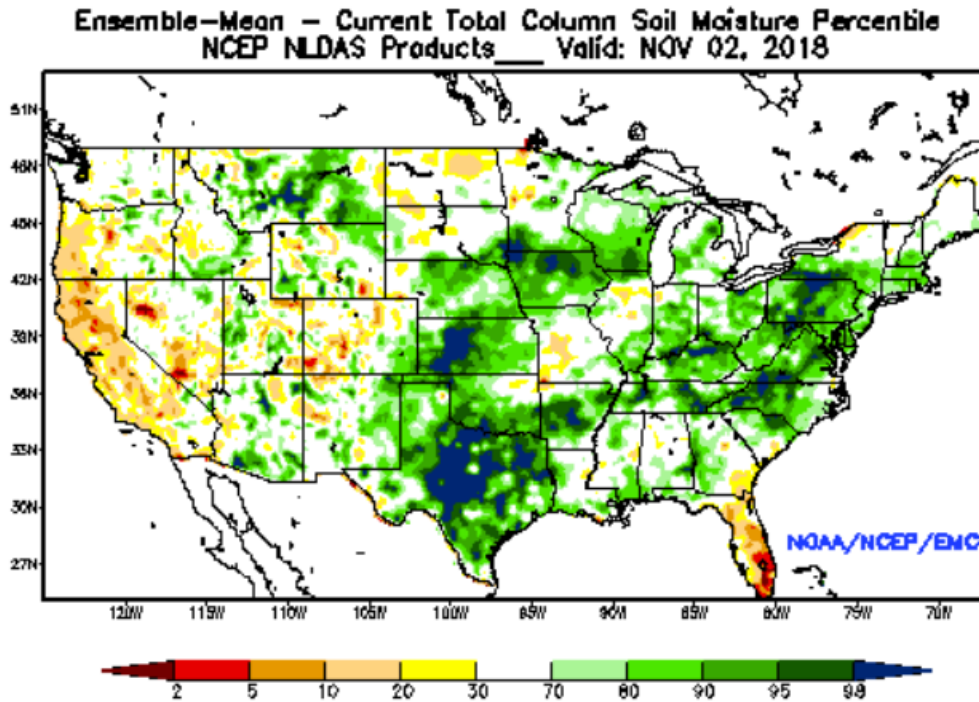


Figure 7. NOAA NLDAS Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

## 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 ENSO and its implications on temperature and precipitation outlooks.

### **ENSO (El Niño Southern Oscillation)**

ENSO-neutral conditions are present in the equatorial Pacific and typically do not influence the chances for fall precipitation and temperatures. The El Niño watch remains in effect. There is currently a 70-75 percent chance that El Niño will develop during the Northern Hemisphere winter (December-January-February). El Niño would favor increased chances for precipitation in the lower Basin, but increased chances for above-normal temperatures in the upper Basin. This could lead to an increased chance for above-average runoff in the winter if temperatures at the beginning of winter are above normal.

## 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/>.

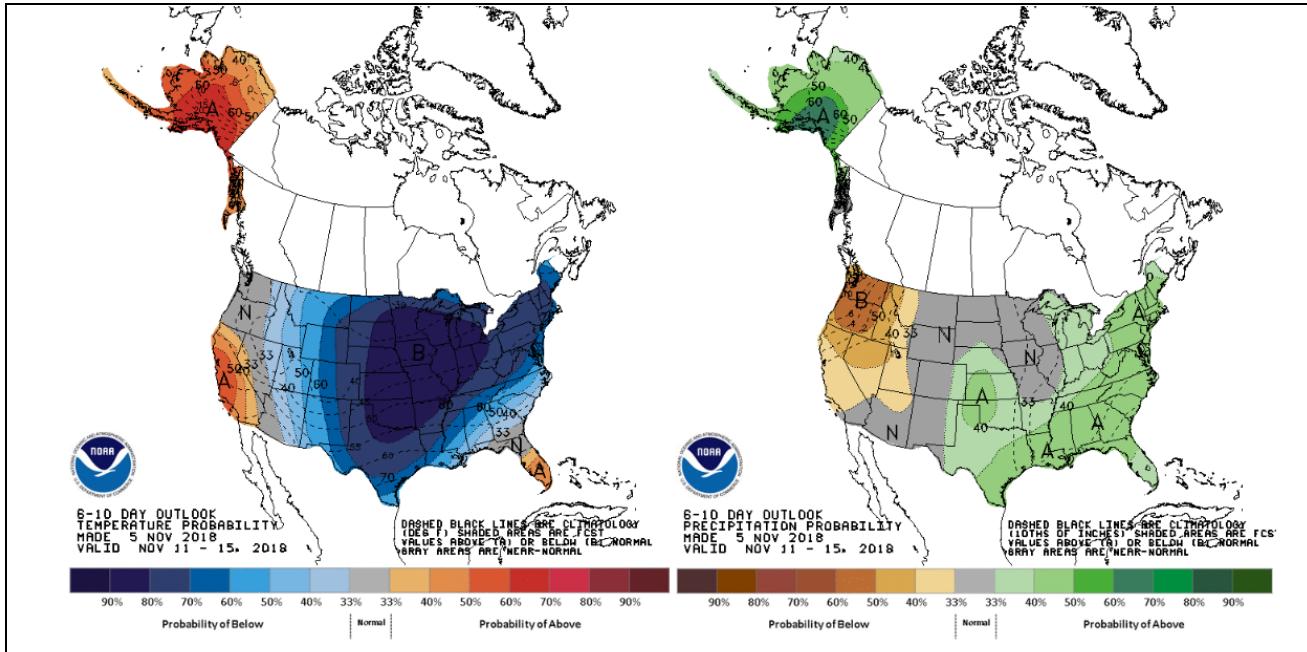


Figure 8. CPC 6-10 Day temperature and precipitation outlooks through November 15, 2018.

The CPC temperature outlook through November 15 in **Figure 8** indicates a significant increase in the chances for below-normal temperatures throughout most of the Basin, and equal chances for above-normal, below-normal, and normal precipitation.

The November CPC temperature outlook in **Figure 9** indicates increased chances for below-normal temperatures in the lower Basin, transitioning to increased chances for above-normal temperatures in the upper Basin. With regard to precipitation, there are increased chances for above-normal precipitation over most of the Missouri Basin.

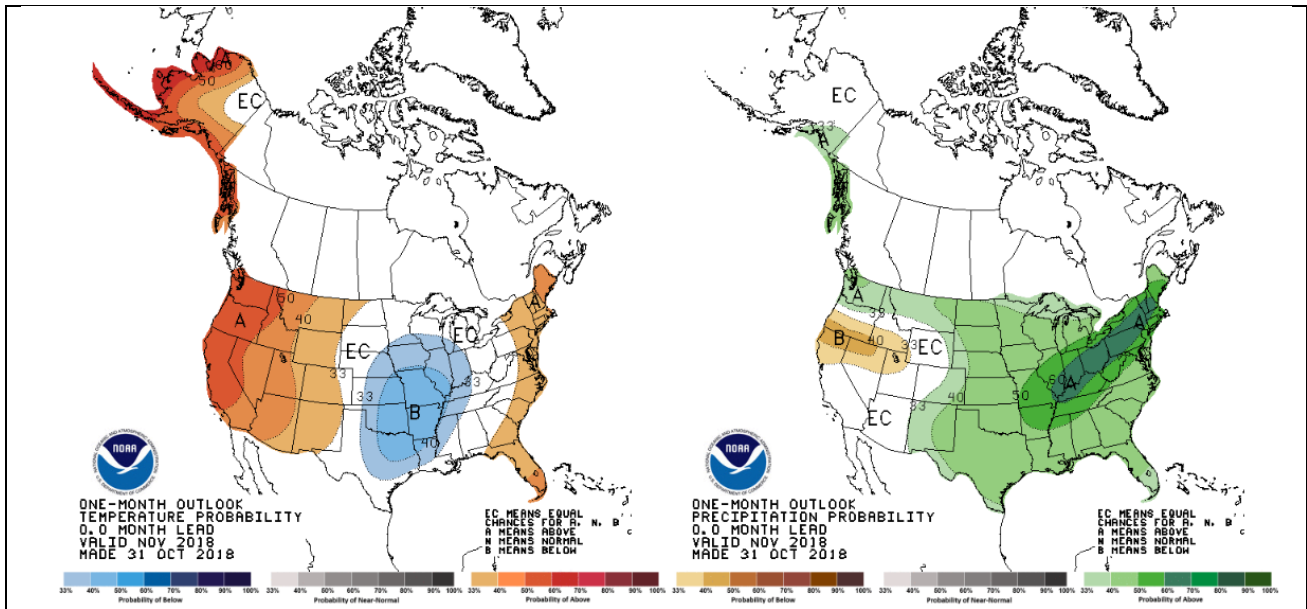


Figure 9. CPC November 2018 temperature and precipitation outlooks.

During the December 2018-January 2019-February 2019 period in **Figure 10**, the CPC temperature outlook indicates increased chances for above-normal temperatures throughout the Basin. With regard to precipitation there are equal chances for below-normal, normal and above-normal precipitation across the lower Basin. There are increased chances for below-normal precipitation in much of the upper Basin including Montana, northern Wyoming, and the western Dakotas.

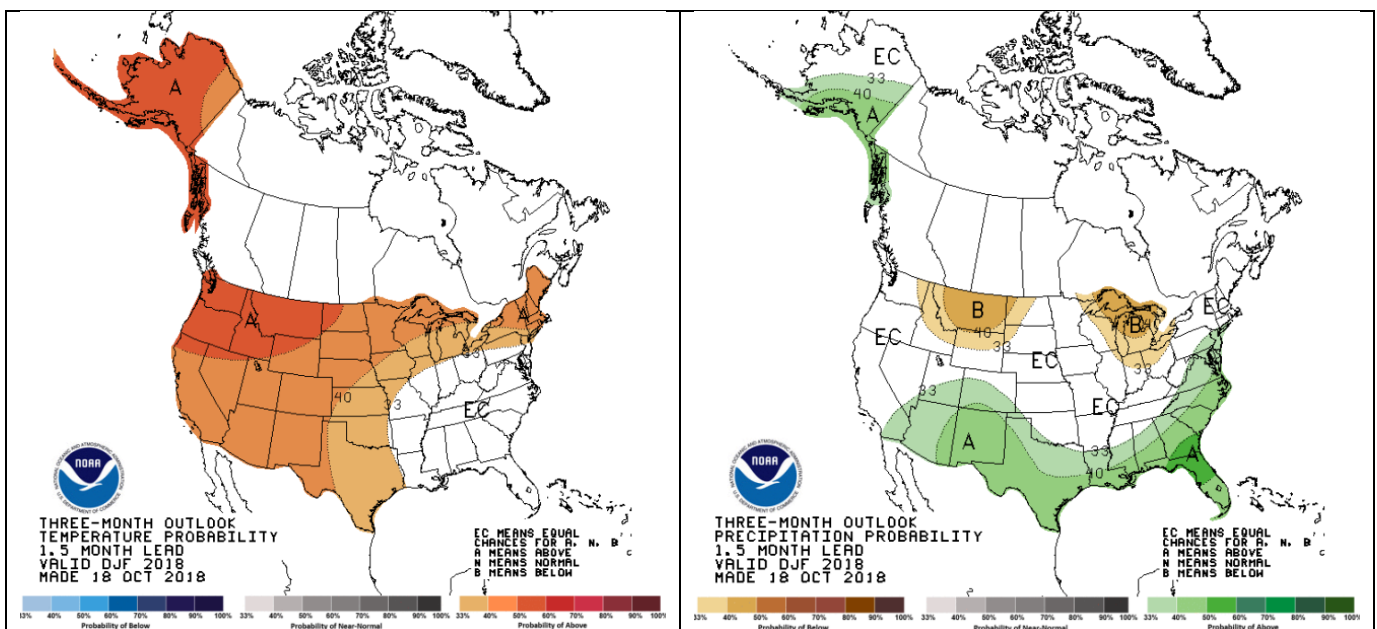


Figure 10. CPC December 2018-January 2019-February 2019 temperature and precipitation outlooks.

## **Summary**

In summary, the annual runoff forecast for the Missouri Basin above Sioux City, IA is **41.4 MAF, 163 percent of average**. This forecast is bracketed by the lower basic forecast of **40.9 MAF** and the upper basic forecast of **42.0 MAF**. The 41.4 MAF of runoff would be the 3<sup>rd</sup> highest in 120 years of record-keeping, exceeded only in 1997 and 2011. Looking short-term, runoff is slightly-below normal in the Fort Peck and Garrison reaches, and in November we expect streamflow and runoff in those reaches to remain below-normal. Runoff has decreased to well-below normal in the Oahe and Fort Randall reaches, but is forecast to return to near normal levels, where soil moisture conditions are currently average to wet. Runoff is forecast to be well-above average in the Gavins Point and Sioux City reaches through the end of the calendar year.

**Upper Missouri River Basin  
December 2018 Calendar Year Runoff Forecast  
December 6, 2018**

**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**

November runoff was 1.2 MAF (118 percent of average) in the upper Missouri River Basin above Sioux City, IA. The November runoff summation above Gavins Point Dam was 0.8 MAF (86 percent of average). Total runoff for the basin above Gavins Point was below average due to below average runoff in the Garrison, Oahe and Fort Randall reaches. The Gavins Point to Sioux City reach runoff for November was almost 5 times average, following the second highest October runoff in the 120 years of record and the record-high runoff in September. This reach's 3-month runoff (September, October and November) of 2.1 MAF nearly equaled its long-term average annual runoff of 2.3 MAF. The calendar year runoff summation above Sioux City, IA as of December 1 is 40.3 MAF.

**2018 Calendar Year Forecast Synopsis**

The 2018 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA, updated on December 1, is **41.3 MAF (163 percent of average)**. The 2018 calendar year runoff forecast above Gavins Point Dam is **33.8 MAF (147 percent of average)**. The 41.3 MAF of runoff would be the 3<sup>rd</sup> highest in 120 years of record-keeping, exceeded only in 1997 and 2011.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next month, expected inflow could range from the 41.5 MAF upper basic forecast to the 41.1 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 or drier conditions, respectively.

## Current Conditions

### Drought Analysis

The National Drought Mitigation Center’s drought monitor for December 4, 2018 is shown in **Figure 1**. The drought monitor is available at <http://droughtmonitor.unl.edu/>. The U.S. Drought Monitor shows that Moderate (D1) drought conditions are present in north central North Dakota. However, it should be noted that most of that area is NOT in the Missouri River basin. Abnormally Dry (D0) conditions are also present in north central North Dakota, and small areas of the upper Basin. In the lower Basin, D0 conditions continue to impact small areas of eastern Kansas and western Missouri. Drought conditions currently cover most of Colorado. The Seasonal Drought Outlook in **Figure 2** indicates drought conditions are likely to persist in North Dakota and central South Dakota through the end of February 2019.

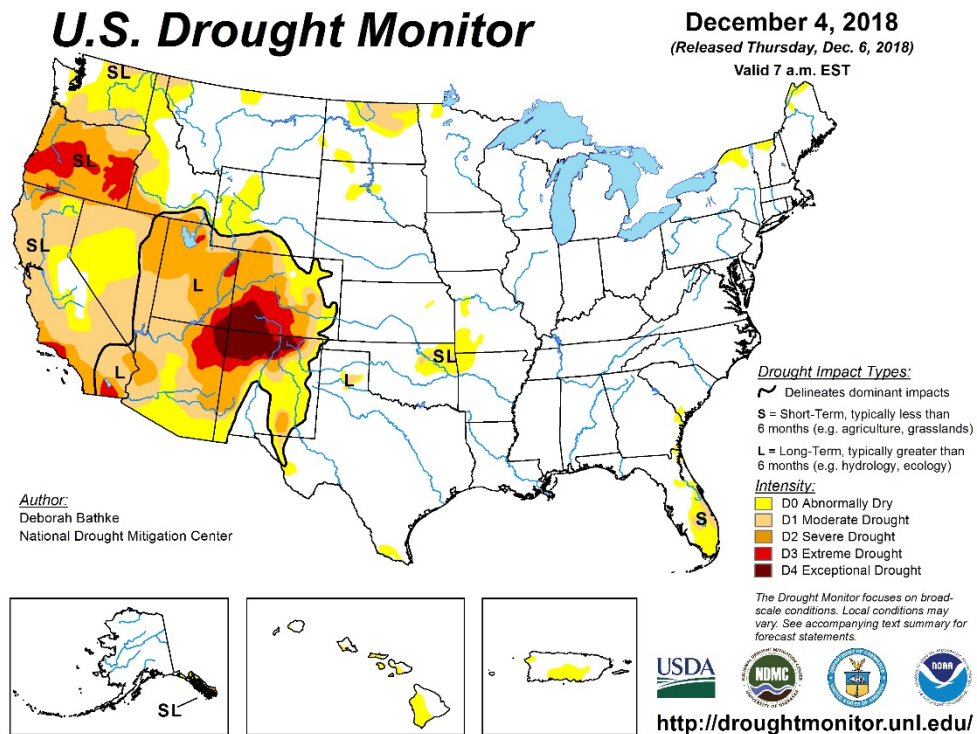


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for December 4, 2018.

**U.S. Seasonal Drought Outlook**  
**Drought Tendency During the Valid Period**

Valid for November 15, 2018 - February 28, 2019  
 Released November 15, 2018

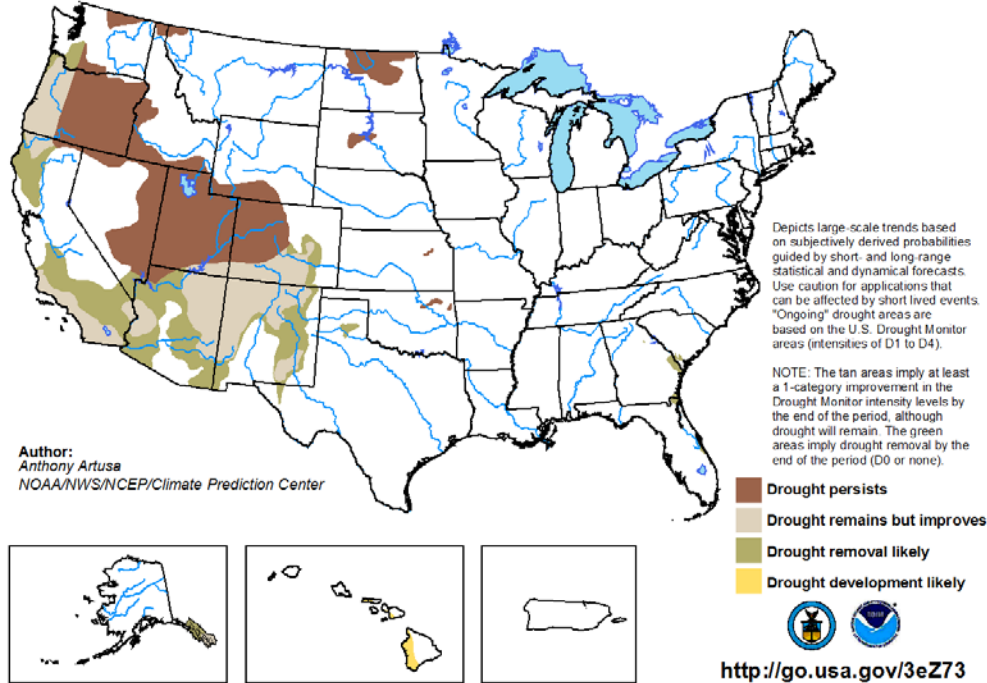


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

**Precipitation**

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at <http://www.hprcc.unl.edu/>. The November precipitation accumulations are shown in **Figure 3** as inches of precipitation (left) and percent of normal precipitation (right). November precipitation was more than 150 percent of normal in areas of Montana, western North Dakota and some areas in Wyoming. Precipitation was below normal in much of the lower Basin, especially in eastern Kansas and western Missouri where it was less than 50 percent of normal.

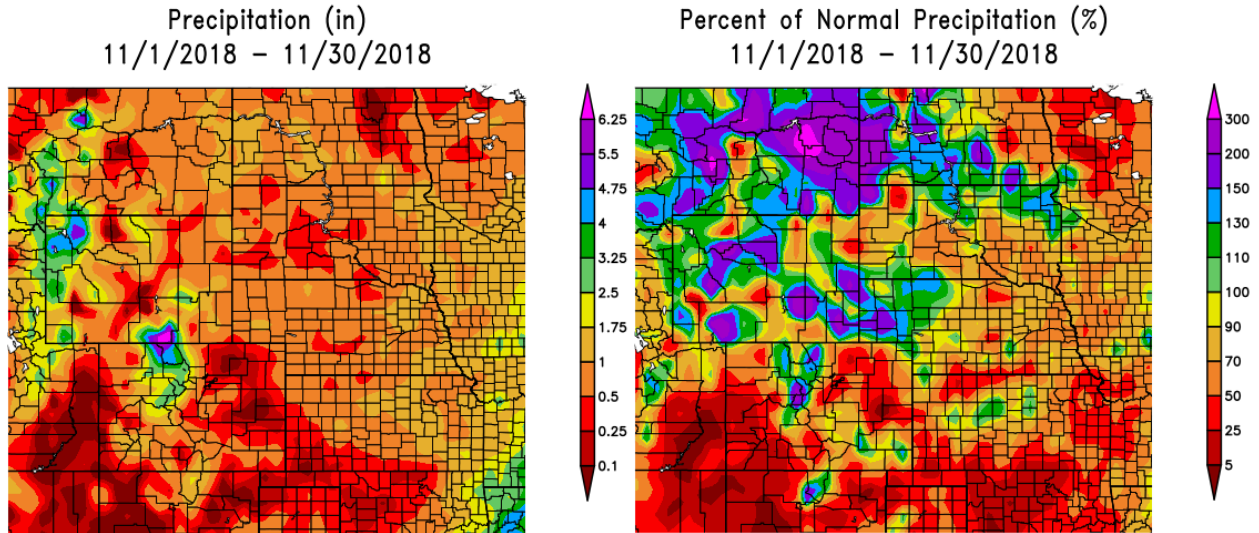


Figure 3. November 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

September-October-November precipitation accumulations are shown in **Figure 4**. In general, more precipitation has occurred in the lower Basin than in the upper Basin (left image). The three-month accumulations reflect an above-normal precipitation pattern in northern Montana, eastern South Dakota, Nebraska, Iowa, Kansas and northern Missouri. During the three-month period, precipitation has been greater than 150 percent of normal over southeastern South Dakota, western Iowa, southeastern Nebraska and much of Kansas. In contrast, some of southern Montana, Wyoming, western South Dakota, the Nebraska Panhandle and Colorado have received well-below-normal precipitation since the beginning of September.

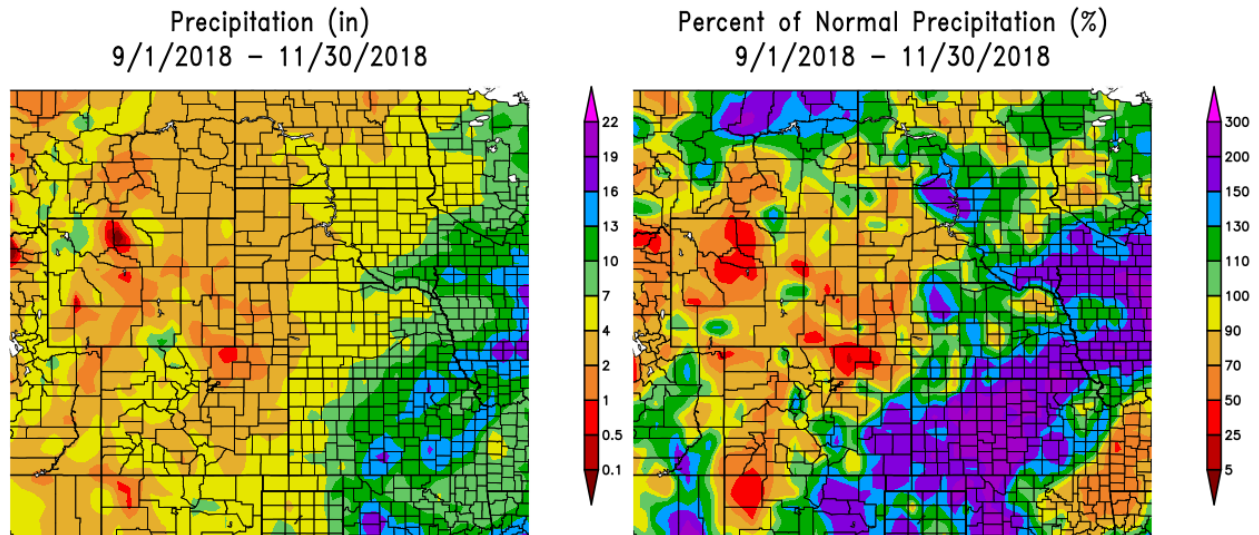


Figure 4. September-October-November 2018 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## Temperature

November temperatures are portrayed by the image of temperature departures in degrees Fahrenheit (deg F) in the left image of **Figure 5**. November temperatures were colder-than-normal in the eastern region of the Missouri Basin, and average to slightly-below-average in the western and central regions of the Missouri Basin. Temperature departures during November ranged from 4 to over 8 deg F below normal in the eastern region. During the September to November period (right image of **Figure 5**), temperatures were near normal to below normal in central and western regions. Over the eastern regions three-month temperatures were 2 to 6 deg F below normal.

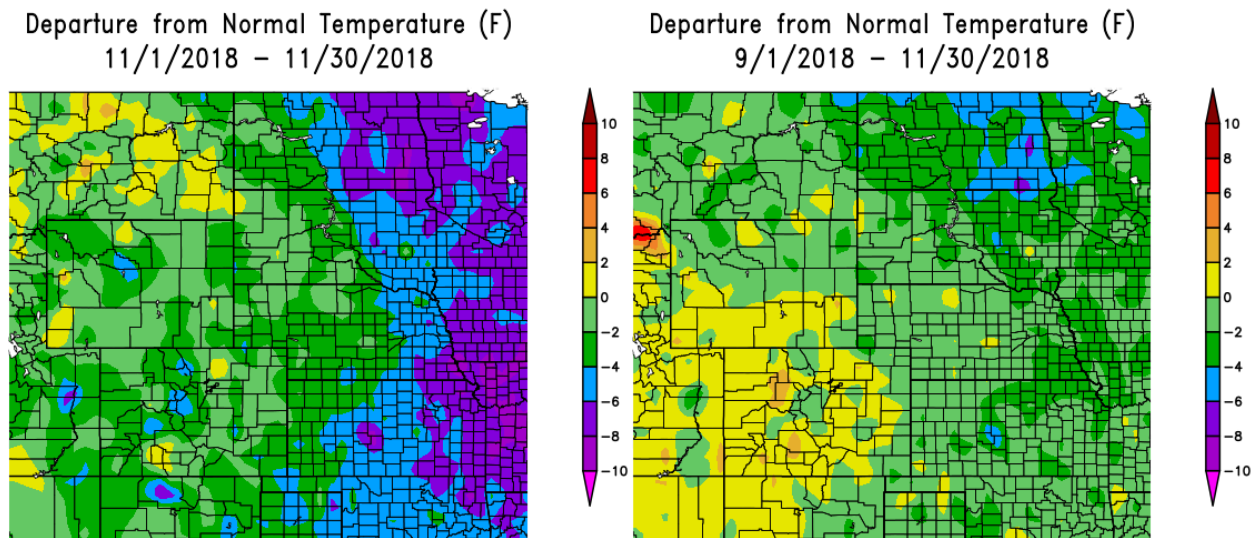


Figure 5. November 2018 and September-October-November 2018 Departure from Normal Temperature (deg F).  
Source: High Plains Regional Climate Center, <http://www.hprcc.unl.edu/>.

## 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. **Figure 6** shows the current NOAA NLDAS ensemble soil moisture anomaly, and **Figure 7** shows the soil moisture percentile on December 1, 2018.

Soil moisture anomalies are 50 mm (about 2 inches) to 100 mm (about 2 inches) above normal and greater in areas of Montana, southeastern South Dakota, Iowa, Nebraska, Iowa and Kansas. In terms of soil moisture severity, soils in these areas rank higher than the 90<sup>th</sup> percentile ranking. During the winter, soil moisture conditions typically undergo very limited change

because surface soils become frozen and precipitation either as snow or rainfall cannot infiltrate into the soil. Furthermore, there is very low evaporation or consumptive use by vegetation during the dormant phase of the year.

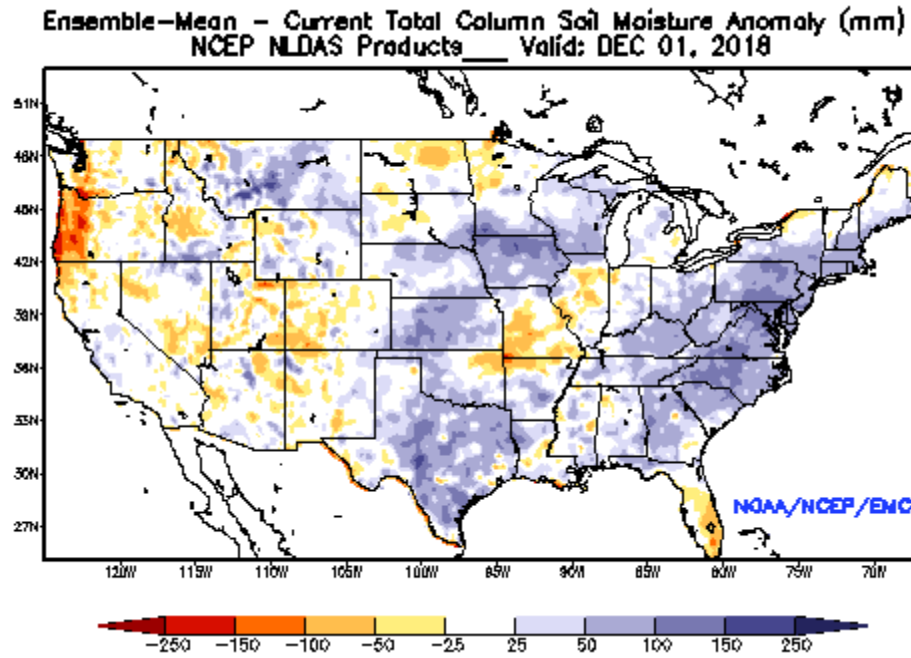


Figure 6. NOAA NLDAS Soil Moisture Anomaly (mm). Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

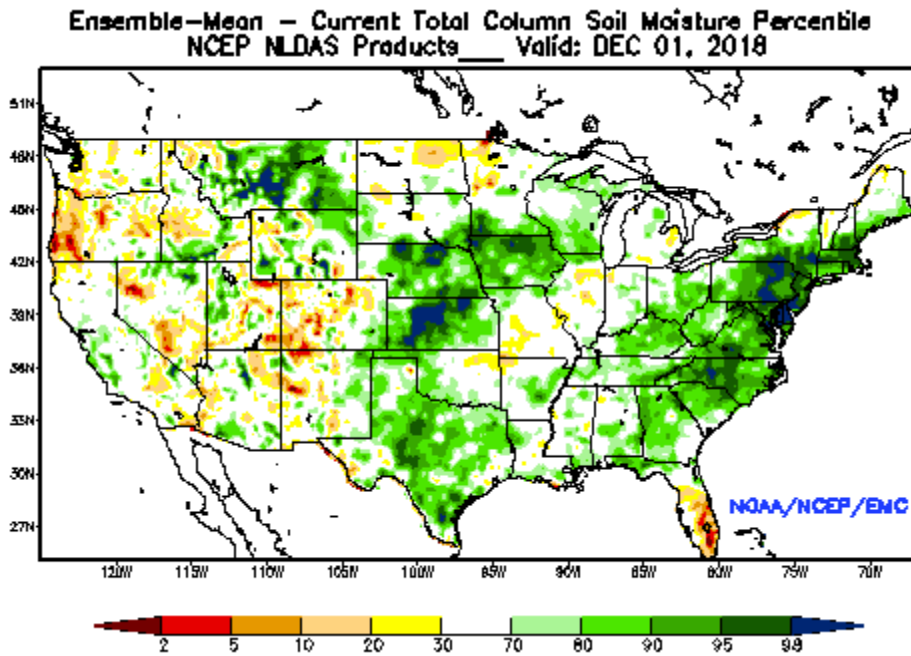


Figure 7. NOAA NLDAS Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. <http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>

## Climate Outlook

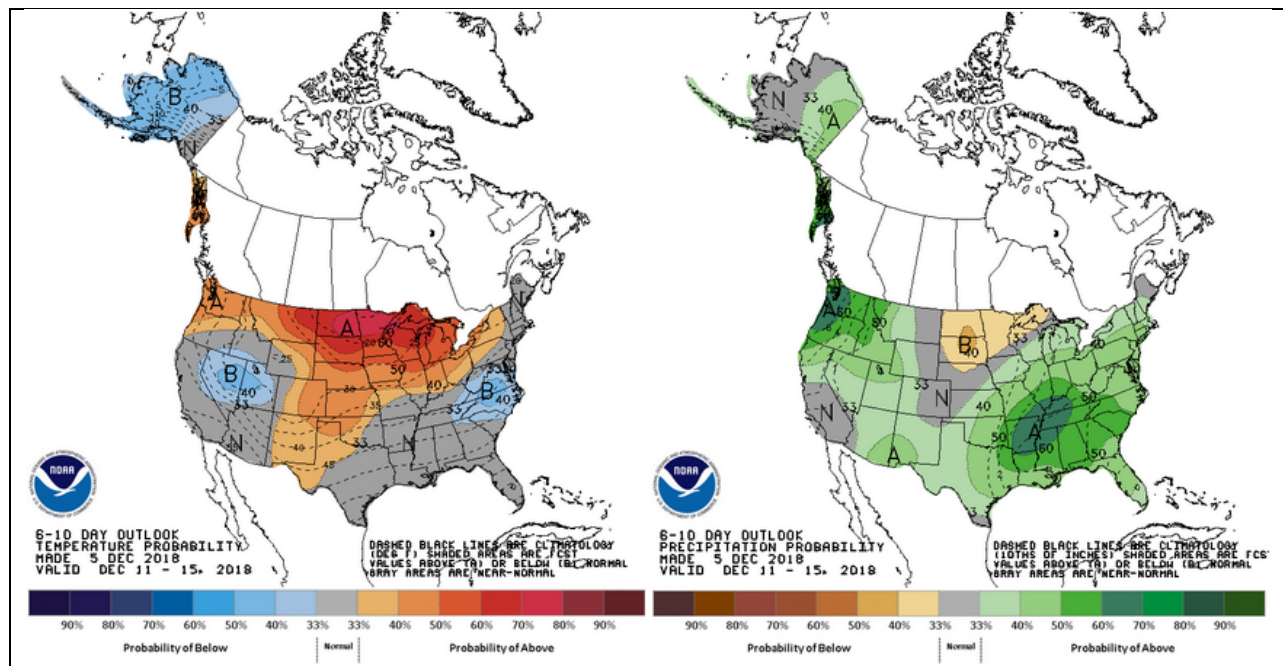
MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including ENSO and its implications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

### **ENSO (El Niño Southern Oscillation)**

ENSO-neutral conditions are present in the equatorial Pacific and typically do not influence the chances for fall precipitation and temperatures. The El Niño watch remains in effect. There is currently an 80 percent chance that El Niño will develop during the Northern Hemisphere winter (December-January-February). El Niño conditions may favor increased chances for precipitation in the lower Basin, and increased chances for above-normal temperatures in the upper Basin. This could lead to an increased chance for above-average runoff in the winter if temperatures at the beginning of winter are above normal.

### **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/>.



**Figure 8. CPC 6-10 Day temperature and precipitation outlooks through December 15 2018.**

The CPC temperature outlook through December 15 in **Figure 8** indicates a significant increase in the chances for above-normal temperatures throughout most of the Basin. With regard to

precipitation, there is a slight increase in the chance for above-normal precipitation in western Montana and Wyoming, and a notable increase in the chance for above-normal precipitation in Kansas and Missouri.

The December CPC temperature outlook in **Figure 9** indicates increased chances for above-normal temperatures in much of the Missouri Basin, with the exception of equal chances in Wyoming, the Nebraska Panhandle and Colorado. With regard to precipitation, there are increased chances for above-normal precipitation over southern South Dakota, Nebraska and the lower Basin. The storm system that followed after this outlook was created occurred between December 1 and 2; therefore a more accurate outlook for precipitation would be indicated by the 6- to 10-day forecast in **Figure 8**. Equal chances for precipitation are indicated for the remainder of the upper Basin.

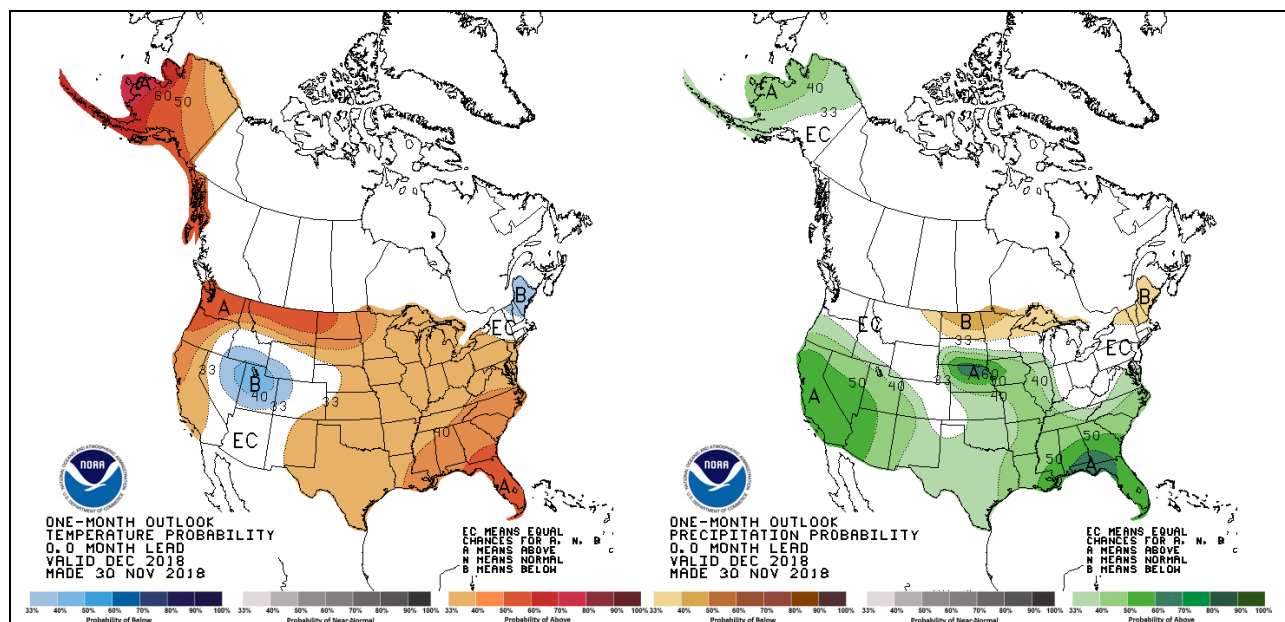


Figure 9. CPC December 2018 temperature and precipitation outlooks.

During the January-February-March 2019 period in **Figure 10**, the CPC temperature outlook indicates increased chances for above-normal temperatures throughout most of the Missouri Basin. The greatest chances for above-normal temperatures are indicated in the upper Basin. With regard to precipitation there are equal chances for below-normal, normal and above-normal precipitation across the upper Basin, and much of the lower Basin. There are increased chances for above-normal precipitation in Colorado, southern Wyoming western Nebraska and western Kansas.

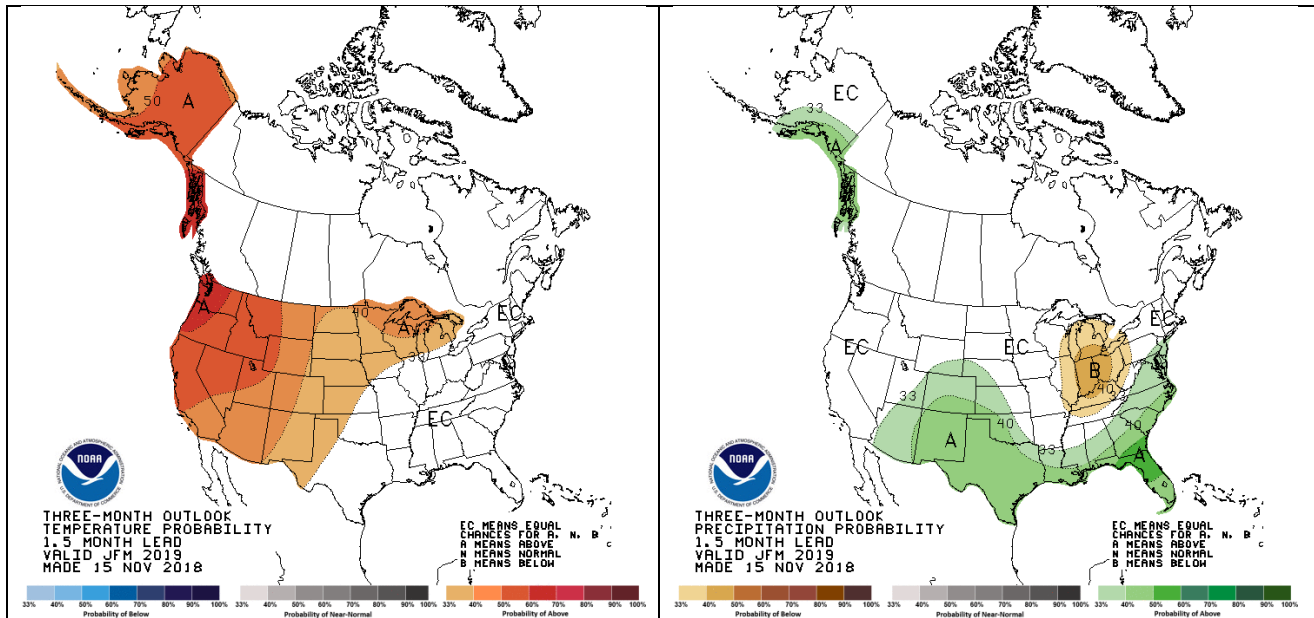


Figure 10. CPC January-February-March 2019 temperature and precipitation outlooks.

## Summary

The annual runoff forecast for the Missouri Basin above Sioux City, IA is **41.3 MAF, 163 percent of average**. The 41.3 MAF of runoff would be the 3<sup>rd</sup> highest in 120 years of record-keeping, exceeded only in 1997 and 2011. Looking short-term, runoff is forecast to be about average in the Fort Peck, Garrison and Oahe reaches. Since runoff has been above average in the Gavins Point and Sioux City reaches due to very moist soil conditions and high streamflows, December runoff is also forecast to be above average. Throughout the winter, MRBWM will continue to closely monitor plains and mountain snowpack accumulations, and streamflow conditions including ice formation. The [Weekly Update](#), which is updated each Tuesday on the [MRBWM website](#), provides current information on basin conditions, the mainstem reservoir status and winter releases.