Upper Missouri River Basin
January 2023 Calendar Year Runoff Forecast
January 4, 2023

US 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 here. 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, IA. 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 2022 calendar year runoff summation for the Missouri Basin above Sioux City, IA was **19.3 MAF, 75% of average**. This was the 30th lowest annual runoff for the Missouri River Basin in 125 years of record keeping.

December 2022 runoff was 0.85 MAF, 109% of average. Runoff was near-normal due to the above-normal precipitation over most of the upper Basin during the month.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **20.8 MAF, 81% of average**. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **18.9 MAF, 81% 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 28.9 MAF upper basic forecast to the 13.7 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively. Given that 12 months are being forecast for this January 1 forecast, the range of possible wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is very large, and is attributed

to all six reaches for the entire year. The result is a range or "bracket" for each reach, and thus, for the total runoff forecast.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for January 3, 2023 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present in over 85% of the Basin, with almost 15% of that being Extreme or Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of March, indicates drought persisting in the Missouri Basin below Sioux City (lower Basin) but improving over most of the upper Basin.

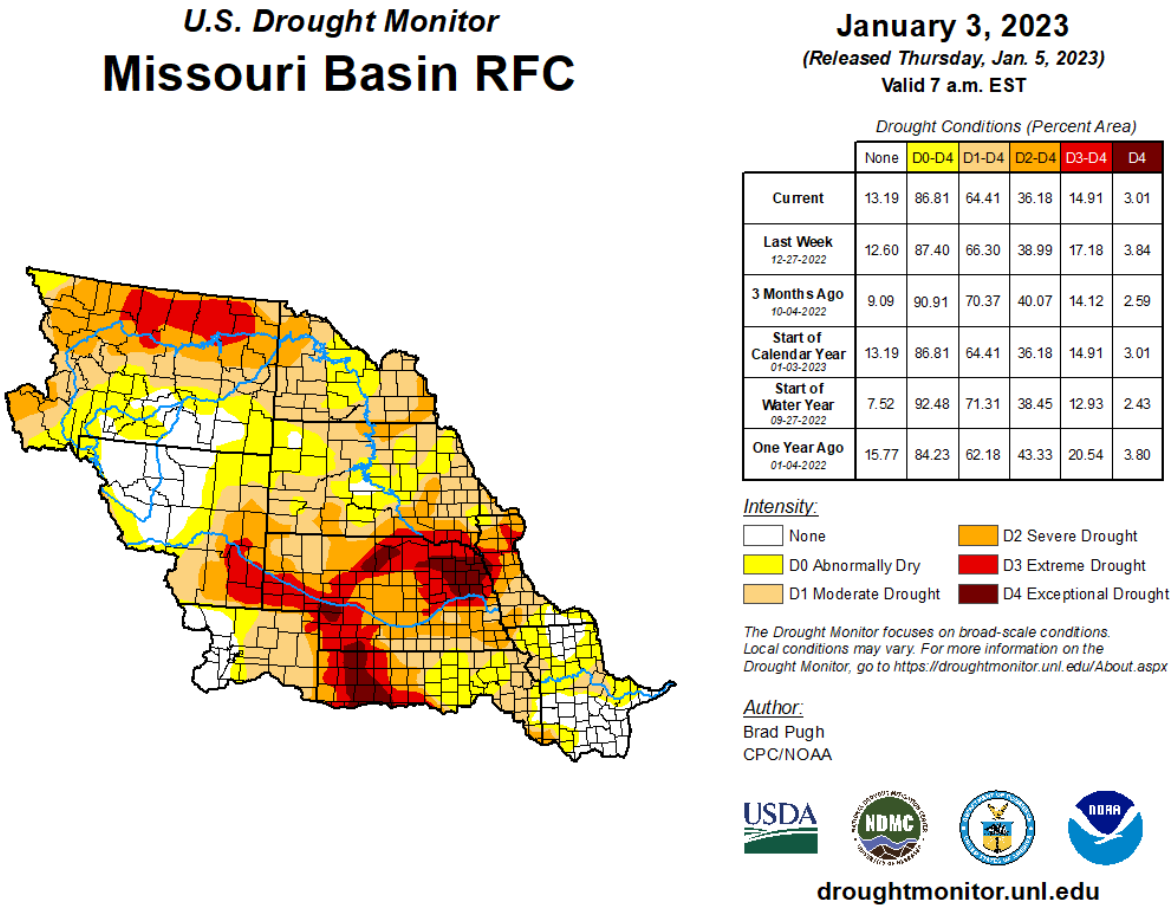


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

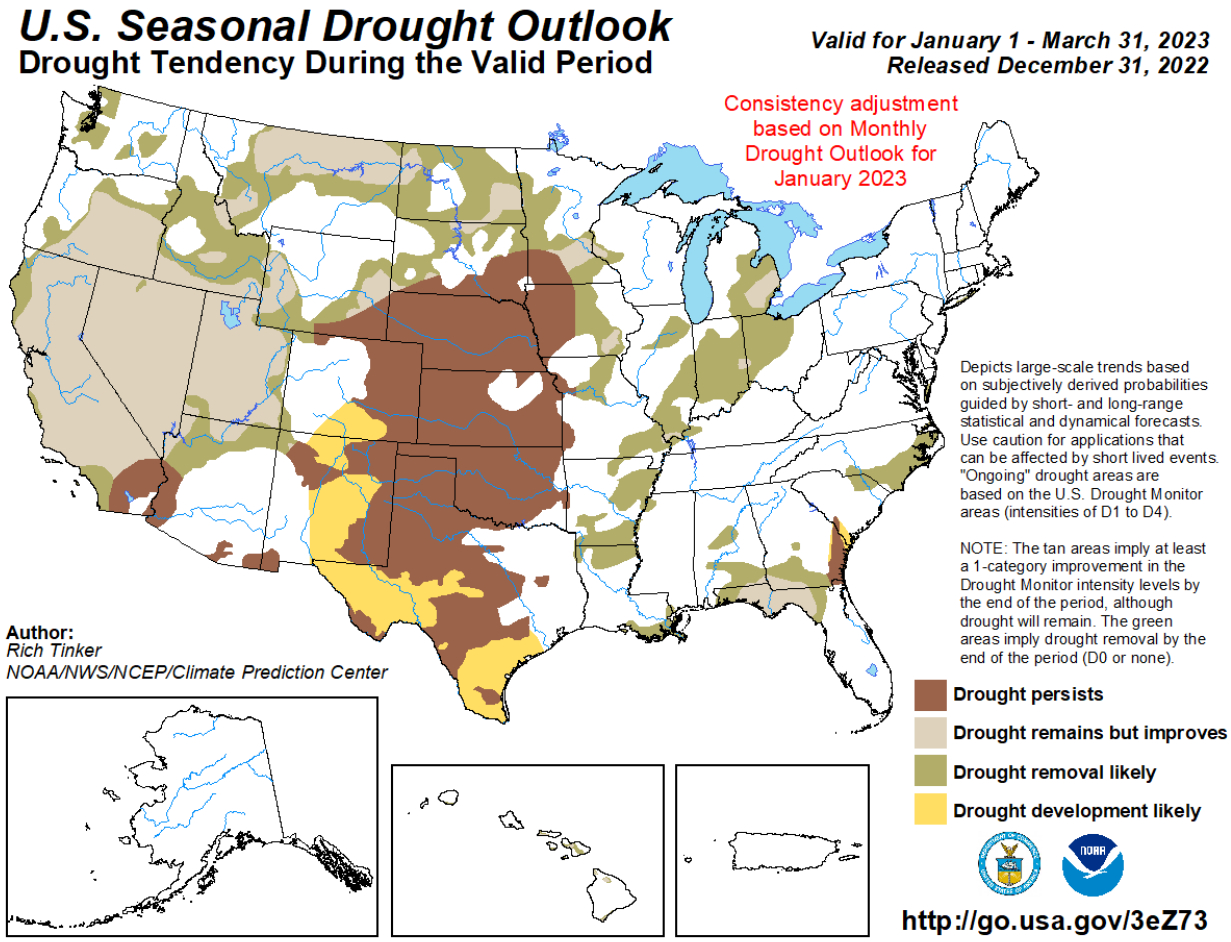


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The December precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was above normal for much of the upper Basin, with most of the Dakotas and parts of Montana seeing over 200% of normal. Normal to below-normal precipitation occurred in most of the lower Basin.

Precipitation as a percent of normal for the October-November-December period (**Figure 4**) has a much larger area of below-normal precipitation in the Basin. Most of the basin saw lower-than-normal precipitation except for Montana and western North Dakota, which saw 130-200% of normal in large areas.

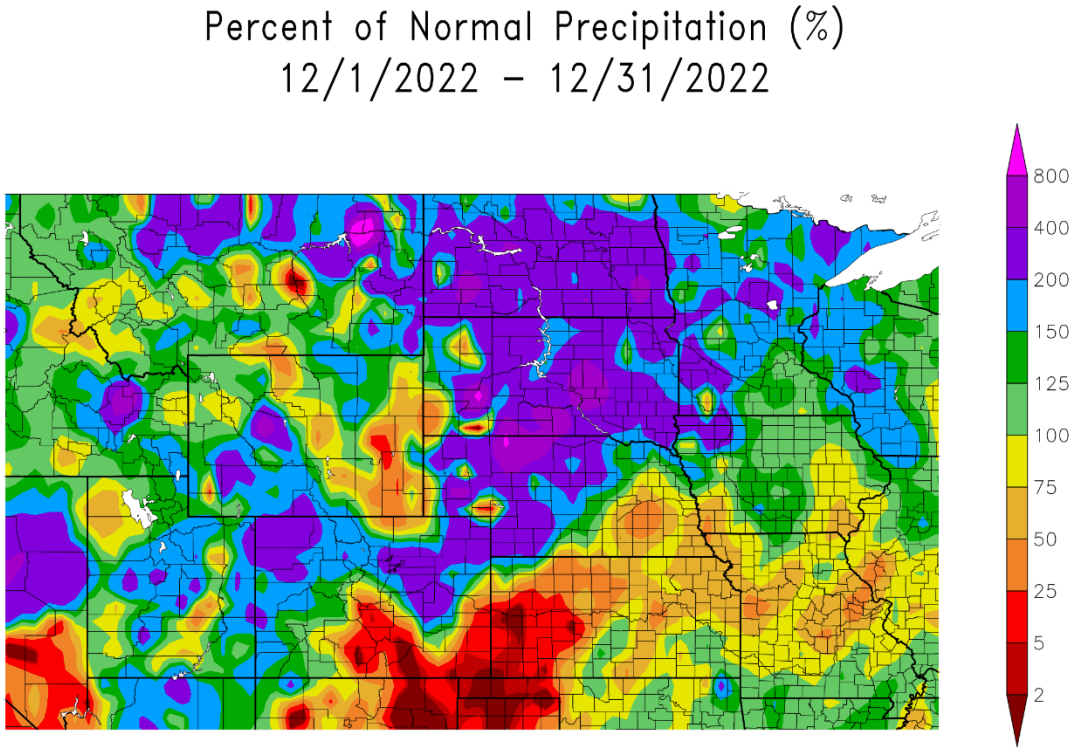


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

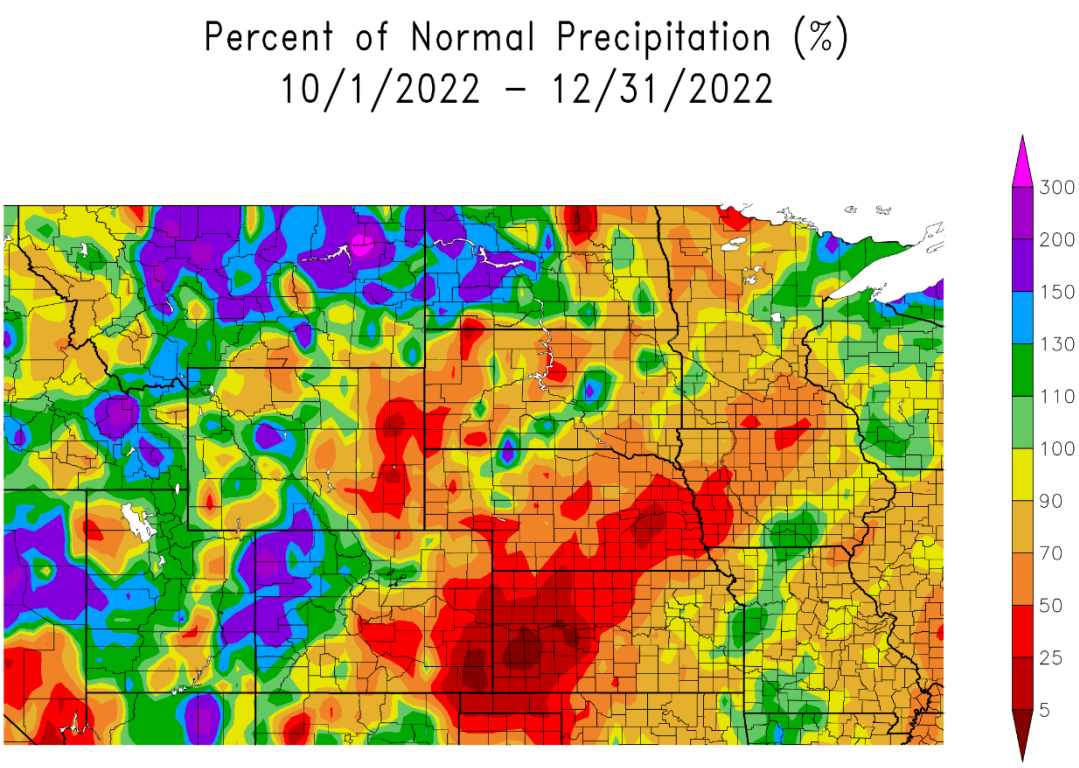


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

December temperature departures in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate cooler temperatures across the entire Basin. Much cooler-than-normal temperatures occurred across most of the upper Basin, ranging from 6 to 15 degrees below normal. October-November-December temperature departures are shown in **Figure 6**. The three-month average departures were also slightly below normal, ranging from normal to 6 degrees below normal for most of the Basin.

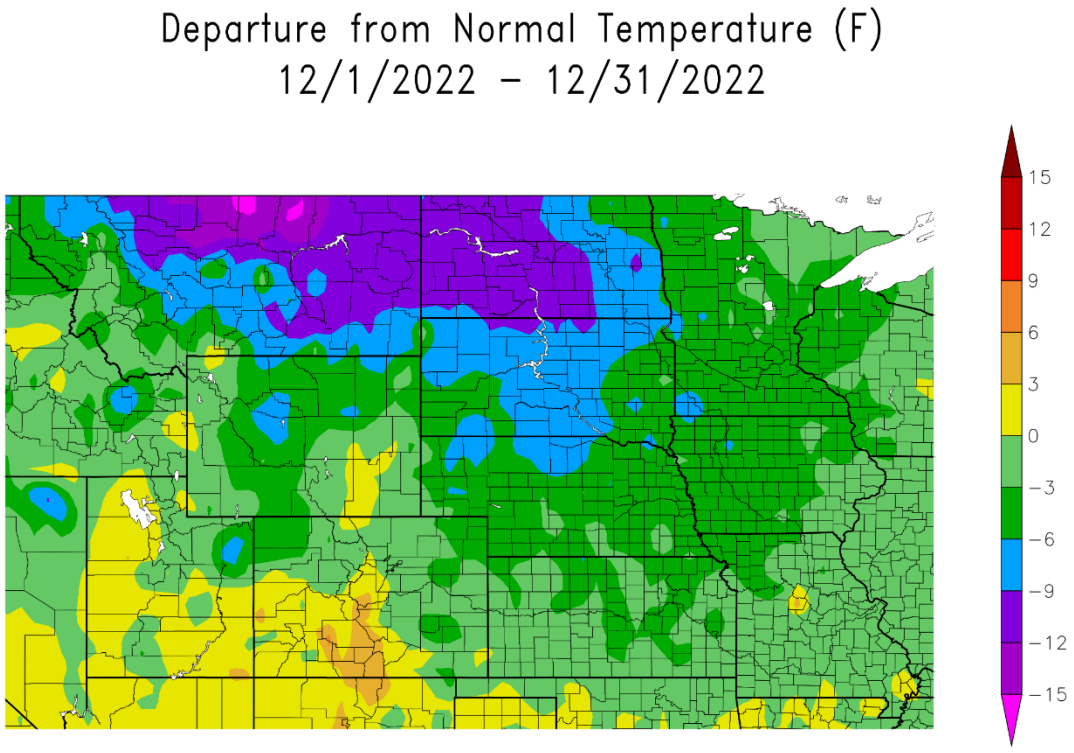


Figure 5. HPRCC Previous Month Departure from Normal Temperature

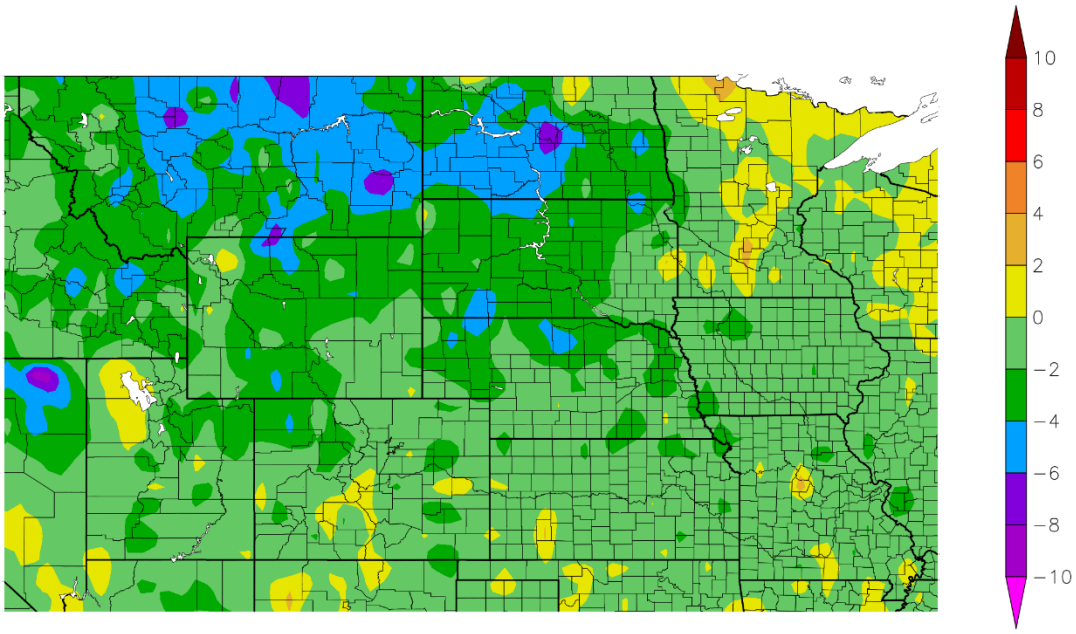


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of December 2022 is shown in **Figure 7**, along with a comparison of soil moisture last year at this time. Soil moisture is drier than normal across much of the basin, similar to last year, however, Montana is much closer to normal conditions and the lower Basin is much drier than this time last year. Generally, when soil moisture is low during the winter, the potential for above-normal March-April runoff is lower.

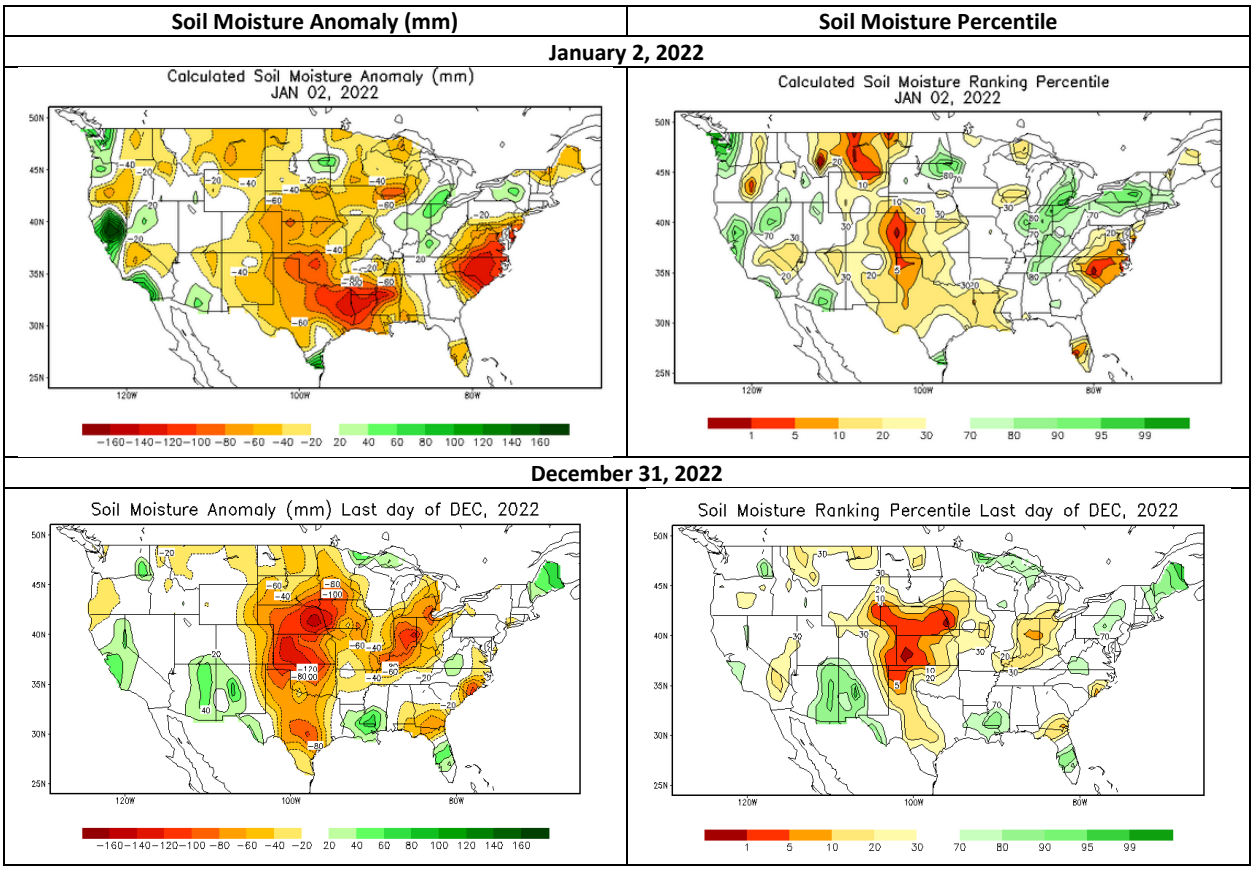


Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. 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 (available here) from January 6, shown in **Figure 8**, indicates widespread snowpack accumulating across much of the plains. While last year at this time also showed wide extents to the plains snowpack, amounts are much higher this year than they were last year. The Dakotas and eastern Montana show over 2" of snow water equivalent (SWE) in most areas, with the Central Dakotas and the James River Basin in North Dakota showing 3-5" of SWE. Snow also extends into the lower Basin, with much of the state of Nebraska and northwestern Iowa having snow cover. Central Nebraska

shows 1-2” of SWE. The amount of runoff received in March and April will depend greatly on precipitation and temperatures over the next few months.

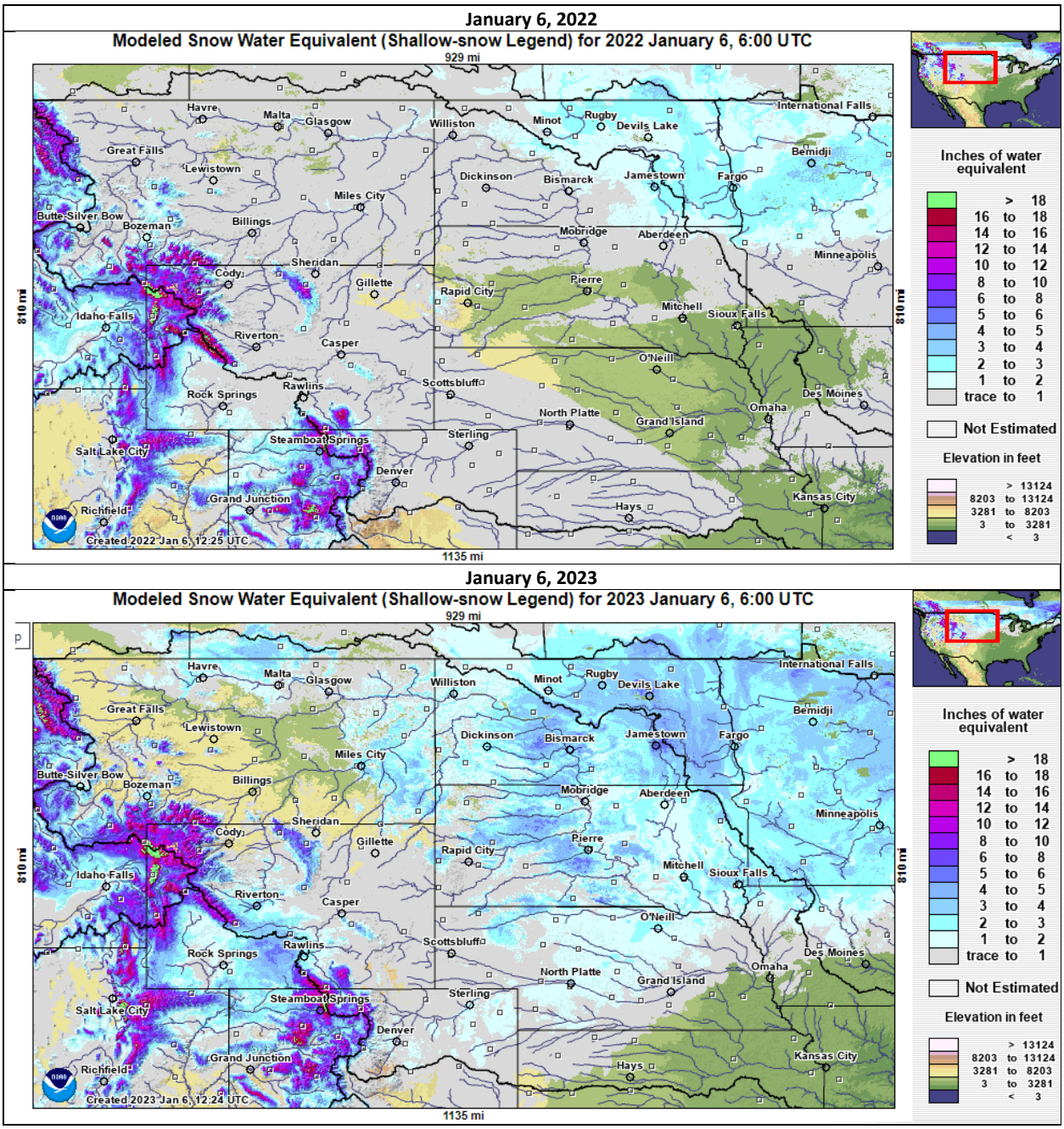


Figure 8. NOHRSC Modeled Snow Water Equivalent

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. May, June, and July runoff in the Fort Peck and Garrison reaches has very little correlation to the January 1 snowpack, because less than half of the mountain snowpack has accumulated by January 1. A majority of the mountain snowfall typically occurs

from January 1 to mid-April, when snowpack typically peaks; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 9** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry 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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line).

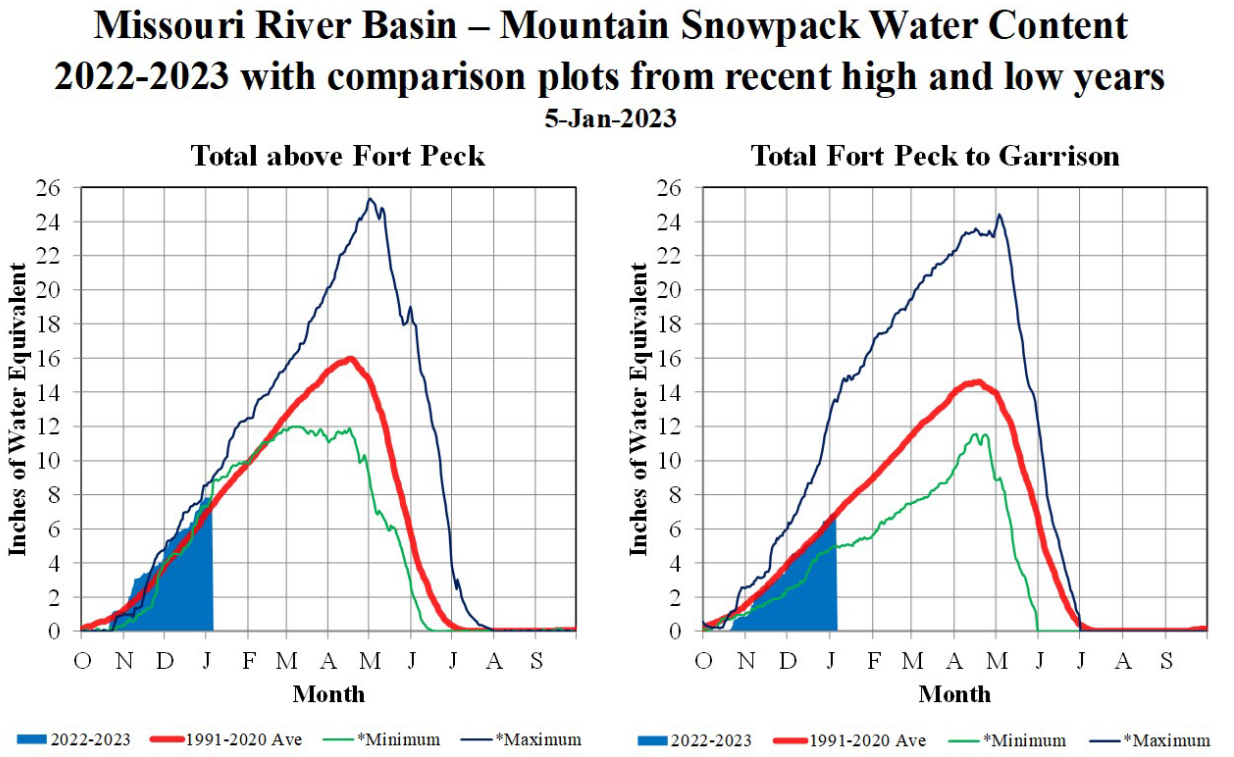


Figure 9. Mountain Snowpack Water Content

As of January 5, the average mountain SWE in the Fort Peck reservoir reach was 8.0”, 109% of average. In the reservoir reach between Fort Peck and Garrison dams, the average mountain SWE was 7.0”, 102% of average. Typically, 44% of the total mountain SWE accumulation has occurred by January 1, and snowpack generally peaks near April 17.

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. 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.

El Niño Southern Oscillation (ENSO)

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

The latest ENSO Outlook indicates La Niña is currently present. There is a 71% chance conditions will transition to ENSO-neutral later in the winter.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for January (**Figure 10**) indicates increased chances for above-normal temperatures across northern Montana and into North Dakota and eastern South Dakota as well as in most of the lower Basin. Equal chances for below-normal, normal, or above-normal (equal chances) temperatures exist across the rest of the Basin. The precipitation outlook (**Figure 10**) indicates a small pocket of increased chances for below-normal precipitation in northeastern Montana and northwestern North Dakota. Increased chances for above-normal precipitation are likely in South Dakota, western Nebraska, and into Wyoming. Equal chances exist across the rest of the Basin.

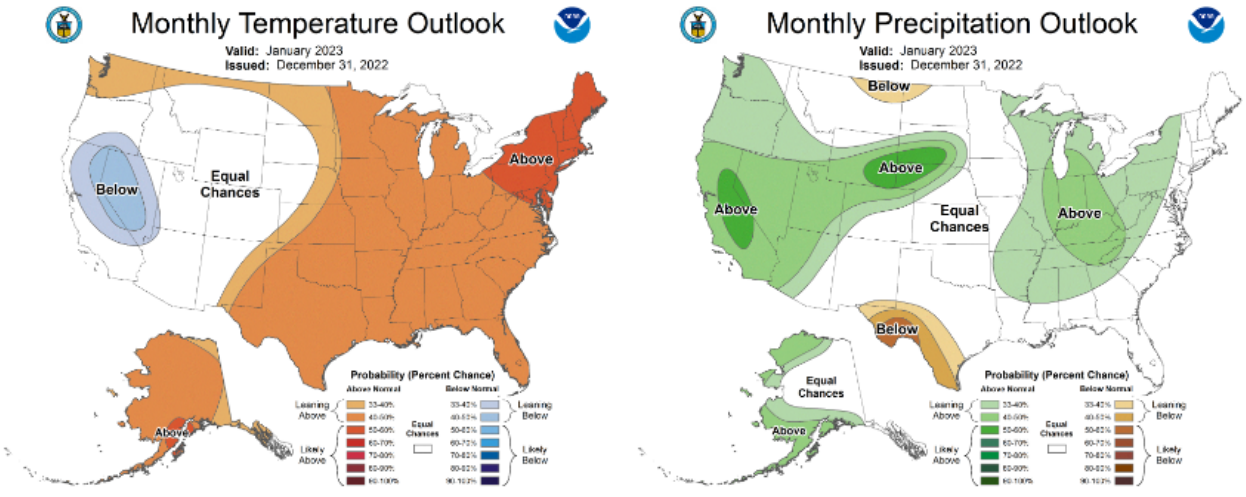


Figure 10. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the four 3-month periods in 2023 are shown in **Figure 11**. The January-February-March temperature outlook indicates below-normal temperatures for much of the upper Basin, and equal chances for the rest of the Basin. The precipitation outlook for the same period indicates above-normal precipitation across Montana, northern Wyoming, and into North Dakota, with equal chances for South Dakota, Iowa, and western Missouri. Increased chances for below-normal precipitation exist in Nebraska and Kansas.

The April-May-June temperature outlook indicates increased chances for above-normal temperatures in the lower Basin, and equal chances in the upper Basin. The precipitation outlook for the same period has no strong indicators either way, with equal chances for below-normal, normal, or above-normal precipitation across the Basin.

The July-August-September temperature outlook shows increased chances for above-normal temperatures across the entire Basin. The precipitation outlook shows increased chances for below-normal precipitation in Montana, increased chances for above-normal precipitation in Missouri, and equal chances for the rest of the Basin.

The October-November-December temperature outlook shows equal chances for Montana, North Dakota, and eastern South Dakota, with increased chances for above-normal temperatures across the rest of the Basin. No strong indicators exist for precipitation for the same period, with equal chances of below-normal, normal, or above-normal precipitation across the Basin.

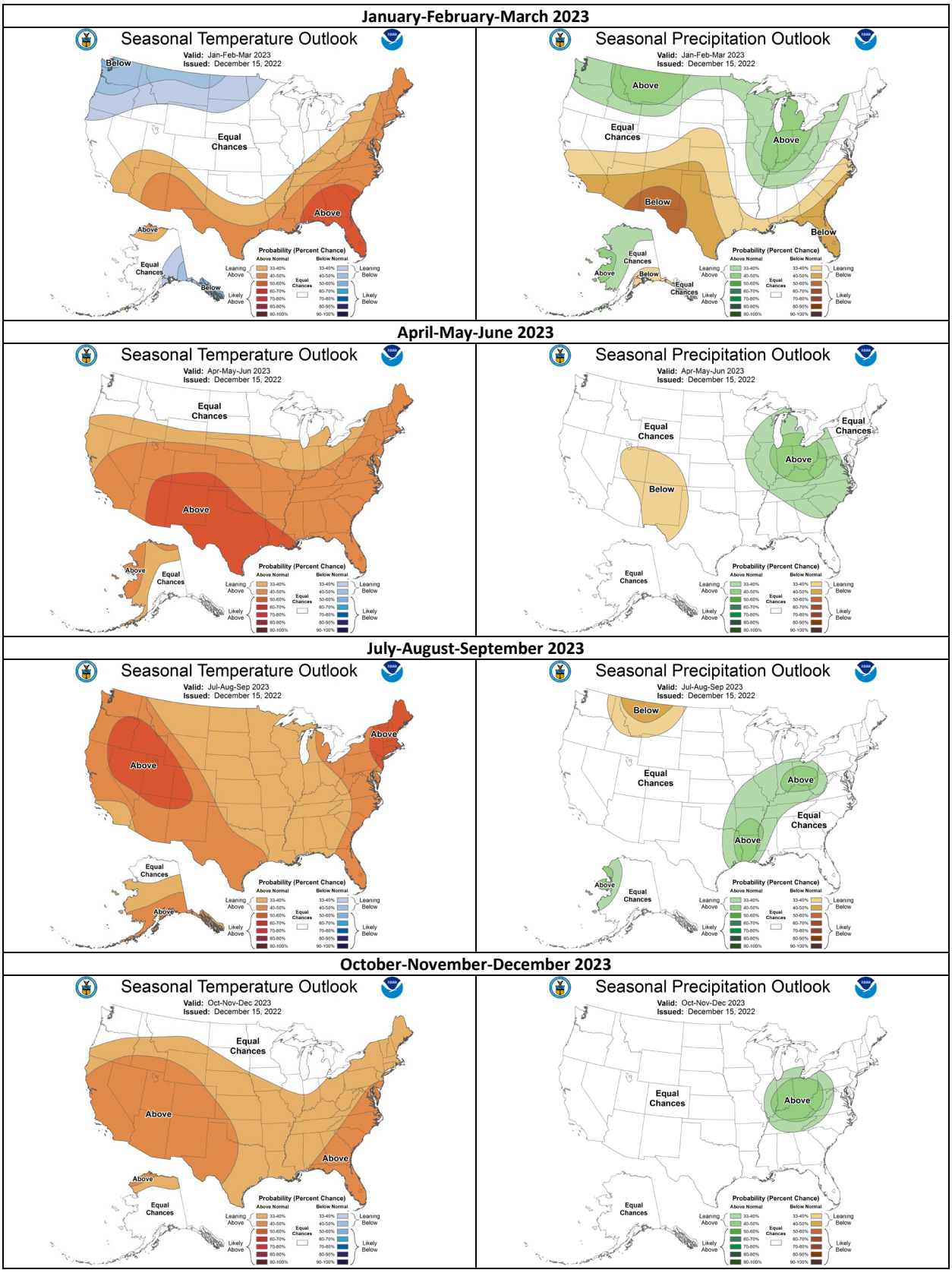


Figure 11. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given current streamflow and the potential for cooler weather in the upper Basin, we expect runoff in January and February to be normal to slightly below normal. March and April runoff potential is normal to slightly below normal due to the higher plains snowpack but drier soil moisture conditions; however, it will depend greatly on the accumulation of additional plains snowpack and temperatures over the next 2-3 months. During May, June, and July, Fort Peck and Garrison runoff is slightly below average due to the normal mountain snowpack and drier soil moisture conditions.

In summary, the 2023 calendar year runoff forecast is **20.8 MAF, 81% of average**.

NRCS Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: January 05, 2023 02:29:48 PM
   - Based on January 01, 2023 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Hebgen Lake Inflow (2)	APR-JUL	420	120	540	470	370	300	350
	APR-SEP	530	116	670	585	475	390	455

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	APR-JUL	64	110	76	69	59	52	58
	APR-SEP	81	108	96	87	75	66	75
Wind R Ab Bull Lake Ck (2)	APR-JUL	505	105	700	585	425	310	480
	APR-SEP	535	114	750	620	450	320	470
Bull Lake Ck nr Lenore (2)	APR-JUL	151	107	198	170	132	104	141
	APR-SEP	182	108	235	205	160	128	168
Boysen Reservoir Inflow (2)	APR-JUL	755	103	1180	930	580	325	730
	APR-SEP	800	102	1260	985	615	340	785
Greybull R at Meeteetse	APR-JUL	138	98	205	165	111	70	141
	APR-SEP	183	92	260	215	152	107	199
Shell Ck nr Shell	APR-JUL	53	90	71	60	46	35	59
	APR-SEP	64	90	83	72	56	45	71
Bighorn R at Kane (2)	APR-JUL	1010	101	1630	1260	760	390	1000
	APR-SEP	1060	102	1730	1330	790	385	1040
NF Shoshone R at Wapiti	APR-JUL	475	106	620	535	415	330	450
	APR-SEP	525	102	680	585	465	370	515
SF Shoshone R nr Valley	APR-JUL	220	98	285	245	194	156	225
	APR-SEP	250	96	325	280	220	176	260
Buffalo Bill Reservoir Inflow (2)	APR-JUL	685	102	925	780	590	445	670
	APR-SEP	745	102	1000	850	640	490	730
Bighorn R nr St. Xavier (2)	APR-JUL	1550	96	2300	1850	1250	795	1610
	APR-SEP	1620	94	2440	1950	1290	795	1720
Tongue R nr Dayton (2)	APR-JUL	82	93	112	94	70	52	88
	APR-SEP	94	92	126	107	81	62	102
Tongue River Reservoir Inflow (2)	APR-JUL	198	90	295	240	158	99	220
	APR-SEP	220	88	325	260	178	116	250
NF Powder R nr Hazelton	APR-JUL	10.5	102	13.5	11.7	9.3	7.5	10.3
	APR-SEP	11.2	101	14.3	12.5	9.9	8.1	11.1
Powder R at Moorhead	APR-JUL	200	105	320	250	152	81	191
	APR-SEP	220	107	345	270	170	96	205

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	MAR-JUL	6.7	103	10.7	8.3	5.1	2.7	6.5
	APR-JUL	5.5	104	9.1	7.0	4.0	1.86	5.3
Pactola Reservoir Inflow (2)	MAR-JUL	25	89	43	32	17.7	7.0	28
	APR-JUL	22	88	39	29	15.1	4.9	25

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	APR-JUL	270	135	405	325	215	133	200
	APR-SEP	295	134	440	355	235	150	220
Encampment R nr Encampment (2)	APR-JUL	166	123	240	195	137	94	135
	APR-SEP	176	125	250	205	146	101	141
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	51	104	71	59	43	31	49
	APR-SEP	53	104	74	61	45	32	51
Seminoe Reservoir Inflow (2)	APR-JUL	760	115	1200	940	580	320	660
	APR-SEP	815	114	1270	1000	630	355	715
Sweetwater R nr Alcova	APR-JUL	63	140	104	80	46	22	45
	APR-SEP	68	139	112	86	50	24	49
La Prele Ck nr Douglas	APR-JUL	16.8	80	32	23	10.5	1.32	21
	APR-SEP	16.2	83	32	23	9.7	0.180	19.5
North Platte R bl Glendo Reservoir (2)	APR-JUL	805	108	1400	1050	565	210	745
	APR-SEP	835	110	1450	1080	585	220	760
North Platte R bl Guernsey Reservoir (2)	APR-JUL	810	109	1420	1060	560	197	745
	APR-SEP	835	108	1460	1090	580	205	775
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	133	114	195	158	108	71	117
	APR-SEP	144	114	210	171	117	78	126
Little Laramie R nr Filmore	APR-JUL	57	108	83	68	46	31	53
	APR-SEP	61	109	89	72	50	33	56

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
February 2023 Calendar Year Runoff Forecast
February 6, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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

January runoff was 1.06 MAF, 134% of average. Runoff was above average due to the warmer temperatures in the upper Basin resulting in some snowmelt runoff.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **21.1 MAF, 82% of average**. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **19.0 MAF, 82% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 11 months, expected inflow could range from the 29.0 MAF upper basic forecast to the 14.2 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.

Current Conditions

Drought Analysis

The National Drought Mitigation Center’s drought monitor for January 31, 2023 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at

least Abnormally Dry conditions are present over 88% of the Basin, with about 13% of that being Extreme or Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of April, indicates drought persisting in the Missouri Basin below Sioux City, IA (lower Basin) but improving over most of the upper Basin.

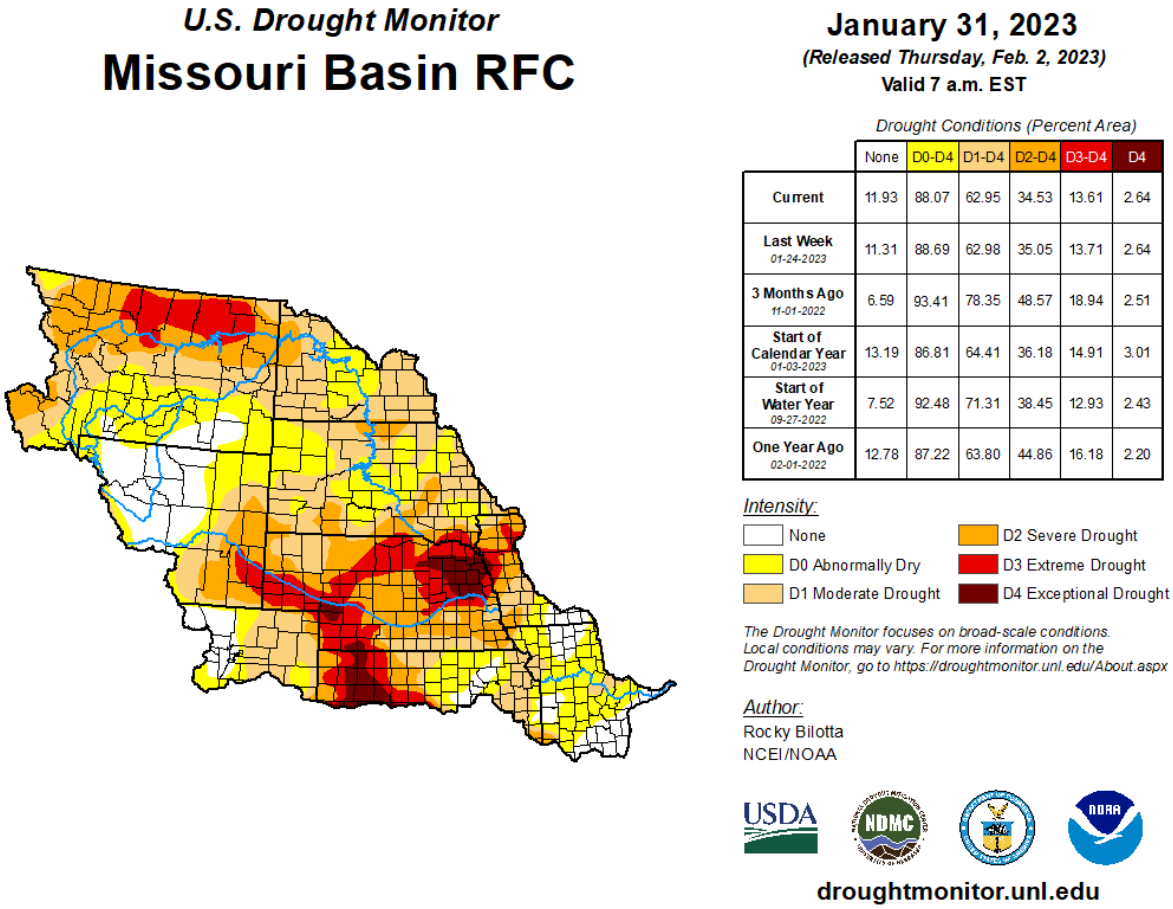


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

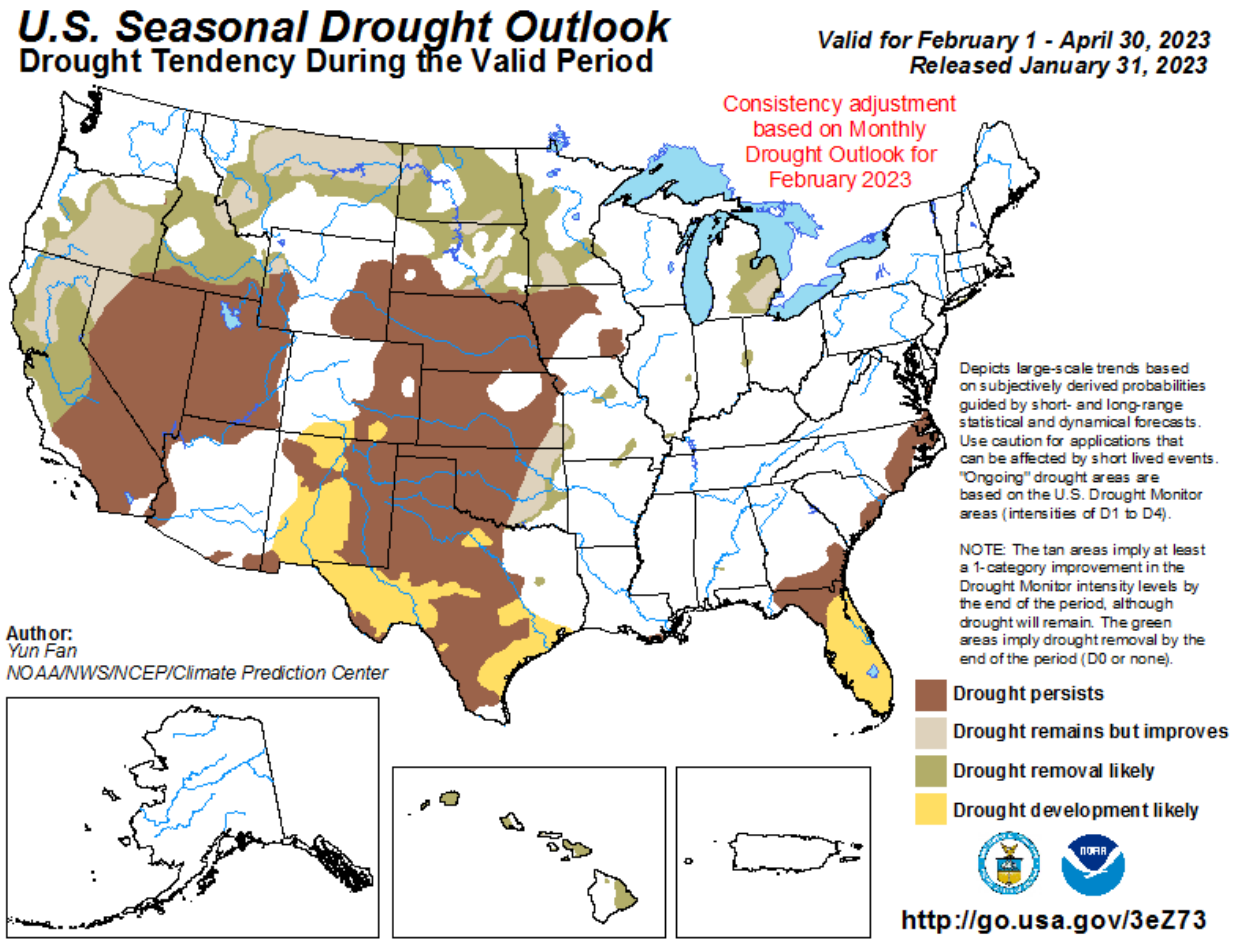


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The January precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was below normal for much of the upper Basin in January. Above-normal precipitation occurred over southern South Dakota and into the lower Basin, with widespread areas receiving over 200% of normal precipitation.

Precipitation as a percent of normal for the November-December-January period (**Figure 4**) was mixed throughout the Basin. Overall, above-normal precipitation occurred across much of the Basin, with pockets of below-normal precipitation mostly in Montana, eastern Nebraska, and western Kansas.

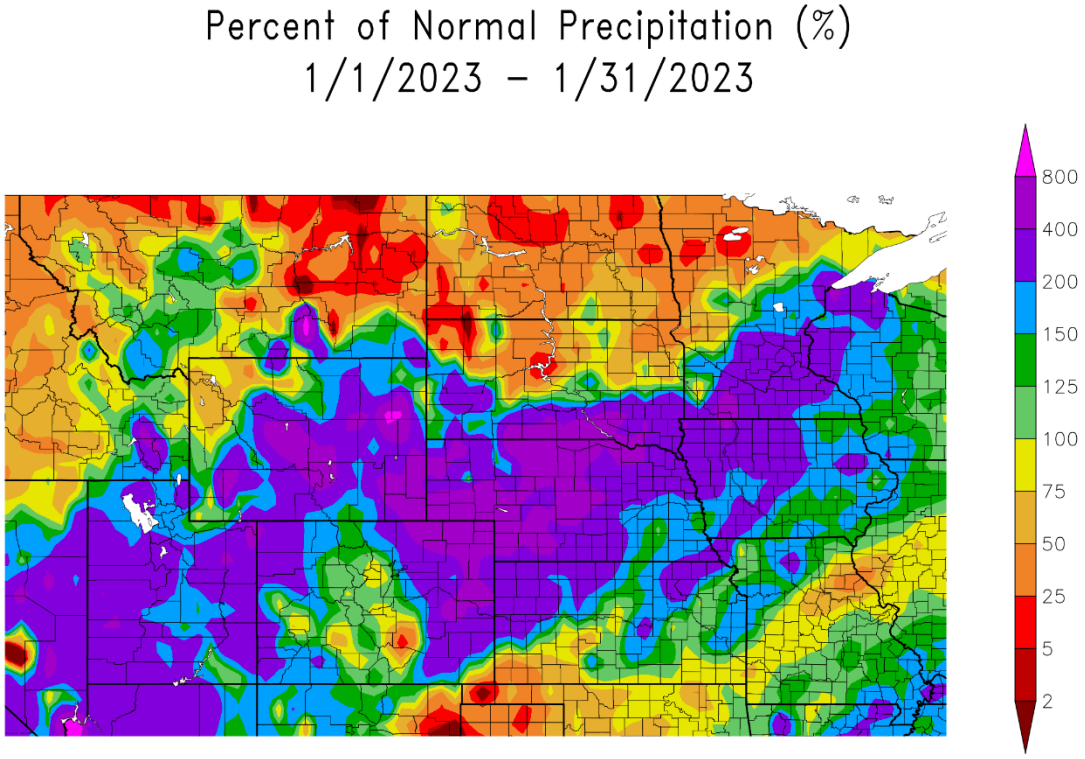


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

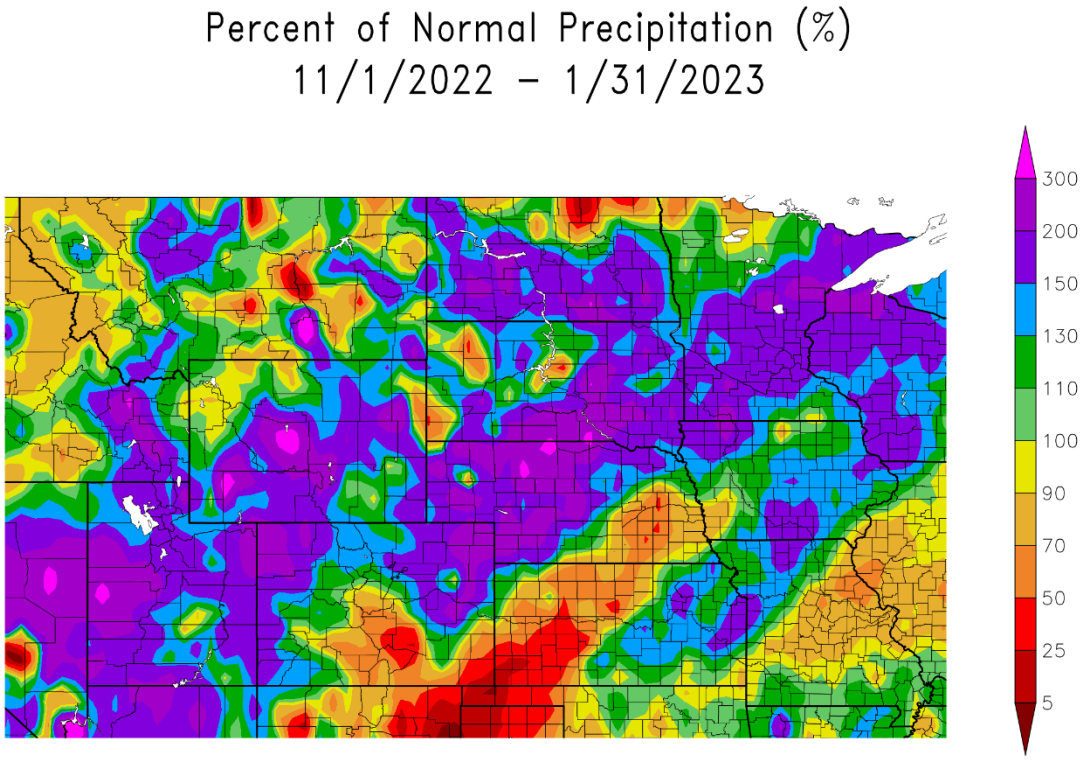


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

January temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate warmer temperatures across much of the Basin, except Wyoming and western Montana. Average temperatures 3-6 degrees above normal occurred in Montana and the western Dakotas, contributing to early-season plains snowmelt. November-December-January temperature departures are shown in **Figure 6**. The three-month average departures were slightly below normal except for Montana, which was 4-8 degrees below normal.

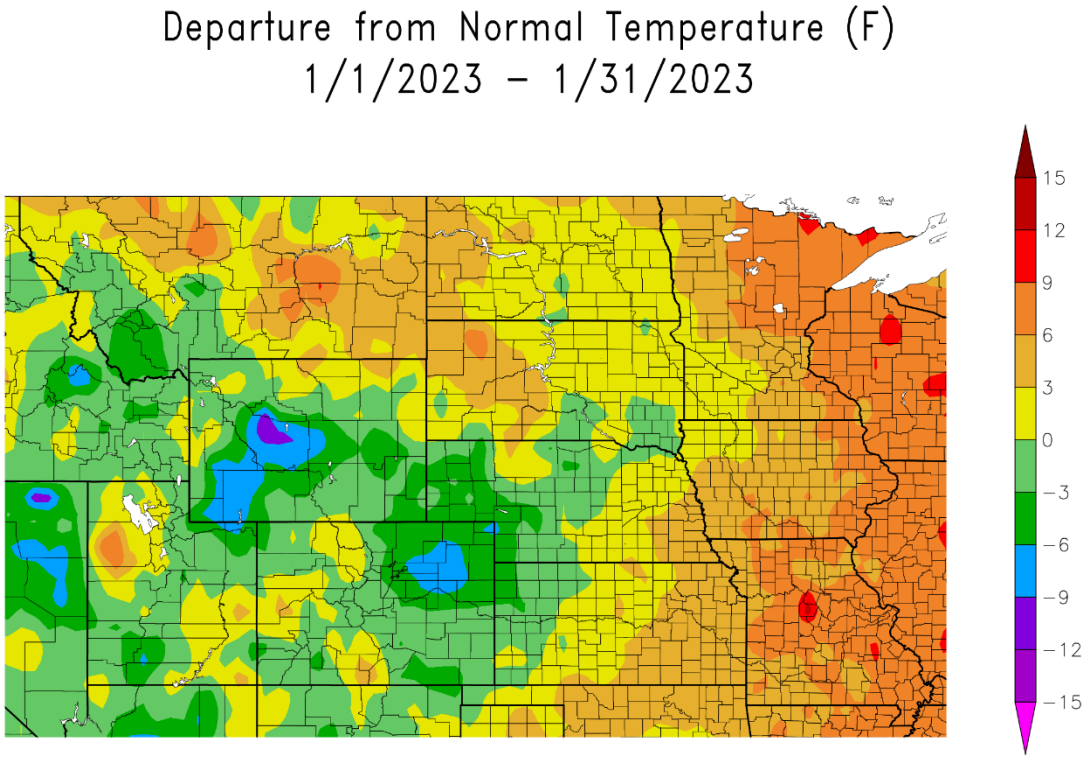


Figure 5. HPRCC Previous Month Departure from Normal Temperature

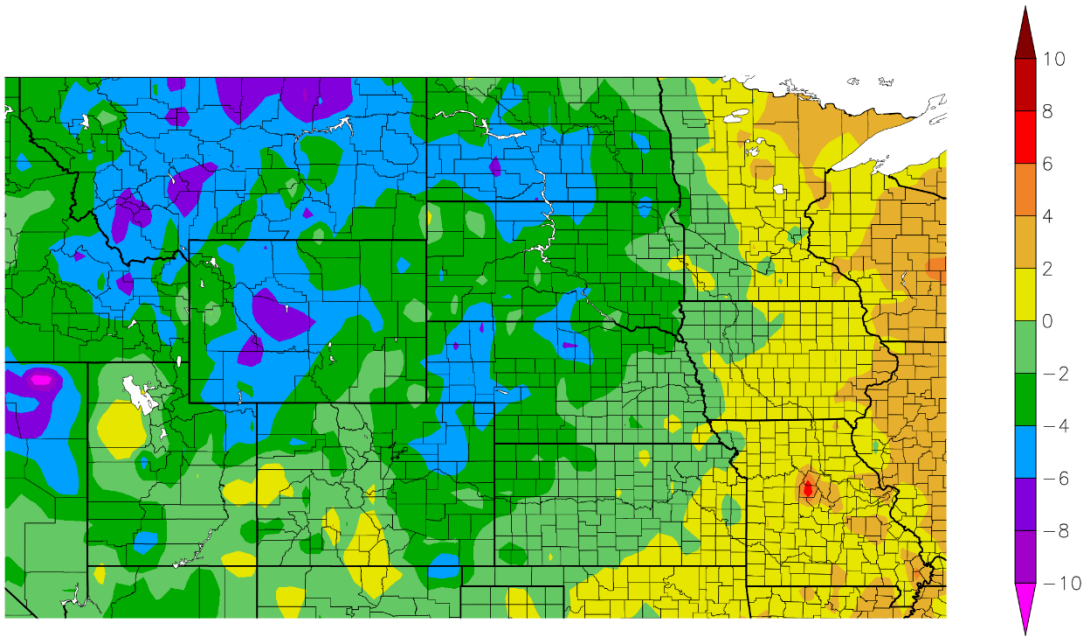


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of January is shown in **Figure 7**. Soil moisture is drier than normal across parts of Montana, the Dakotas, and into the lower Basin. Generally, when soil moisture is low during the winter, the potential for above-normal March-April runoff is lower.

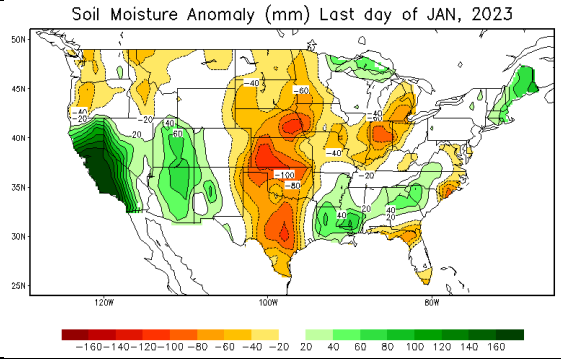
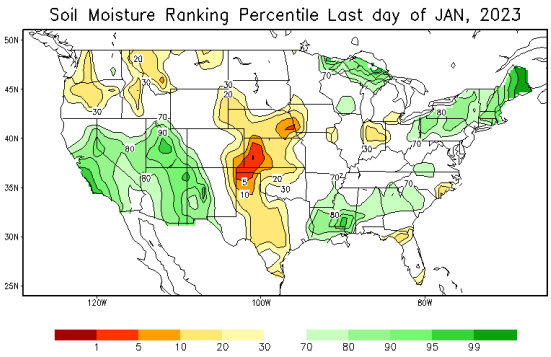
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
January 31, 2023	
	

Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. 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 (available here) from February 6, shown in **Figure 8**, indicates plains snow coverage across much of the Dakotas and into parts of eastern Montana and Nebraska. The Dakotas have widespread amounts of 2-4" of snow water equivalent (SWE), with some localized areas modeling up to 6" SWE. Nebraska shows swaths of trace to 2" of SWE. The amount of runoff received in March and April will depend greatly on precipitation and temperatures over the next few months.

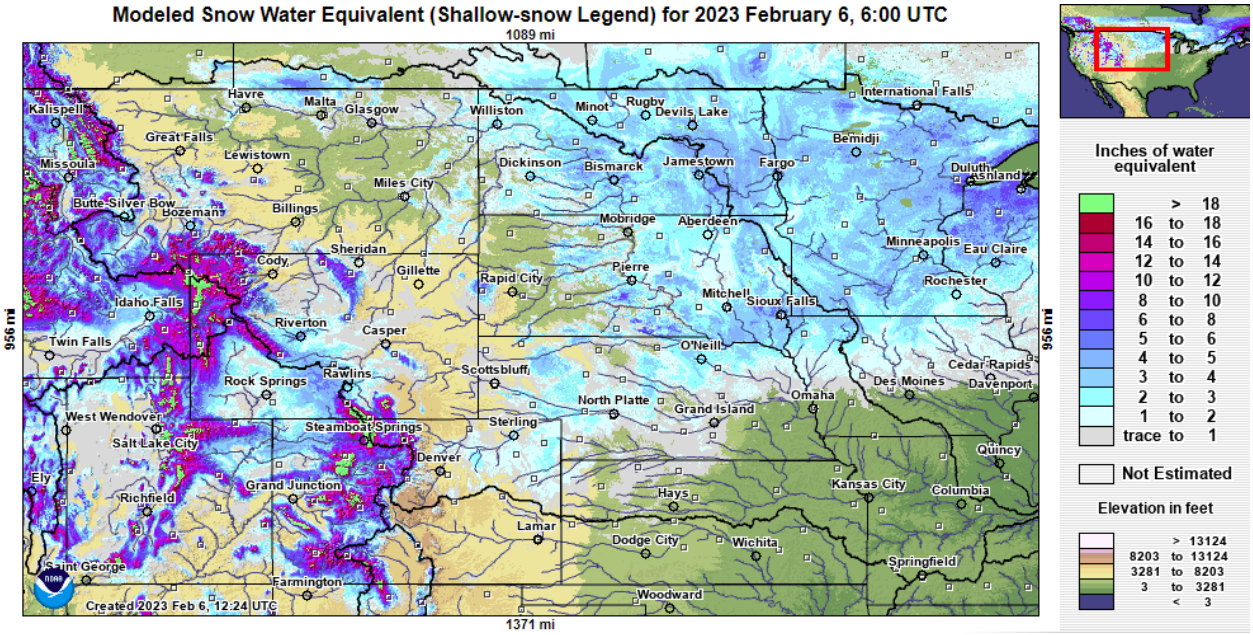


Figure 8. NOHRSC Modeled Snow Water Equivalent

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. May, June, and July runoff in the Fort Peck and Garrison reaches has very little correlation to the February 1 snowpack, because 60 percent of the mountain snowpack has accumulated by February 1. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 9** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry 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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line).

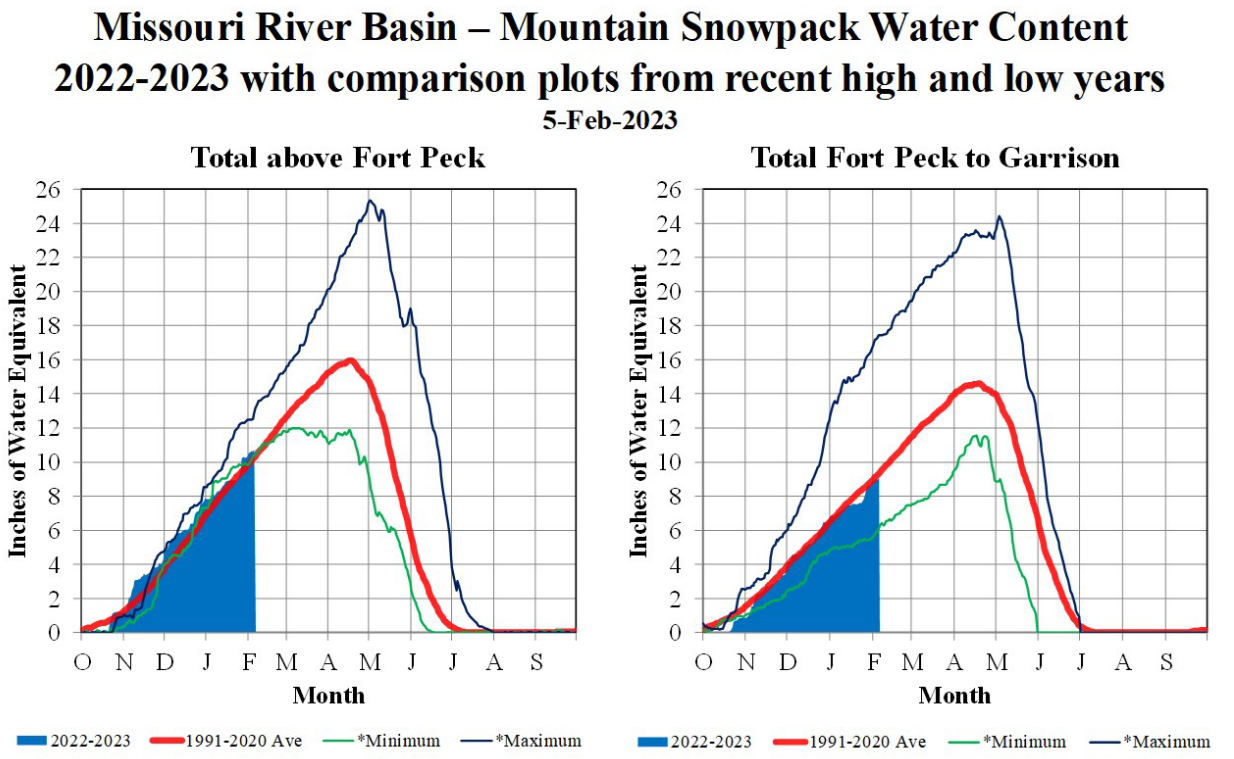


Figure 9. Mountain Snowpack Water Content

As of February 5, the average mountain SWE in the Fort Peck reservoir reach was 10.7”, 105% of average. In the reservoir reach between Fort Peck and Garrison dams, the average mountain SWE was 9.0”, 97% of average.

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

The latest ENSO Outlook indicates La Niña is currently present. By March-May 2023, there is an 82% chance of transitioning to ENSO-neutral conditions.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for February (**Figure 10**) indicates equal chances for above-normal, normal, or below-normal temperatures. The precipitation outlook (**Figure 10**) indicates increased chances for above-normal precipitation across Montana and North Dakota as well as in eastern Kansas and into Missouri. Equal chances for above-normal, normal or below-normal precipitation exists across the rest of the Basin.

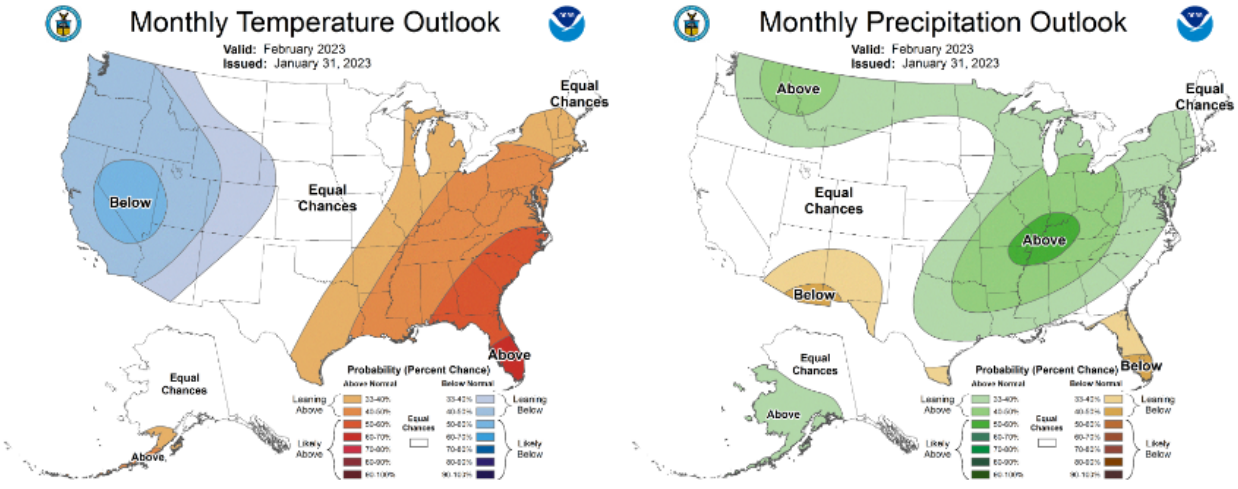


Figure 10. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 11**. The February-March-April temperature outlook indicates below-normal temperatures for much of the upper Basin, and equal chances for the rest of the Basin. The precipitation outlook for the same

period indicates above-normal precipitation across Montana, northern Wyoming, and into North Dakota, with equal chances for South Dakota, Iowa, and northwestern Missouri.

The May-June-July temperature outlook indicates equal chances for above-normal, normal, or below-normal temperatures in Montana and North Dakota, with increased chances for above-normal temperatures in the rest of the Basin. The precipitation outlook for the same period has increased chances for below-normal precipitation in Montana and equal chances for the rest of the Basin.

The August-September-October temperature outlook shows increased chances for above-normal temperatures across the entire Basin. The precipitation outlook shows increased chances for above-normal precipitation in Missouri and equal chances in the rest of the Basin.

The November-December-January temperature outlook shows increased chances for above-normal temperatures in southern Montana and into Wyoming, western Nebraska, and western Kansas. Equal chances for above-normal, normal, or below-normal temperatures exist across the rest of the Basin. No strong indicators exist for precipitation for the same period, with equal chances of below-normal, normal, or above-normal precipitation across the Basin.

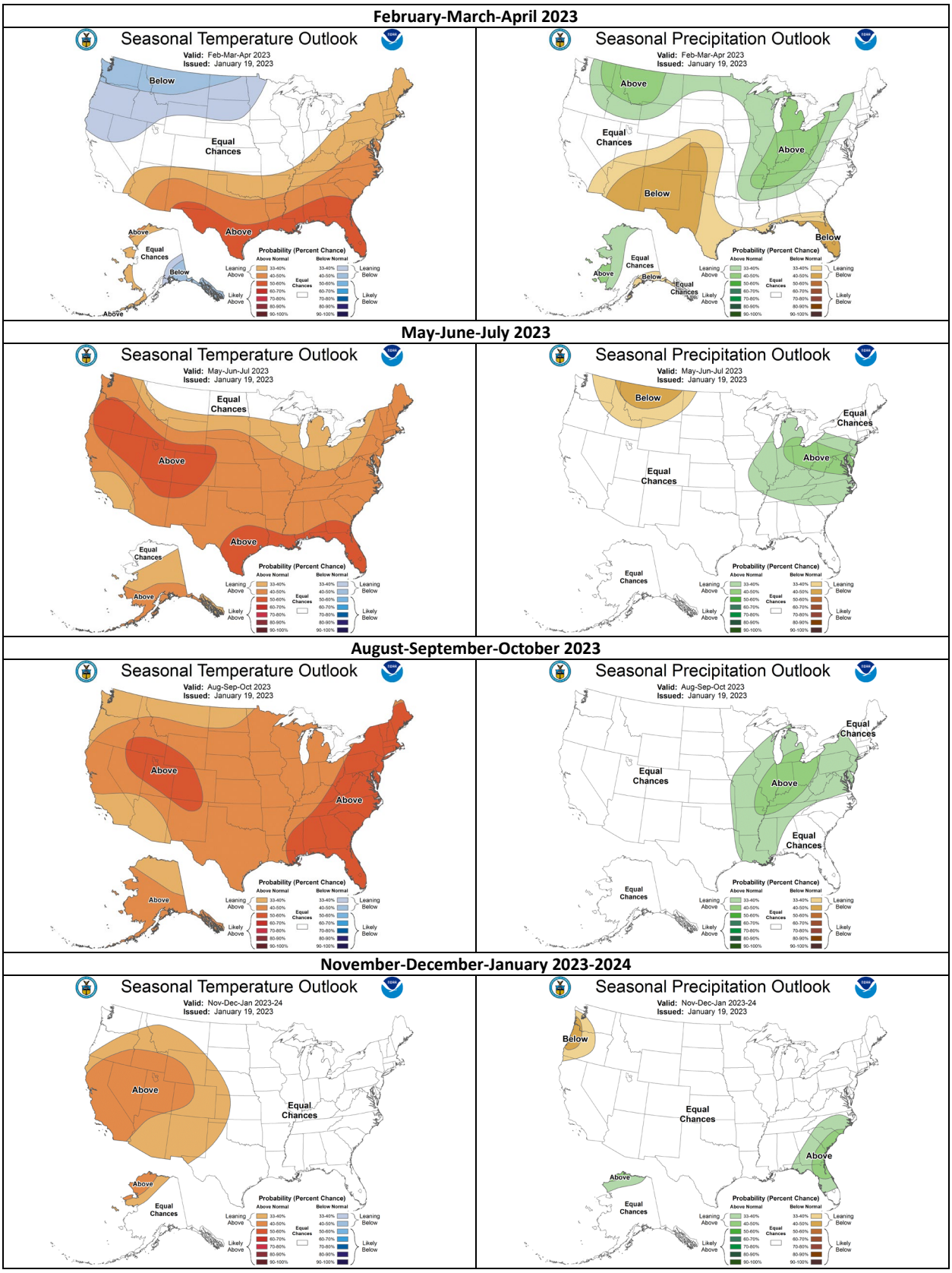


Figure 11. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given these conditions, we expect runoff in February to be slightly below normal. March and April runoff potential is slightly below normal due to the higher plains snowpack but drier soil moisture conditions; however, it will depend greatly on the accumulation of additional plains snowpack and temperatures over the next 2-3 months. During May, June, and July, Fort Peck and Garrison runoff is slightly below average due to the normal mountain snowpack and drier soil moisture conditions.

In summary, the 2023 calendar year runoff forecast is **21.1 MAF, 82% of average**.

NRCS Water Supply Forecasts

USDA NRCS National Water & Climate Center
* - DATA CURRENT AS OF: February 03, 2023 02:06:52 PM
- Based on February 01, 2023 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Hebgen Lake Inflow (2)	APR-JUL	390	111	480	425	355	300	350
	APR-SEP	495	109	600	540	450	390	455

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	APR-JUL	60	103	72	65	56	49	58
	APR-SEP	76	101	91	82	70	62	75
Wind R Ab Bull Lake Ck (2)	APR-JUL	515	107	700	590	445	335	480
	APR-SEP	550	117	750	630	470	350	470
Bull Lake Ck nr Lenore (2)	APR-JUL	156	111	200	174	138	111	141
	APR-SEP	188	112	240	210	168	138	168
Boysen Reservoir Inflow (2)	APR-JUL	820	112	1250	995	650	400	730
	APR-SEP	885	113	1330	1070	705	435	785
Greybull R at Meeteetse	APR-JUL	181	128	245	210	155	115	141
	APR-SEP	240	121	310	270	210	165	199
Shell Ck nr Shell	APR-JUL	56	95	73	63	49	39	59
	APR-SEP	67	94	85	74	60	49	71
Bighorn R at Kane (2)	APR-JUL	1150	115	1760	1400	905	540	1000
	APR-SEP	1240	119	1900	1510	975	585	1040
NF Shoshone R at Wapiti	APR-JUL	465	103	600	520	410	330	450
	APR-SEP	515	100	660	575	455	370	515
SF Shoshone R nr Valley	APR-JUL	215	96	275	240	191	155	225
	APR-SEP	245	94	315	275	215	176	260
Buffalo Bill Reservoir Inflow (2)	APR-JUL	670	100	900	765	575	440	670
	APR-SEP	730	100	975	830	630	485	730
Bighorn R nr St. Xavier (2)	APR-JUL	1680	104	2430	1980	1380	930	1610
	APR-SEP	1790	104	2610	2120	1460	975	1720
Little Bighorn R nr Hardin	APR-JUL	110	108	161	130	90	59	102
	APR-SEP	124	102	180	146	102	68	121
Tongue R nr Dayton (2)	APR-JUL	84	95	113	96	72	55	88
	APR-SEP	97	95	128	109	85	66	102
Tongue River Reservoir Inflow (2)	APR-JUL	198	90	295	240	158	99	220
	APR-SEP	220	88	325	260	178	116	250
NF Powder R nr Hazelton	APR-JUL	11.0	107	13.7	12.1	9.9	8.3	10.3
	APR-SEP	11.7	105	14.5	12.9	10.6	9.0	11.1
Powder R at Moorhead	APR-JUL	235	123	355	285	187	117	191
	APR-SEP	255	124	375	305	205	133	205

Powder R nr Locate	APR-JUL	265	118	395	320	210	134	225
	APR-SEP	285	119	425	340	230	147	240

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	MAR-JUL	7.2	111	10.9	8.7	5.7	3.5	6.5
	APR-JUL	6.0	113	9.4	7.4	4.6	2.6	5.3
Pactola Reservoir Inflow (2)	MAR-JUL	29	104	45	36	22	12.7	28
	APR-JUL	25	100	41	31	18.7	9.4	25

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	APR-JUL	310	155	430	360	260	189	200
	APR-SEP	335	152	465	385	285	205	220
Encampment R nr Encampment (2)	APR-JUL	210	156	270	235	184	148	135
	APR-SEP	220	156	285	245	195	158	141
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	57	116	75	64	50	39	49
	APR-SEP	60	118	79	68	52	41	51
Seminoe Reservoir Inflow (2)	APR-JUL	880	133	1280	1040	720	485	660
	APR-SEP	930	130	1350	1100	760	515	715
Sweetwater R nr Alcova	APR-JUL	70	156	109	86	54	31	45
	APR-SEP	74	151	115	91	57	33	49
La Prele Ck nr Douglas	APR-JUL	23	110	39	29	16.7	7.4	21
	APR-SEP	22	113	38	29	15.4	5.8	19.5
North Platte R bl Glendo Reservoir (2)	APR-JUL	1030	138	1580	1250	805	480	745
	APR-SEP	1050	138	1620	1280	820	485	760
North Platte R bl Guernsey Reservoir (2)	APR-JUL	1040	140	1610	1270	810	470	745
	APR-SEP	1060	137	1640	1300	825	475	775
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	146	125	205	170	122	86	117
	APR-SEP	158	125	220	184	133	95	126
Little Laramie R nr Filmore	APR-JUL	65	123	89	75	55	41	53
	APR-SEP	70	125	95	80	60	44	56

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
March 2023 Calendar Year Runoff Forecast
March 2, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 upper Basin. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

Observed Runoff

February runoff was 0.98 MAF (86% of average) for the basin above Sioux City and 0.86 MAF (84% of average) above Gavins Point. Runoff was below-average in the upper 3 reaches, and above-average in the lower 3 reaches.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **21.5 MAF, 84% of average**. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **19.2 MAF, 83% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 10 months, expected inflow could range from the 29.3 MAF upper basic forecast to the 14.7 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for February 28, 2023 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 78% of the Basin, with about 10% of that being Extreme or Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of May, indicates drought removal or improvement likely over most of the Basin.

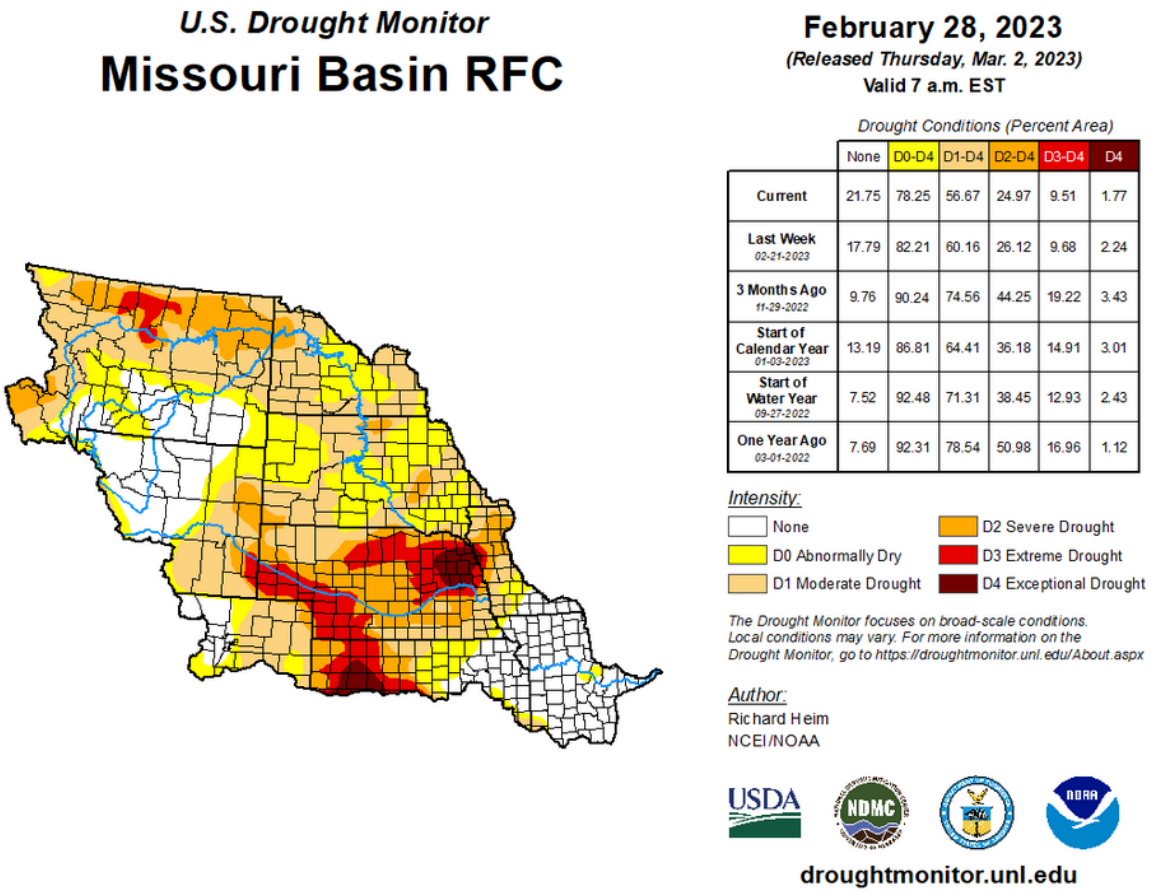


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

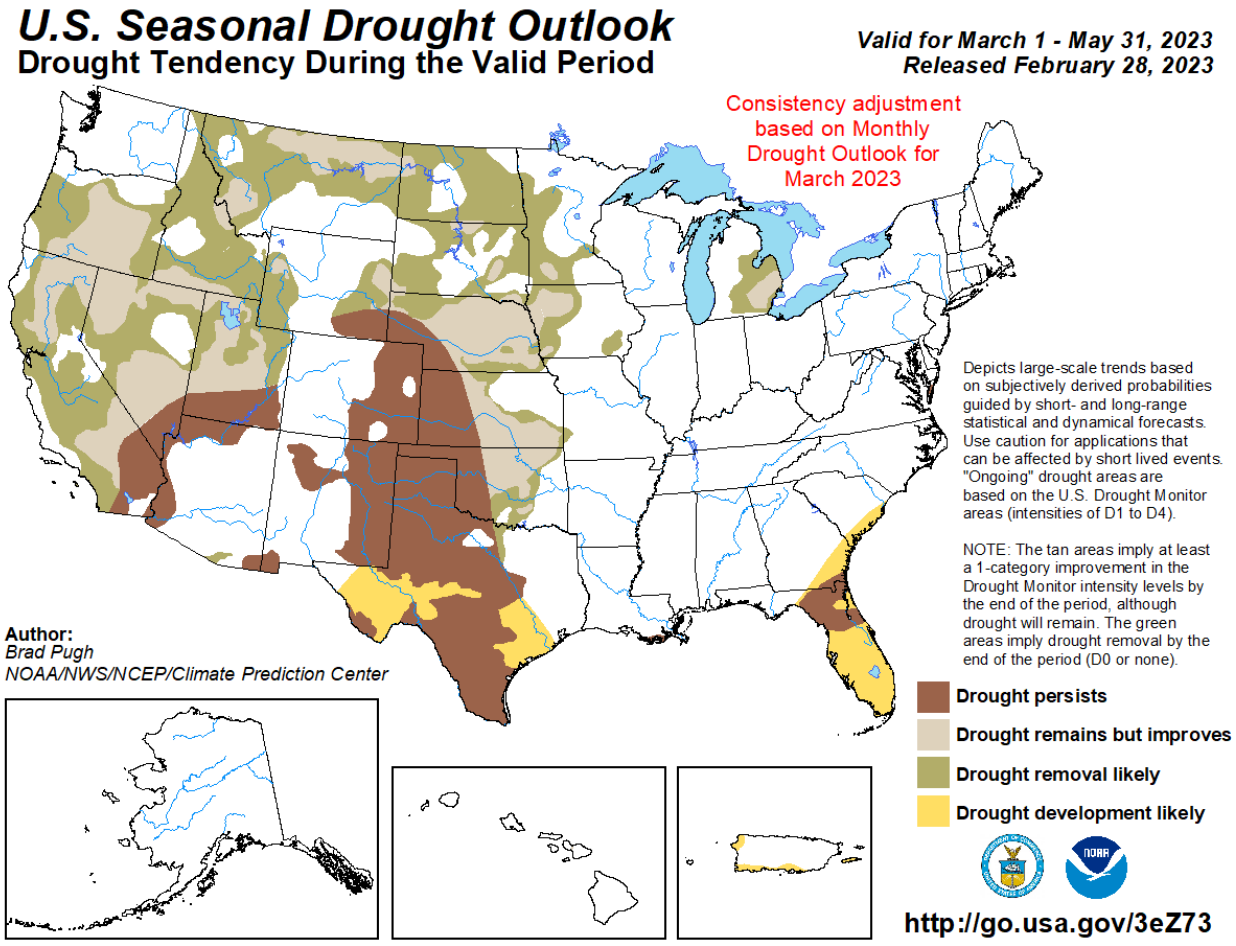


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The February precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Total precipitation across the upper Basin was less than 2 inches over the past 30 days, with pockets of both above- and below-normal precipitation in every state.

Precipitation as a percent of normal for the December-January-February period (**Figure 4**) was mixed throughout the Basin. Overall, above-normal precipitation occurred across much of the Basin, with pockets of below-normal precipitation mostly in Montana, eastern Nebraska, and western Kansas.

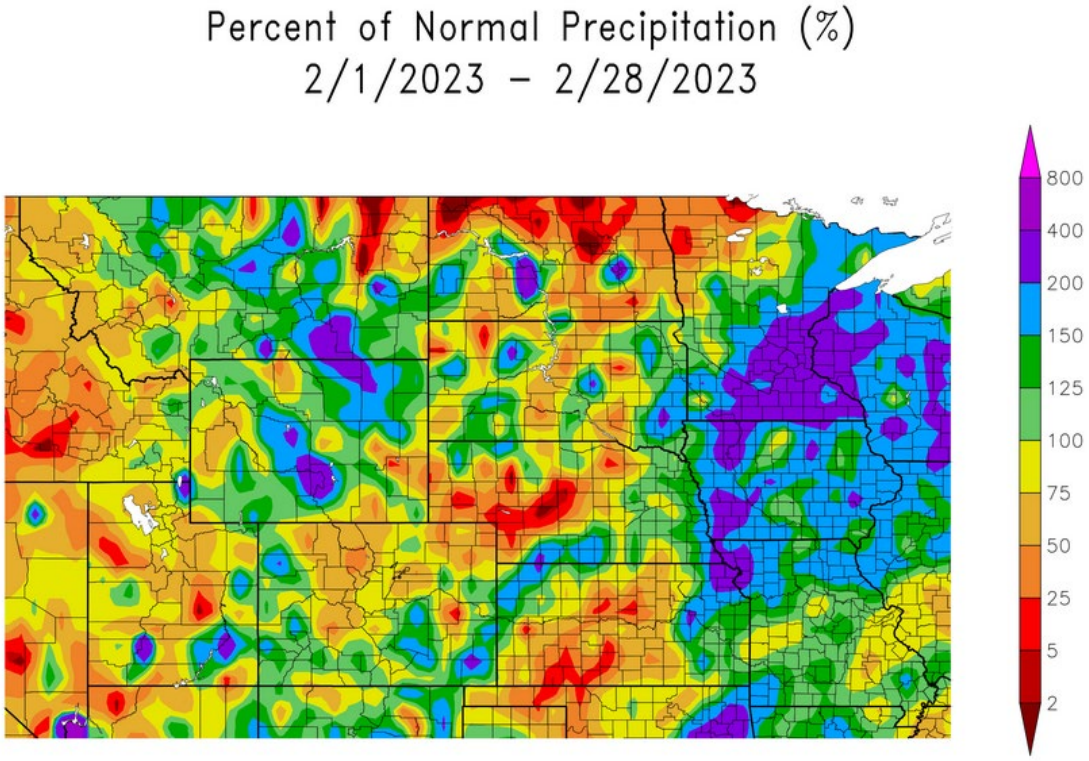


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

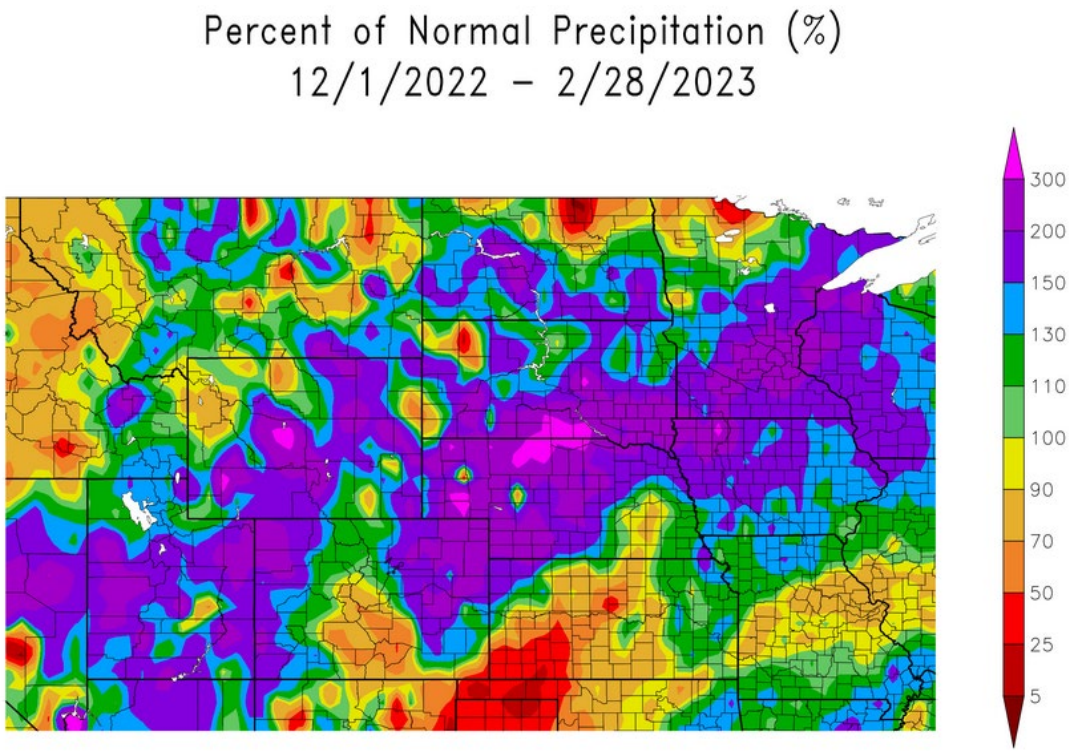


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

February temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate near normal temperatures across the Basin, with colder temperatures around the Rockies and western Nebraska. Average temperatures 0-6 degrees above normal occurred in Montana and the western Dakotas, resulting in most of the plains snowpack melting in those areas. December-January-February temperature departures are shown in **Figure 6**. The three-month average departures were slightly below normal except for central Montana and western South Dakota, which had areas of slightly above-normal temperatures.

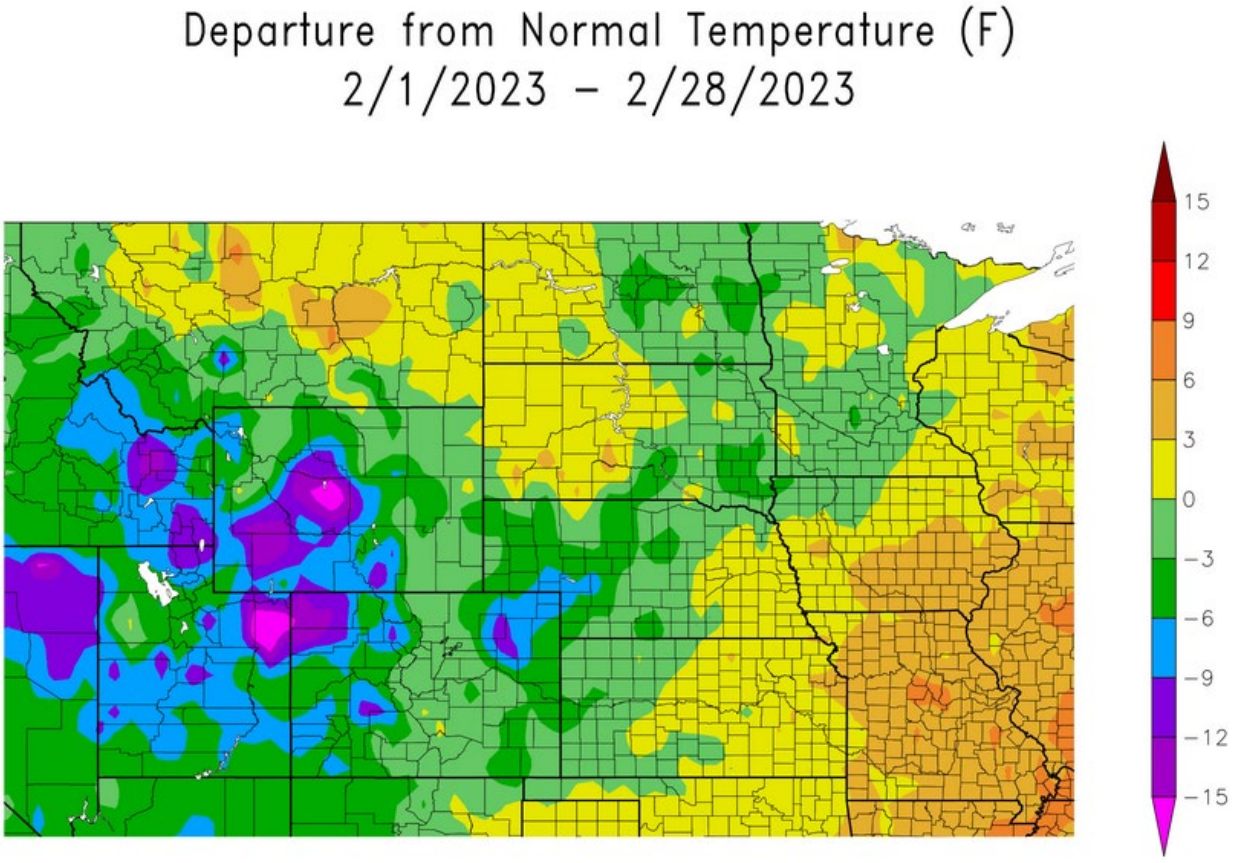


Figure 5. HPRCC Previous Month Departure from Normal Temperature

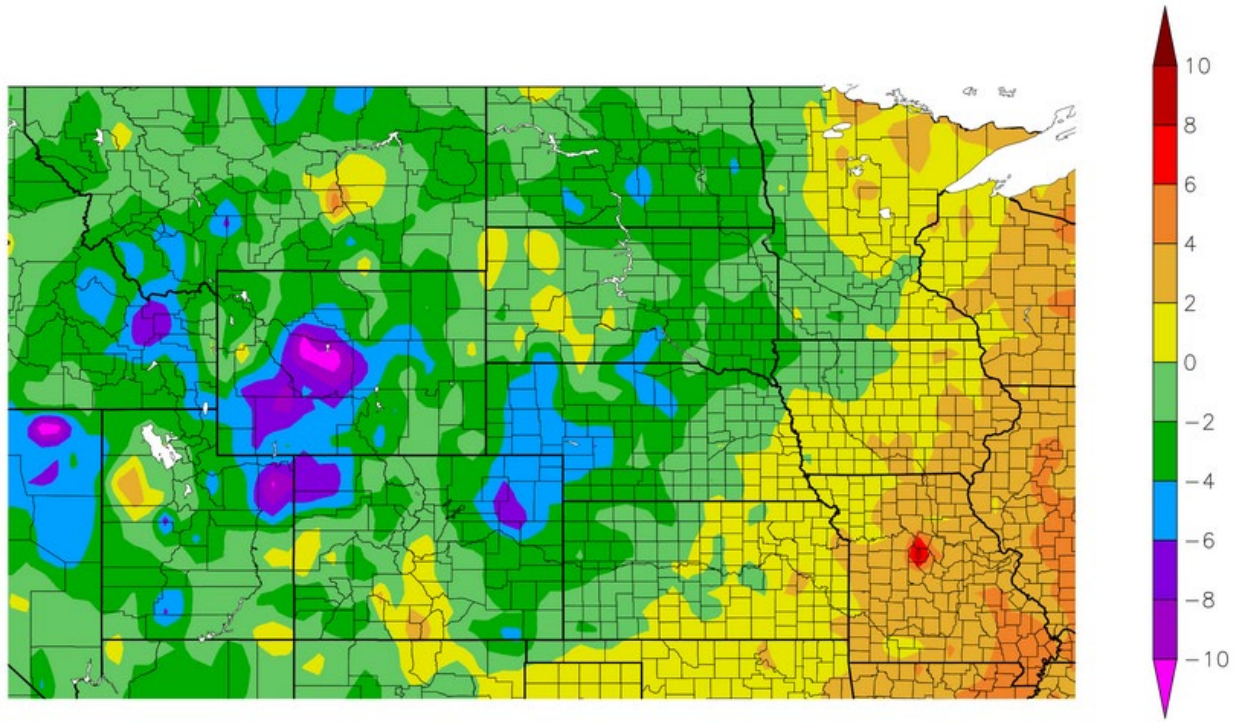


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

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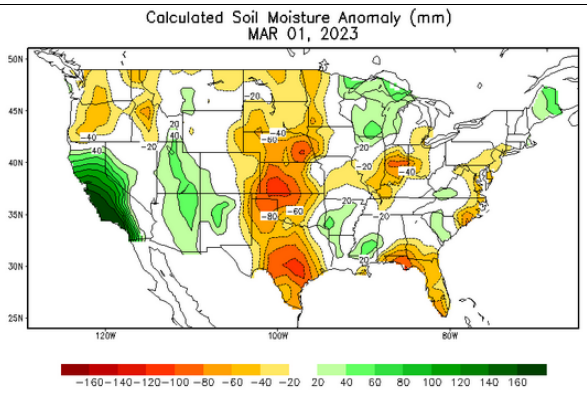
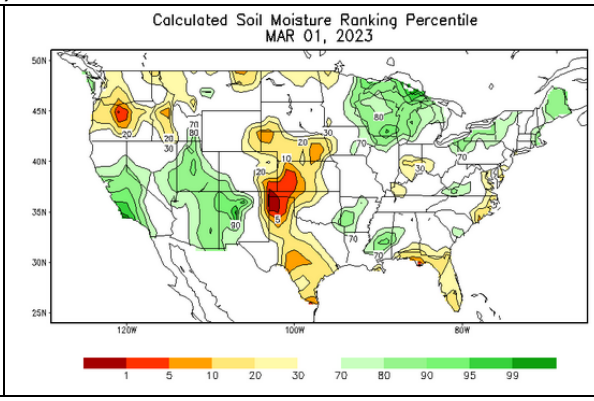
Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the beginning of March is shown in **Figure 7**. Soil moisture is drier than normal across parts of Montana, the Dakotas, and into the lower Basin. Generally, when soil moisture is low during the winter, the potential for above-normal March-April runoff is lower.

Soil Moisture Anomaly (mm)	Soil Moisture Percentile
March 1, 2023	





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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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. 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 (available here) from March 2, shown in **Figure 8**, indicates plains snow coverage is mostly concentrated in North and South Dakota. They have widespread amounts of 1-6" of snow water equivalent (SWE), with some localized areas modeling up to 8" SWE. Only trace amounts of plains SWE remain in the rest of the Basin. The amount of runoff received in March and April will depend greatly on precipitation and temperatures over the next two months.

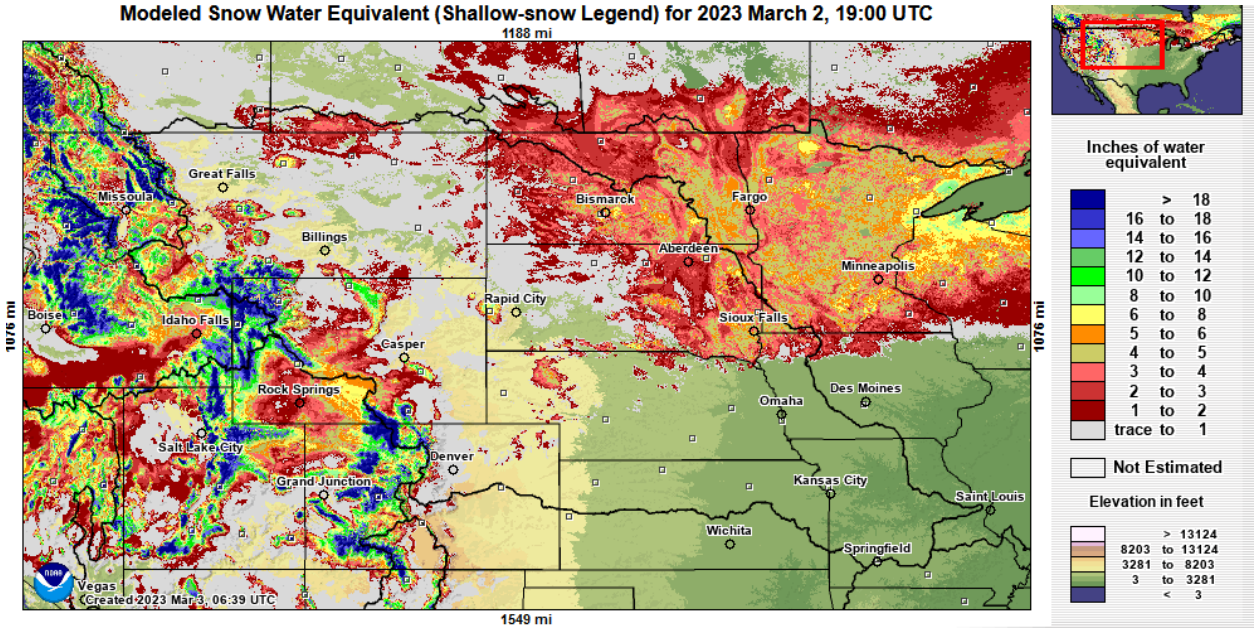

Figure 8. NOHRSC Modeled Snow Water Equivalent

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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. May, June, and July runoff in the Fort Peck and Garrison reaches has a small correlation to the March 1 snowpack, because approximately 80 percent of the mountain snowpack has accumulated by March 1. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 9** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line).

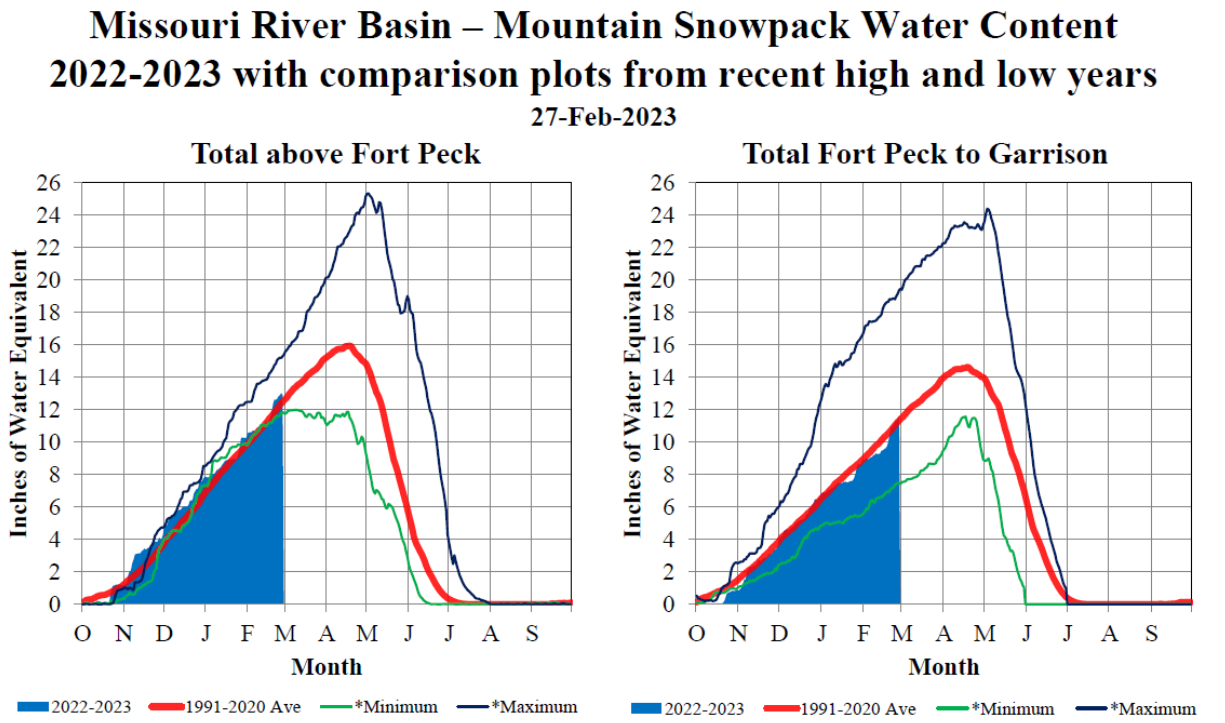

Figure 9. Mountain Snowpack Water Content

As of February 27, the average mountain SWE in the Fort Peck reservoir reach was 12.9”, 104% of average. In the reservoir reach between Fort Peck and Garrison dams, the average mountain SWE was 11.6”, 102% of average.

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

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

The latest ENSO Outlook indicates La Niña is currently present. A transition to ENSO-neutral conditions is expected in the next couple of months, and is expected to remain through the spring and early summer.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for March (**Figure 10**) indicates increased chances for below-normal temperatures over the Basin. The precipitation outlook (**Figure 10**) indicates increased chances for above-normal precipitation across most of the Basin except for most of Nebraska and Kansas where there is equal chances for above-normal, normal or below-normal precipitation.

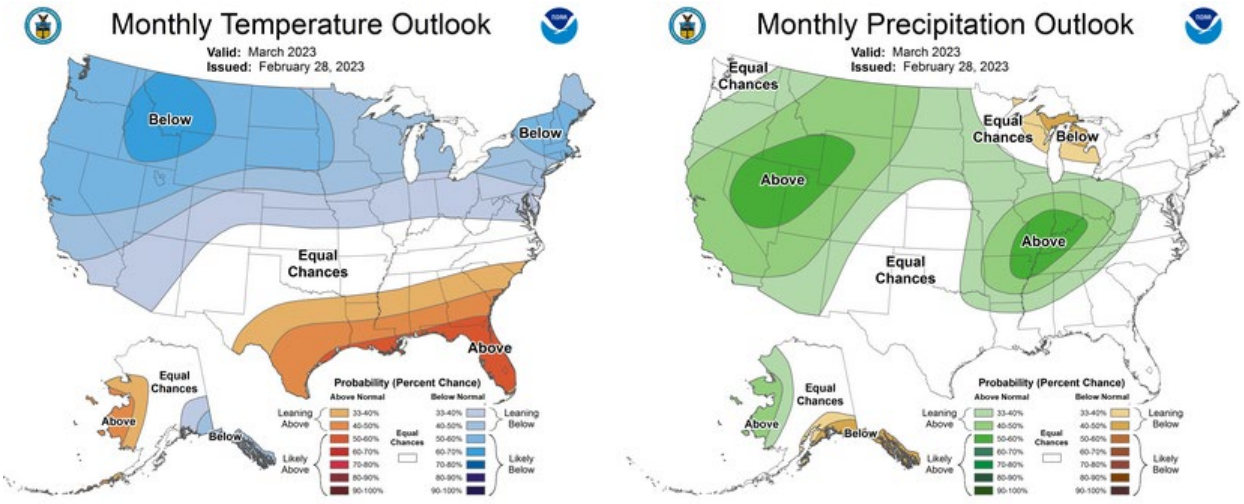


Figure 10. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 11**. The April-May-June temperature outlook indicates increased chances below-normal temperatures

for Montana, and equal chances for the rest of the upper Basin. The precipitation outlook for the same period indicates increased chances for below-normal precipitation in western Montana, with equal chances across the rest of the Basin.

The July-August-September temperature outlook indicates equal chances for above-normal, normal, or below-normal temperatures across most of the Basin, with increased chances for above-normal temperatures in Wyoming, Colorado, and Kansas. The precipitation outlook for the same period has increased chances for below-normal precipitation in Montana and equal chances for the rest of the Basin.

The October-November-December temperature outlook shows increased chances for above-normal temperatures across most of the Basin except for Montana and North Dakota, which have equal chances. The precipitation outlook shows equal chances for above-normal, normal or below-normal precipitation across the entire Basin.

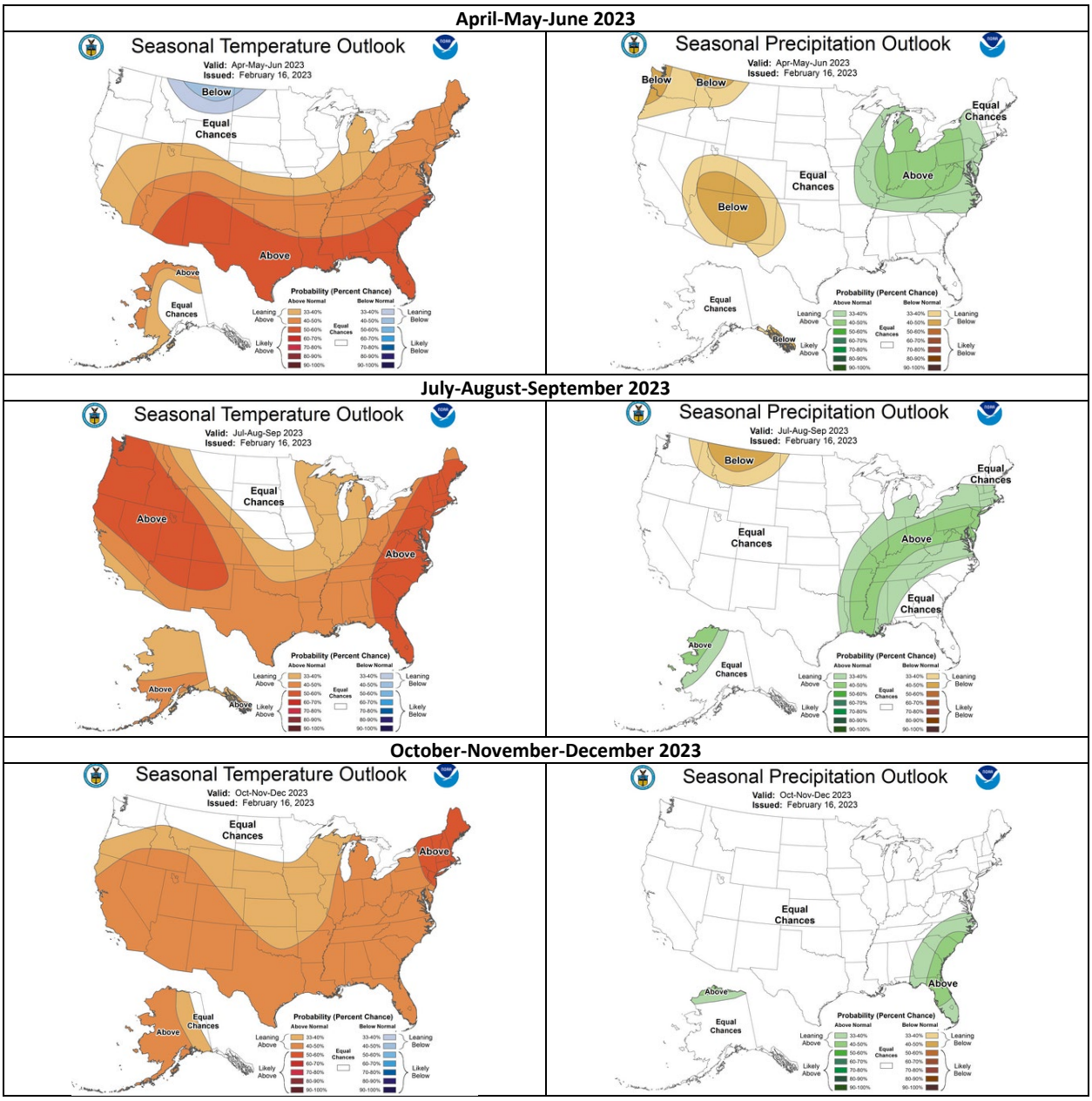


Figure 11. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given these conditions, forecasted runoff in March and April is below average due to minimal plains snowpack remaining in most reaches, except the Gavins Point to Sioux City reach. During May, June, and July, Fort Peck and Garrison runoff is slightly below average due to the normal mountain snowpack and below-normal soil moisture conditions. For the remainder of the reaches, conditions are forecasted to trend back towards normal as the drought conditions improve.

In summary, the 2023 calendar year runoff forecast is **21.5 MAF, 84% of average**.

NRCS Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: March 03, 2023 11:24:53 AM
   - Based on March 01, 2023 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Lake Sherburne Inflow (2)	APR-JUL	90	91	112	99	81	68	99
	APR-SEP	103	89	127	113	93	79	116
St. Mary R at Intl Boundary (2)	APR-JUL	410	91	530	460	360	290	450
	APR-SEP	475	93	605	530	420	345	510
Lima Reservoir Inflow (2)	APR-JUL	82	130	118	96	68	46	63
	APR-SEP	89	122	128	105	73	50	73
Clark Canyon Inflow (2)	APR-JUL	80	127	138	104	56	22	63
	APR-SEP	90	129	153	115	65	27	70
Jefferson R nr Three Forks (2)	APR-JUL	765	106	1190	935	595	340	720
	APR-SEP	930	132	1360	1100	755	500	705
Hebgen Lake Inflow (2)	APR-JUL	395	113	480	430	360	310	350
	APR-SEP	495	109	595	535	455	395	455
Ennis Lake Inflow (2)	APR-JUL	730	119	880	790	670	580	615
	APR-SEP	895	119	1070	965	825	720	750
Missouri R at Toston (2)	APR-JUL	1960	110	2630	2230	1690	1290	1780
	APR-SEP	2410	122	3150	2710	2110	1670	1970
Smith R bl Eagle Ck (2)	APR-JUL	112	104	163	133	91	61	108
	APR-SEP	122	107	178	144	100	66	114
Gibson Reservoir Inflow (2)	APR-JUL	360	96	470	405	315	250	375
	APR-SEP	395	95	515	445	345	275	415
Marias R nr Shelby (2)	APR-JUL	365	111	535	435	295	196	330
	APR-SEP	370	109	550	440	300	191	340

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	APR-JUL	61	105	71	65	57	51	58
	APR-SEP	77	103	90	82	72	64	75
Wind R Ab Bull Lake Ck (2)	APR-JUL	495	103	650	560	430	340	480
	APR-SEP	530	113	700	600	460	360	470
Bull Lake Ck nr Lenore (2)	APR-JUL	146	104	186	162	130	106	141
	APR-SEP	176	105	220	194	158	131	168
Boysen Reservoir Inflow (2)	APR-JUL	785	108	1170	940	630	400	730
	APR-SEP	850	108	1260	1010	685	445	785
Greybull R at Meeteetse	APR-JUL	148	105	215	175	121	82	141
	APR-SEP	199	100	275	230	169	125	199
Shell Ck nr Shell	APR-JUL	56	95	73	63	49	39	59
	APR-SEP	68	96	87	76	60	49	71
Bighorn R at Kane (2)	APR-JUL	1070	107	1650	1300	835	490	1000
	APR-SEP	1160	112	1780	1410	910	540	1040
NF Shoshone R at Wapiti	APR-JUL	470	104	595	520	420	345	450
	APR-SEP	520	101	655	575	465	385	515
SF Shoshone R nr Valley	APR-JUL	210	93	265	235	187	153	225
	APR-SEP	240	92	305	265	215	174	260
Buffalo Bill Reservoir Inflow (2)	APR-JUL	670	100	875	755	585	465	670
	APR-SEP	725	99	950	815	635	500	730
Bighorn R nr St. Xavier (2)	APR-JUL	1600	99	2320	1890	1310	885	1610
	APR-SEP	1700	99	2490	2020	1380	915	1720
Little Bighorn R nr Hardin	APR-JUL	114	112	167	136	92	61	102
	APR-SEP	128	106	187	152	104	69	121
Tongue R nr Dayton (2)	APR-JUL	92	105	123	104	80	61	88

	APR-SEP	104	102	137	117	91	71	102
Tongue River Reservoir Inflow (2)	APR-JUL	235	107	340	280	194	132	220
	APR-SEP	260	104	370	305	215	150	250
NF Powder R nr Hazelton	APR-JUL	11.2	109	14.3	12.5	9.9	8.1	10.3
	APR-SEP	12.0	108	15.2	13.3	10.7	8.8	11.1
Powder R at Moorhead	APR-JUL	245	128	375	295	193	117	191
	APR-SEP	265	129	400	320	210	132	205
Powder R nr Locate	APR-JUL	270	120	415	330	210	127	225
	APR-SEP	290	121	440	350	230	139	240

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	MAR-JUL	7.4	114	10.7	8.8	6.0	4.1	6.5
	APR-JUL	6.3	119	9.4	7.5	5.1	3.2	5.3
Pactola Reservoir Inflow (2)	MAR-JUL	30	107	44	35	25	16.5	28
	APR-JUL	26	104	39	31	21	13.1	25

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	APR-JUL	280	140	395	325	235	163	200
	APR-SEP	305	139	430	355	255	179	220
Encampment R nr Encampment (2)	APR-JUL	210	156	270	235	185	149	135
	APR-SEP	225	160	290	250	199	161	141
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	56	114	73	63	49	39	49
	APR-SEP	58	114	76	65	51	40	51
Seminoe Reservoir Inflow (2)	APR-JUL	900	136	1300	1060	740	505	660
	APR-SEP	965	135	1380	1130	795	550	715
Sweetwater R nr Alcova	APR-JUL	68	151	104	83	53	32	45
	APR-SEP	72	147	110	87	57	34	49
La Prele Ck nr Douglas	APR-JUL	24	114	40	31	17.4	7.6	21
	APR-SEP	25	128	42	32	18.2	8.1	19.5
North Platte R bl Glendo Reservoir (2)	APR-JUL	1050	141	1600	1270	825	495	745
	APR-SEP	1080	142	1650	1310	850	510	760
North Platte R bl Guernsey Reservoir (2)	APR-JUL	1060	142	1630	1290	830	485	745
	APR-SEP	1090	141	1680	1330	850	500	775
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	128	109	184	151	105	72	117
	APR-SEP	139	110	199	163	115	79	126
Little Laramie R nr Filmore	APR-JUL	60	113	82	69	51	38	53
	APR-SEP	64	114	88	74	54	40	56

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
April 2023 Calendar Year Runoff Forecast
April 3, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 1.7 MAF (57% of average) for the basin above Sioux City and 1.5 MAF (56% of average) above Gavins Point. Runoff was below-average in all reaches except for Gavins Point, due to below-normal temperatures reducing plains snowmelt.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **26.4 MAF, 103% of average** and 4.9 MAF higher than last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **23.6 MAF, 102% 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 35.6 MAF upper basic forecast to the 18.3 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.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for March 28, 2023 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 76% of the Basin, with about 7% of that being Extreme or Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of June, indicates drought removal or improvement likely over most of the Basin.

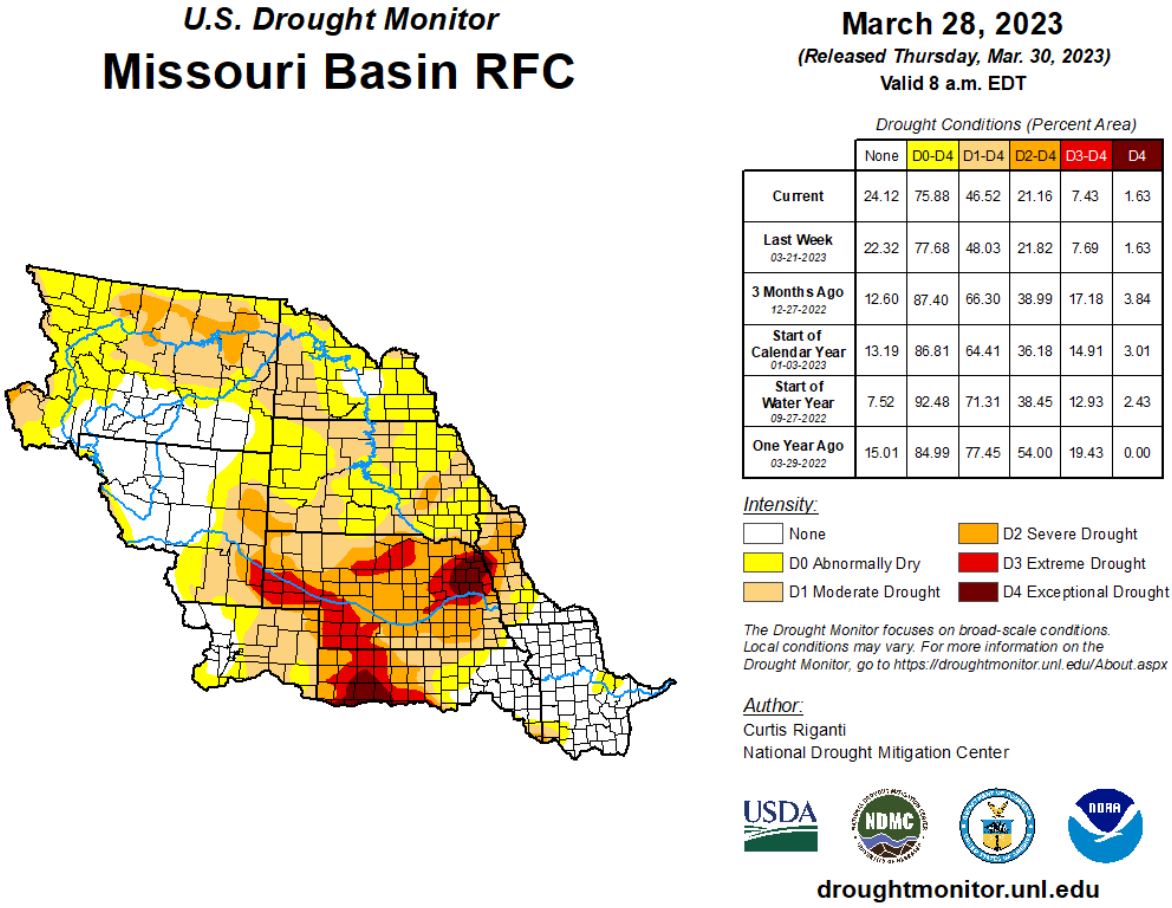


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

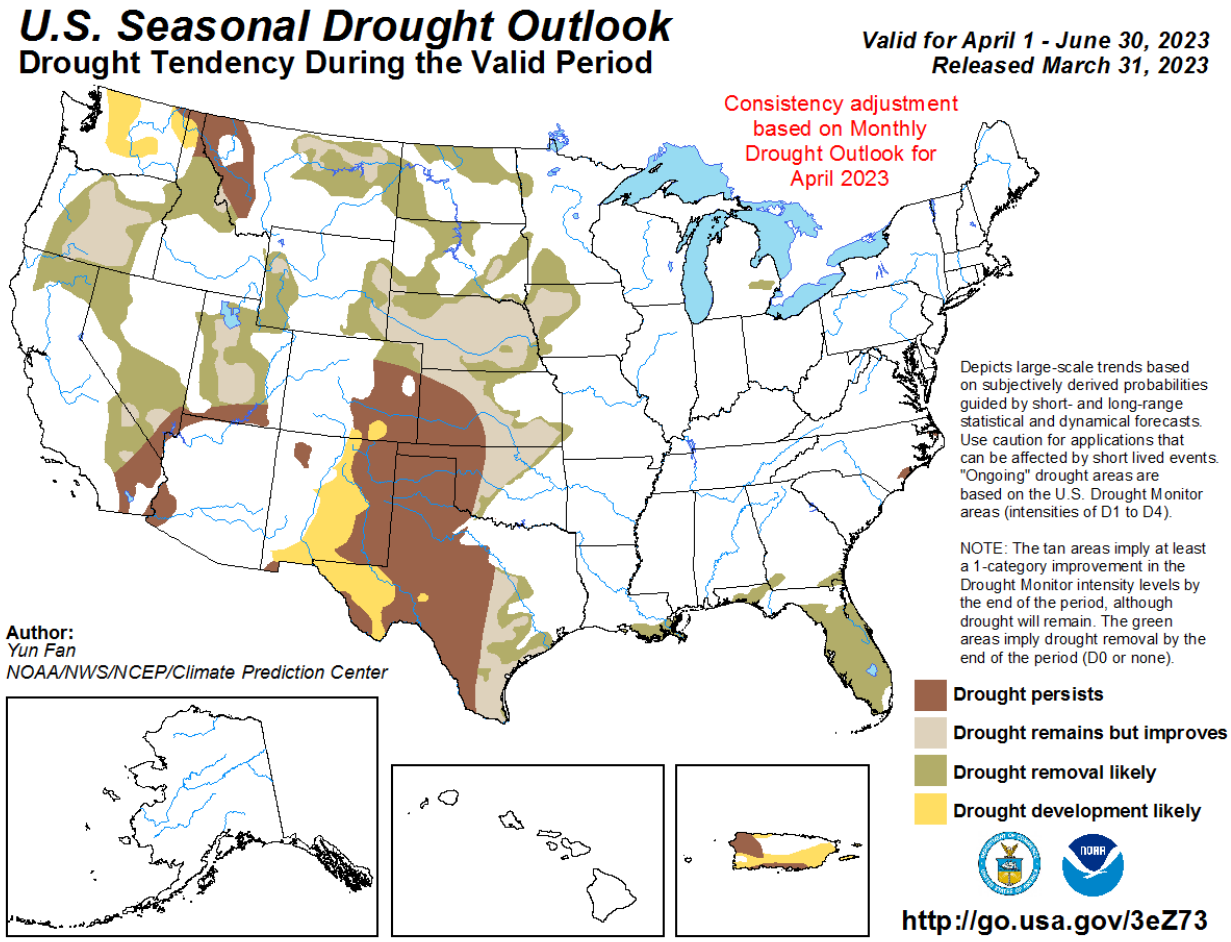


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The March precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Pockets of 150%-300% of normal precipitation occurred last month in the upper Basin. Southern South Dakota and most of the lower Basin remained dry.

Precipitation as a percent of normal for the January-February-March period (**Figure 4**) was mixed throughout the Basin. Below-normal precipitation occurred in eastern Montana, northern North Dakota, Kansas, and pockets in South Dakota. Above-normal precipitation occurred in central Montana, southern North Dakota, much of Nebraska and northern Missouri, and in parts of South Dakota.

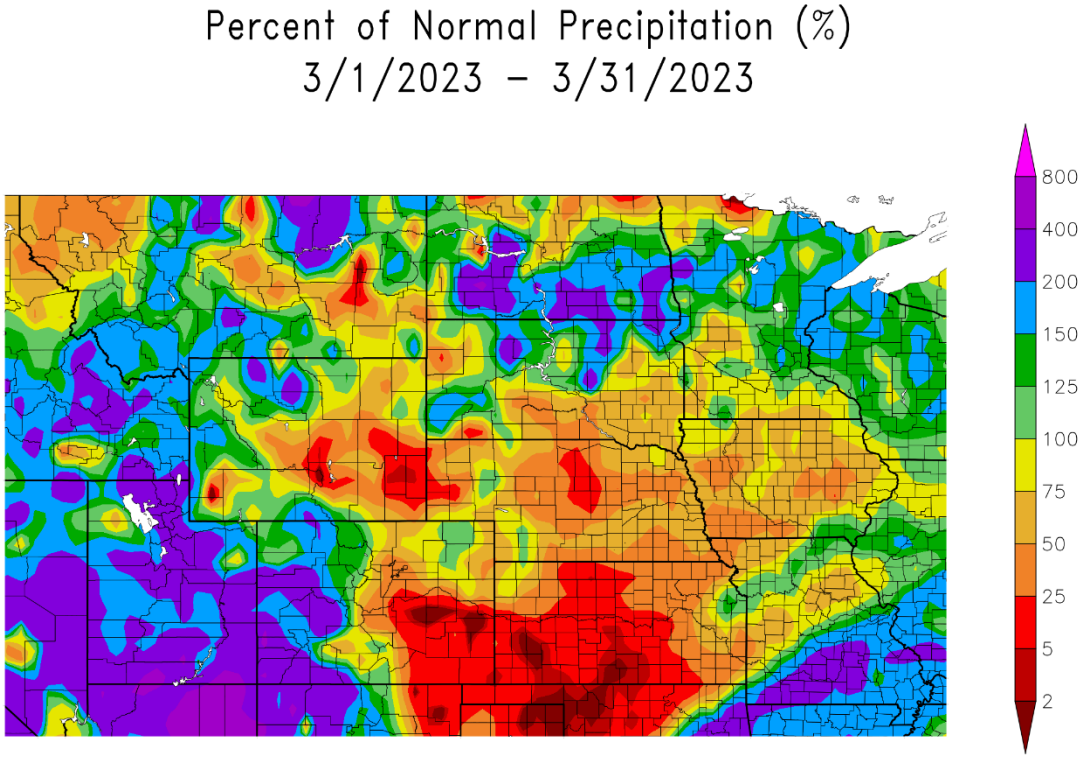


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

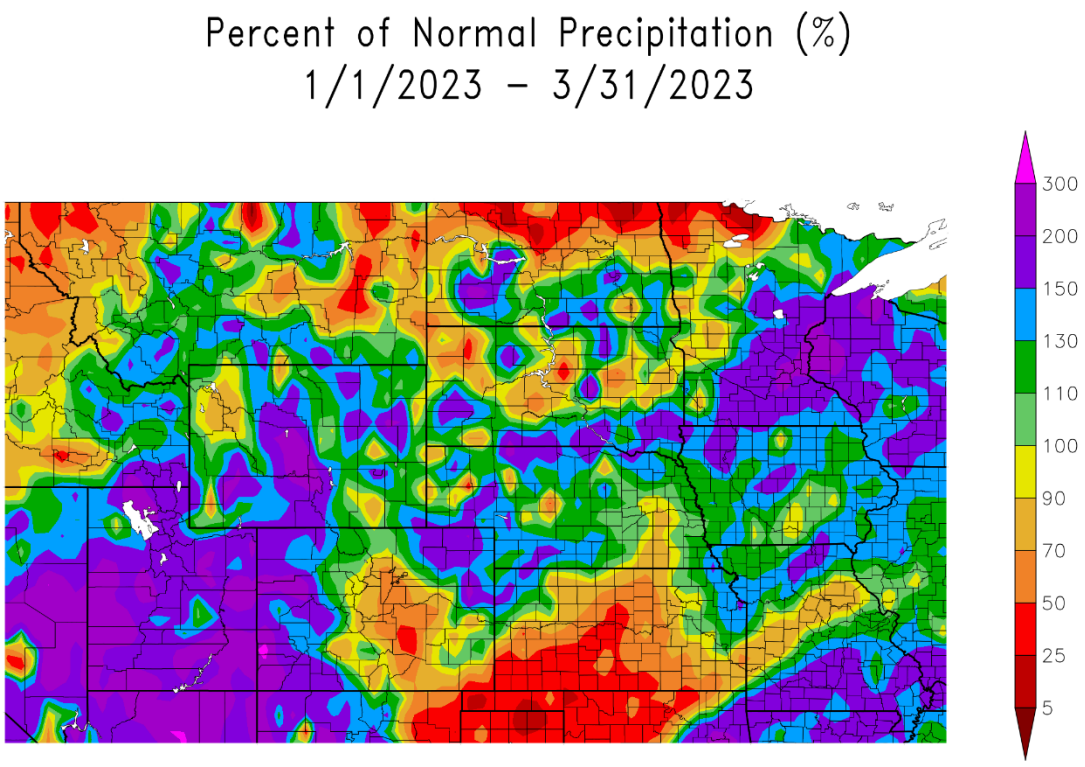


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

March temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate below-normal temperatures across the Basin. The upper Basin saw temperatures as low as 15 degrees below normal. January-February-March temperature departures are shown in **Figure 6**. The three-month average departures were slightly below normal for the upper Basin and into Nebraska, and slightly above normal for the rest of the Basin.

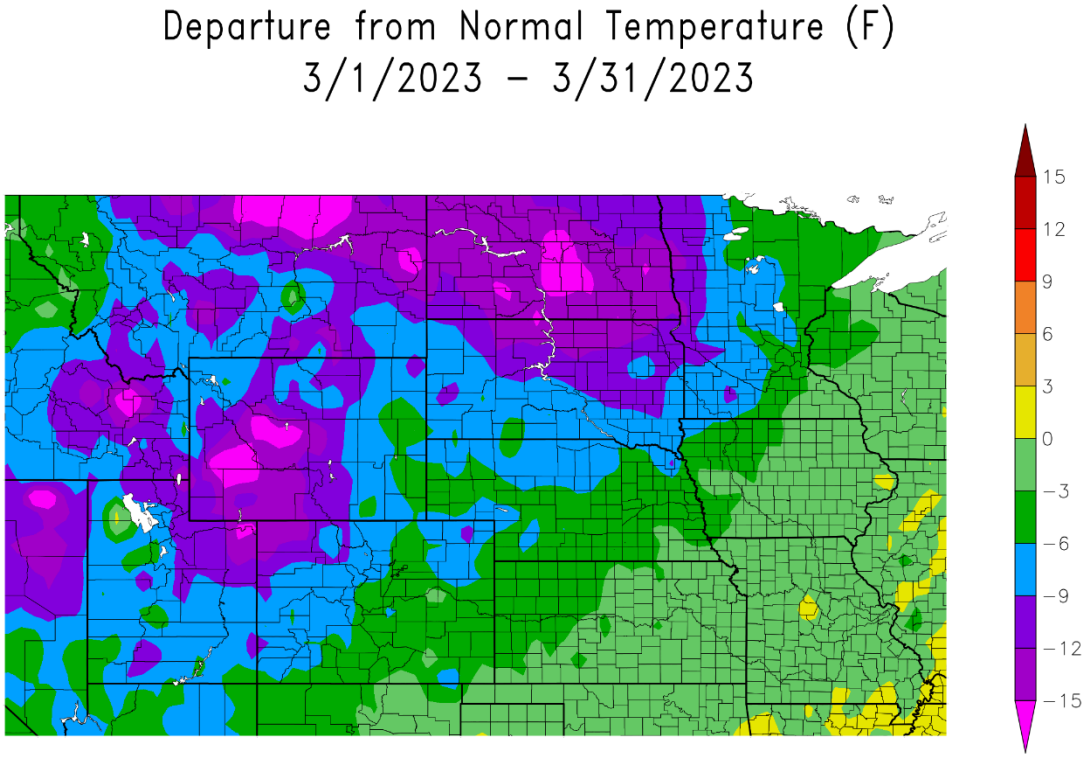


Figure 5. HPRCC Previous Month Departure from Normal Temperature

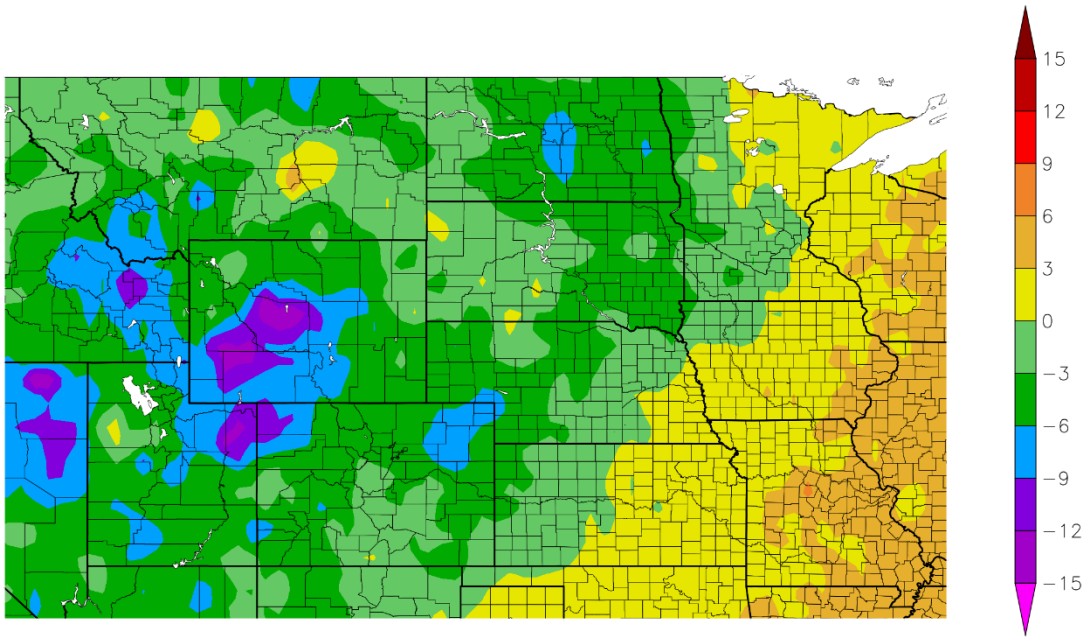


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of March is shown in **Figure 7**. Soil moisture improved over the month, with near-normal anomalies observed across much of Montana and into western North Dakota. The rest of the Basin continues to be drier than normal.

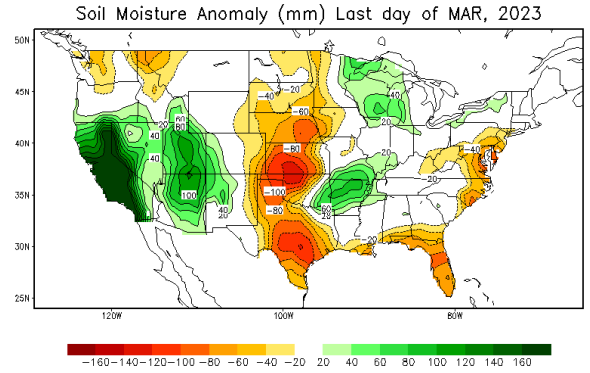
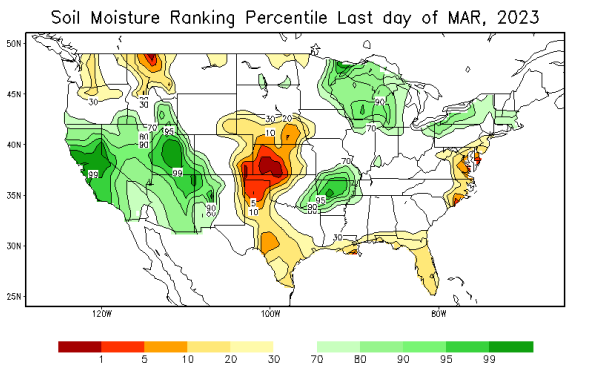
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
March 1, 2023	
	

Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. 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 (available here) from April 1, shown in **Figure 8**, shows a widespread increase in plains snowpack over the past month, particularly in the northeastern parts of Montana, western North Dakota, and the eastern Dakotas. Widespread amounts of 4-8" of snow water equivalent (SWE) in north-central Montana, eastern South Dakota, and much of North Dakota, with 1-4" of SWE surrounding those areas. Plains snowmelt has begun in South Dakota with some response in the lower tributaries.

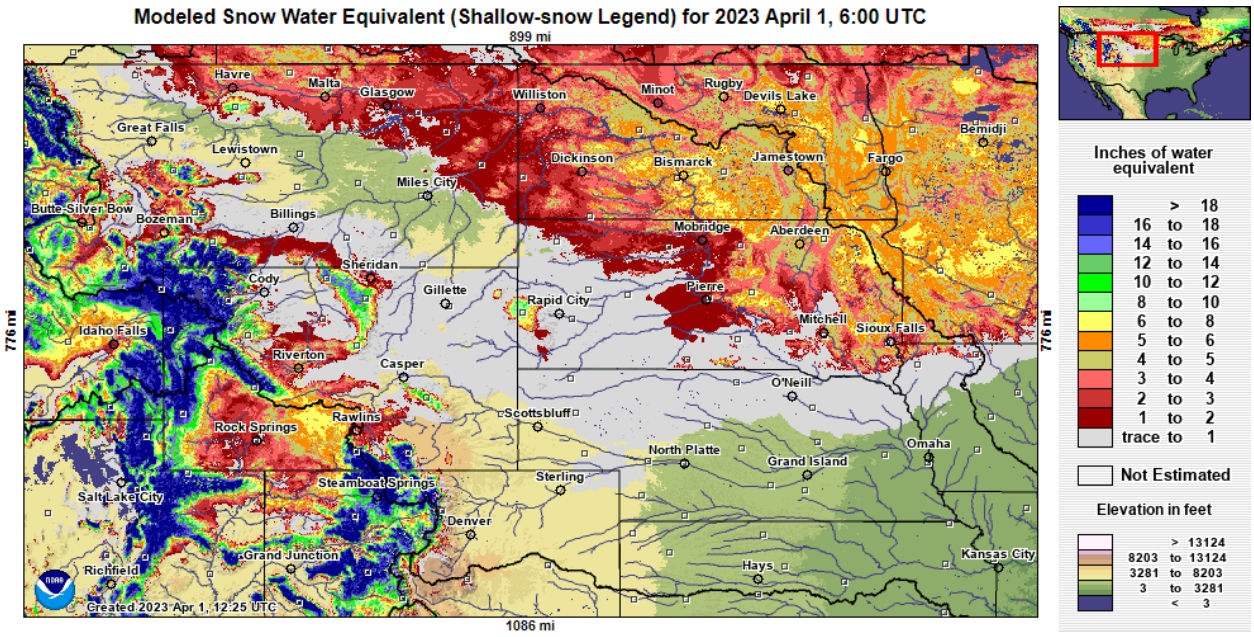


Figure 8. NOHRSC Modeled Snow Water Equivalent

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. May, June, and July runoff in the Fort Peck and Garrison reaches has a small correlation to the April 1 snowpack, because approximately 96 percent of the mountain snowpack has accumulated by April 1. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 9** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line).

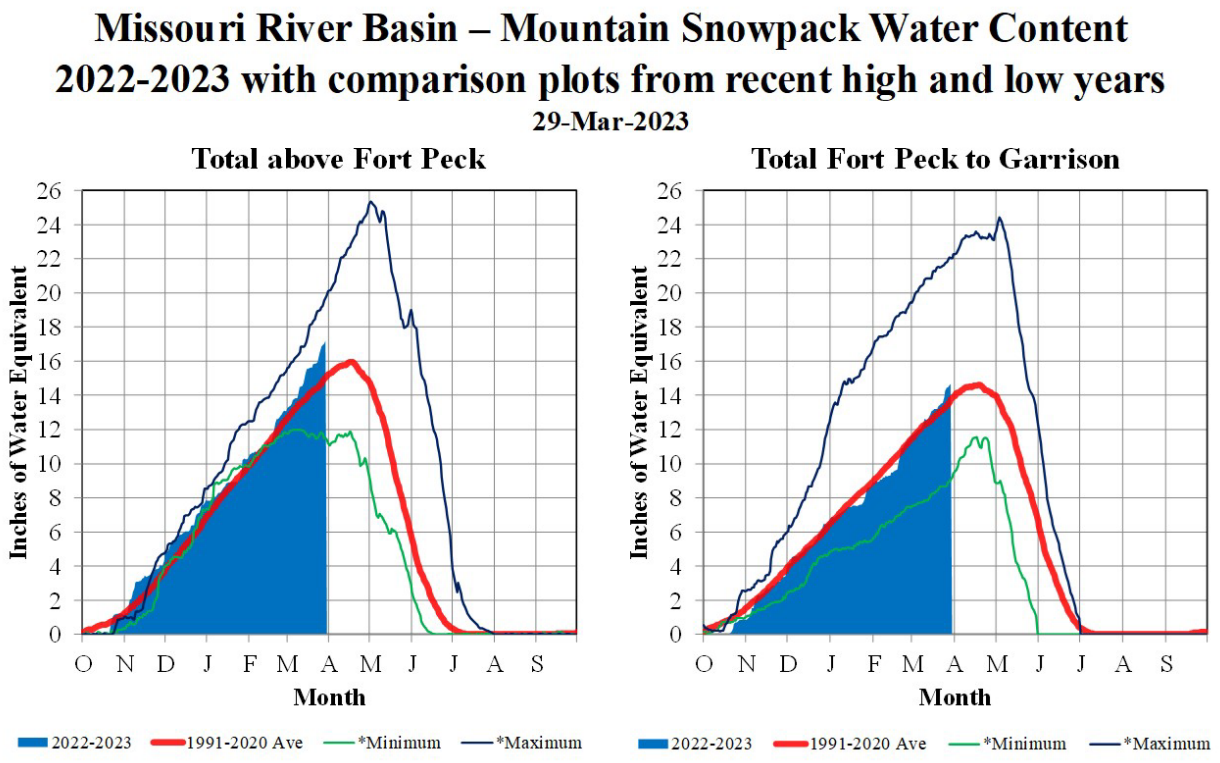


Figure 9. Mountain Snowpack Water Content

As of March 29, the average mountain SWE in the Fort Peck reservoir reach was 17.2", 114% of average. In the reservoir reach between Fort Peck and Garrison dams, the average mountain SWE was 14.7", 107% of average.

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

The latest ENSO Outlook indicates ENSO-neutral conditions are currently present. These conditions are expected to persist through spring and early summer.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for April (**Figure 10**) indicates increased chances for below-normal temperatures over the Basin. The precipitation outlook (**Figure 10**) indicates equal chances for below-normal, normal, or above-normal precipitation in the Basin.

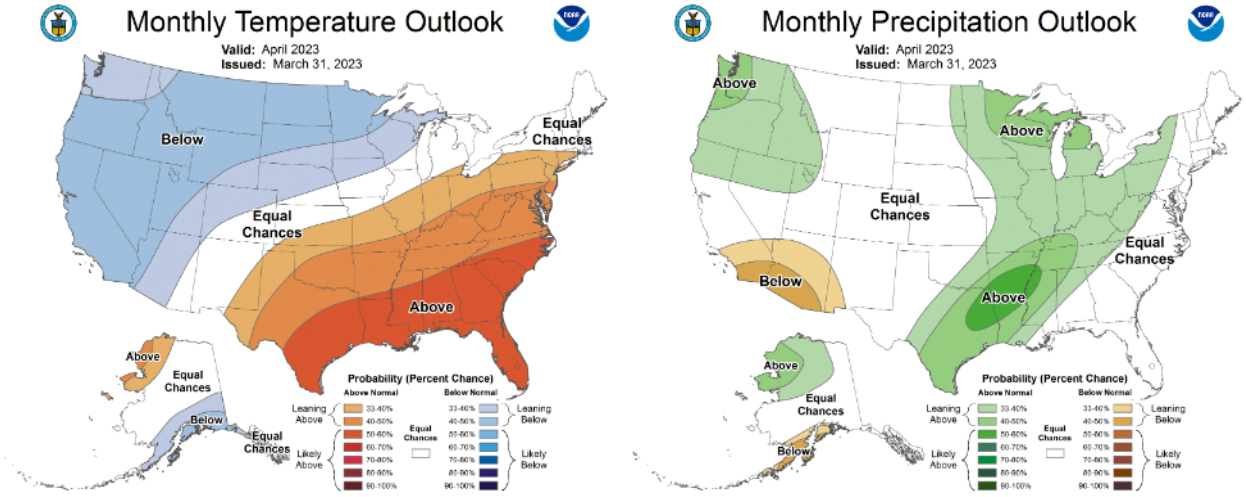


Figure 10. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 11**. The April-May-June temperature outlook indicates increased chances below-normal temperatures for the Dakotas, increased chances for above-normal temperatures in Kansas and Missouri, and equal chances for the rest of the Basin. The precipitation outlook for the same period indicates equal chances for the Basin.

The July-August-September outlooks show equal chances for below-normal, normal, or above-normal temperatures and precipitation across the Basin. No indicators are shown for temperatures or precipitation in the October-November-December outlooks either.

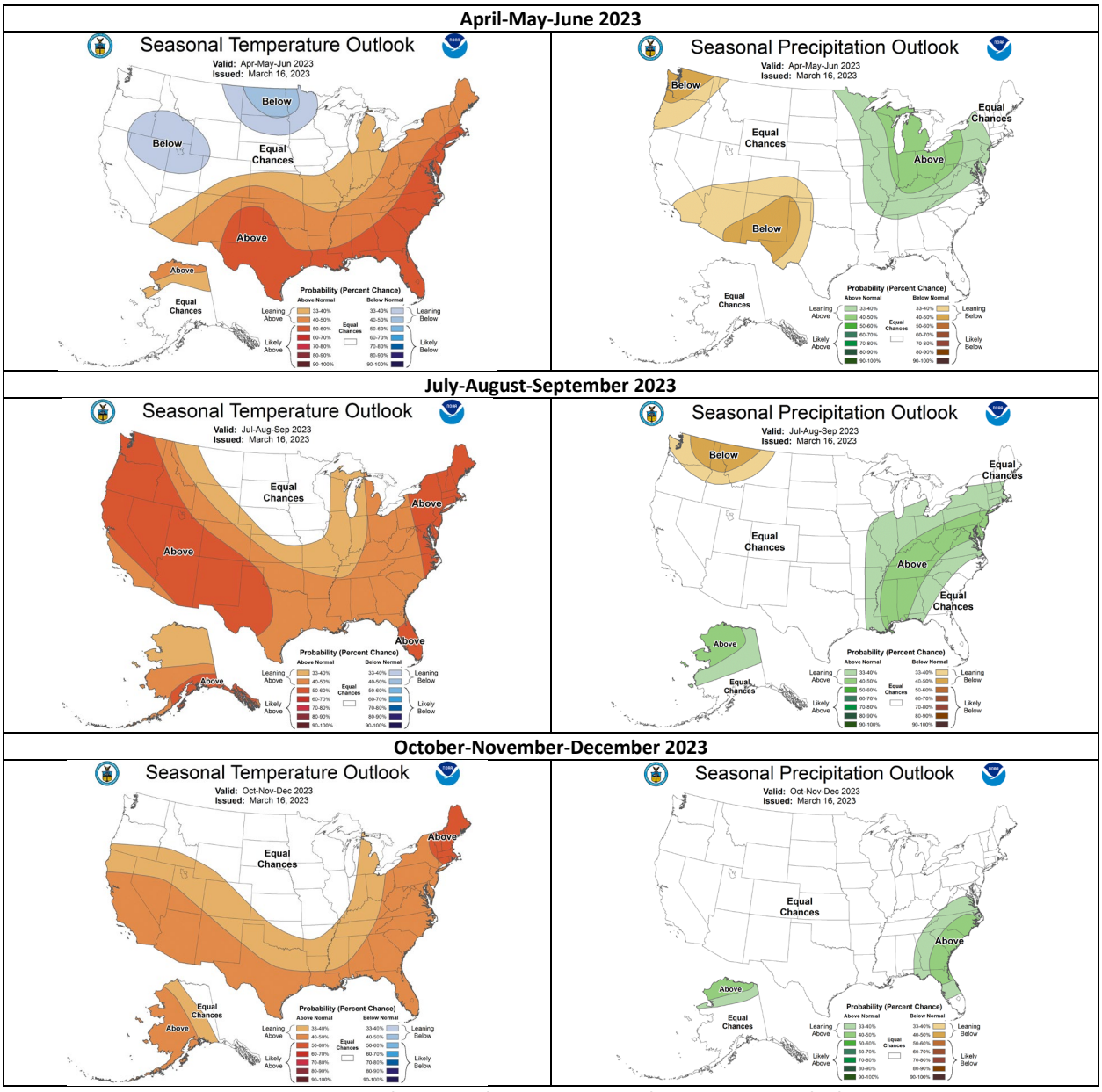


Figure 11. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given these conditions, forecasted runoff in April and May is above average over all reaches. Mountain snowpack in the Fort Peck and Garrison reaches is expected to be near normal. For the remainder of the reaches, conditions are forecasted to be near normal as the drought conditions improve.

In summary, the 2023 calendar year runoff forecast is **26.4 MAF, 103% of average**.

NRCS Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: April 05, 2023 04:03:56 PM
   - Based on April 01, 2023 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Lake Sherburne Inflow (2)	APR-JUL	85	86	104	93	77	66	99
	APR-SEP	99	85	120	107	90	77	116
St. Mary R at Intl Boundary (2)	APR-JUL	390	87	495	435	345	285	450
	APR-SEP	450	88	570	495	400	330	510
Lima Reservoir Inflow (2)	APR-JUL	110	175	138	121	99	82	63
	APR-SEP	121	166	151	133	109	91	73
Clark Canyon Inflow (2)	APR-JUL	120	190	169	140	100	71	63
	APR-SEP	133	190	188	155	111	78	70
Jefferson R nr Three Forks (2)	APR-JUL	880	122	1220	1020	745	540	720
	APR-SEP	1050	149	1420	1200	900	685	705
Hebgen Lake Inflow (2)	APR-JUL	450	129	520	480	420	380	350
	APR-SEP	565	124	650	600	530	480	455
Ennis Lake Inflow (2)	APR-JUL	820	133	940	870	770	700	615
	APR-SEP	995	133	1140	1050	935	850	750
Missouri R at Toston (2)	APR-JUL	2190	123	2800	2440	1940	1580	1780
	APR-SEP	2700	137	3380	2970	2430	2020	1970
Smith R bl Eagle Ck (2)	APR-JUL	118	109	169	139	98	67	108
	APR-SEP	129	113	184	151	107	74	114
Gibson Reservoir Inflow (2)	APR-JUL	365	97	450	400	325	275	375
	APR-SEP	400	96	500	440	360	300	415
Marias R nr Shelby (2)	APR-JUL	345	105	505	410	280	183	330
	APR-SEP	355	104	530	425	285	180	340

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	APR-JUL	63	109	72	66	59	54	58
	APR-SEP	79	105	91	84	74	67	75
Wind R Ab Bull Lake Ck (2)	APR-JUL	505	105	655	565	445	355	480
	APR-SEP	535	114	705	605	470	370	470
Bull Lake Ck nr Lenore (2)	APR-JUL	147	104	183	162	132	111	141
	APR-SEP	177	105	220	194	160	135	168
Boysen Reservoir Inflow (2)	APR-JUL	785	108	1130	925	645	435	730
	APR-SEP	830	106	1200	980	680	465	785
Greybull R at Meeteetse	APR-JUL	180	128	245	205	153	115	141
	APR-SEP	235	118	310	265	205	160	199
Shell Ck nr Shell	APR-JUL	58	98	73	64	52	43	59
	APR-SEP	70	99	87	77	63	53	71
Bighorn R at Kane (2)	APR-JUL	1120	112	1660	1340	900	580	1000
	APR-SEP	1180	113	1760	1410	945	600	1040
NF Shoshone R at Wapiti	APR-JUL	480	107	585	520	440	375	450
	APR-SEP	535	104	645	580	490	425	515
SF Shoshone R nr Valley	APR-JUL	225	100	275	245	205	174	225
	APR-SEP	255	98	315	280	230	196	260
Buffalo Bill Reservoir Inflow (2)	APR-JUL	700	104	875	770	630	525	670
	APR-SEP	765	105	955	840	690	575	730
Bighorn R nr St. Xavier (2)	APR-JUL	1680	104	2360	1950	1410	1000	1610
	APR-SEP	1760	102	2510	2060	1460	1010	1720
Little Bighorn R nr Hardin	APR-JUL	114	112	163	134	94	65	102
	APR-SEP	128	106	183	150	106	73	121
Tongue R nr Dayton (2)	APR-JUL	96	109	122	107	85	70	88

	APR-SEP	108	106	137	120	96	79	102
Tongue River Reservoir Inflow (2)	APR-JUL	235	107	325	270	199	147	220
	APR-SEP	260	104	355	300	220	166	250
NF Powder R nr Hazelton	APR-JUL	11.1	108	14.2	12.3	9.8	8.0	10.3
	APR-SEP	11.8	106	15.0	13.1	10.5	8.6	11.1
Powder R at Moorhead	APR-JUL	240	126	365	290	190	115	191
	APR-SEP	255	124	380	305	205	128	205
Powder R nr Locate	APR-JUL	265	118	400	320	210	130	225
	APR-SEP	280	117	420	335	225	140	240

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	APR-JUL	7.5	142	10.6	8.7	6.3	4.4	5.3
Pactola Reservoir Inflow (2)	APR-JUL	33	132	47	39	27	19.0	25

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	APR-JUL	340	170	440	380	300	240	200
	APR-SEP	365	166	475	410	320	255	220
Encampment R nr Encampment (2)	APR-JUL	245	181	295	265	225	193	135
	APR-SEP	260	184	315	280	240	205	141
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	58	118	73	64	52	43	49
	APR-SEP	61	120	76	67	55	46	51
Seminoe Reservoir Inflow (2)	APR-JUL	1050	159	1390	1190	920	720	660
	APR-SEP	1120	157	1470	1260	980	770	715
Sweetwater R nr Alcova	APR-JUL	75	167	106	87	63	44	45
	APR-SEP	80	163	113	93	67	47	49
La Prele Ck nr Douglas	APR-JUL	24	114	37	29	18.9	11.4	21
	APR-SEP	25	128	38	30	19.7	12.0	19.5
North Platte R bl Glendo Reservoir (2)	APR-JUL	1230	165	1700	1420	1040	755	745
	APR-SEP	1270	167	1760	1470	1070	780	760
North Platte R bl Guernsey Reservoir (2)	APR-JUL	1250	168	1740	1450	1050	755	745
	APR-SEP	1290	166	1800	1490	1090	785	775
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	147	126	195	167	127	99	117
	APR-SEP	159	126	210	180	138	107	126
Little Laramie R nr Filmore	APR-JUL	66	125	85	74	58	47	53
	APR-SEP	70	125	90	78	62	50	56

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
May 2023 Calendar Year Runoff Forecast
May 3, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 4.7 MAF, or 159% of average, for the basin above Sioux City, and 4.1 MAF, or 162% of average, above Gavins Point. Runoff was above average in all reaches due to additional plains snowpack accumulation and its almost complete subsequent melting during April.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **26.9 MAF, 105% of average** and 0.5 MAF higher than last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **24.1 MAF, 104% 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 34.0 MAF upper basic forecast to the 20.7 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for May 2, 2023 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 74% of the Basin, with about 11% of that being Extreme or Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of July, indicates drought removal or improvement is likely over most of the Basin. Drought is likely to persist through July in Nebraska, southeast South Dakota, and northwest Iowa.

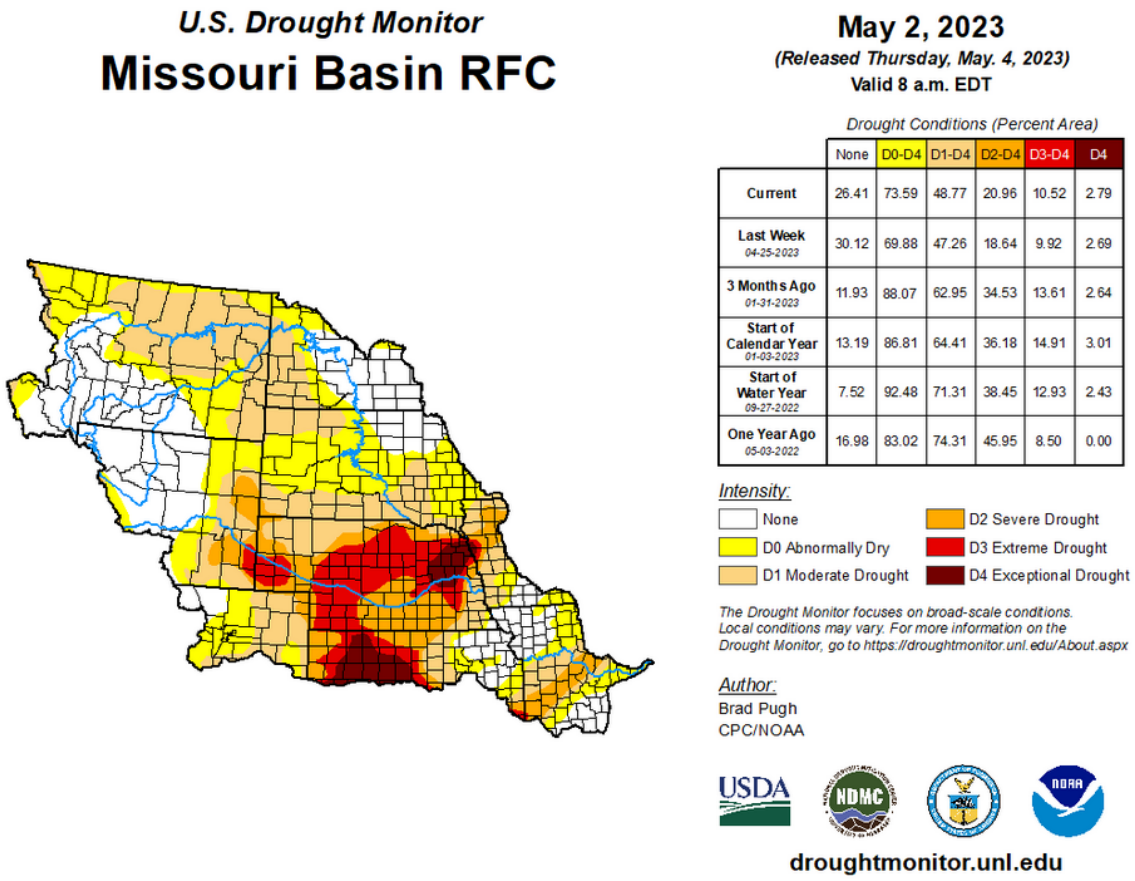


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

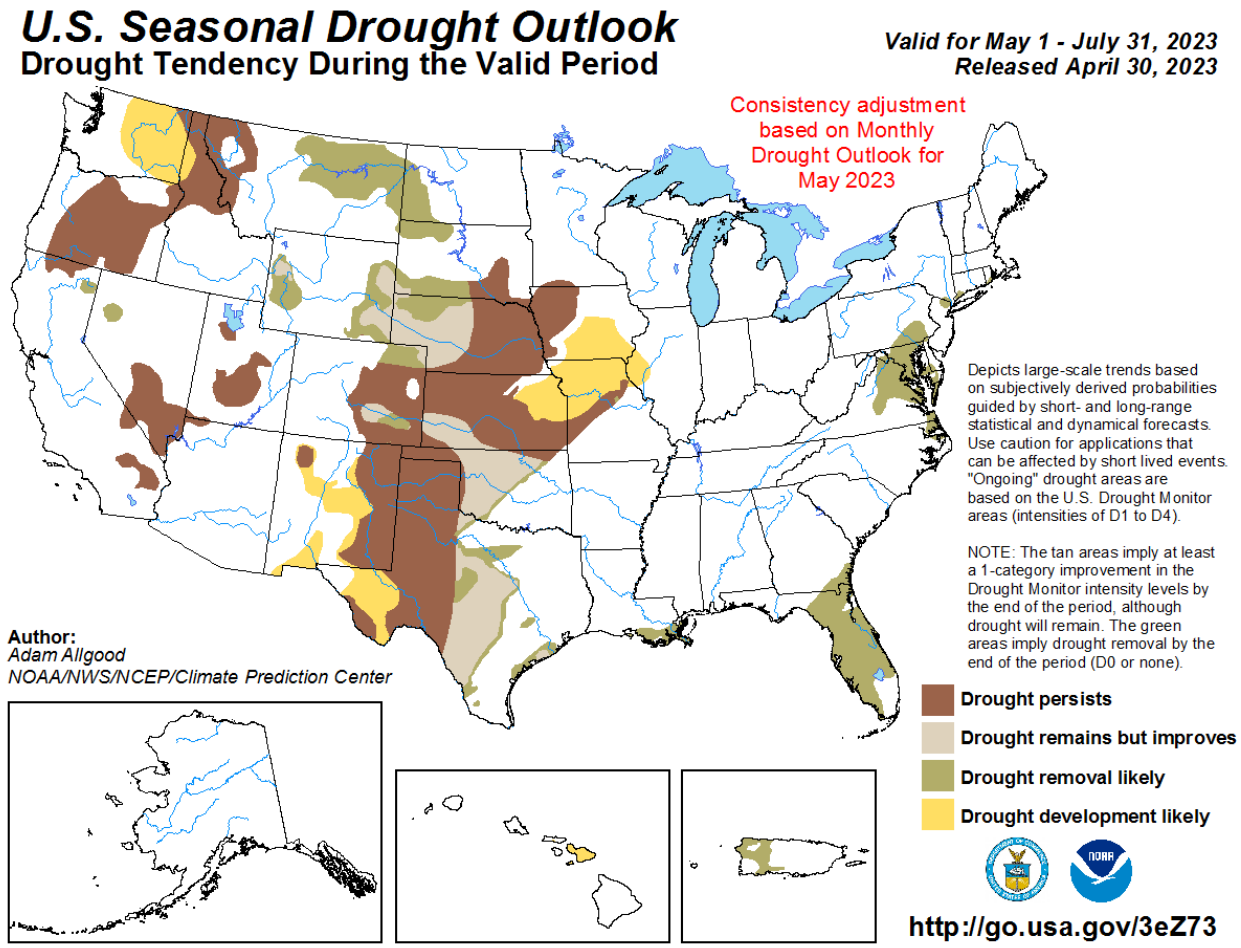


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The April precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was 2 to 75 percent of normal over most of the Basin during April, except for the James River Basin and central Montana, which were 100 to 200 percent of normal.

Precipitation as a percent of normal for the February-March-April period (**Figure 4**) was below normal throughout most of the Basin. Above-normal precipitation occurred in central Montana, southeast North Dakota, and northeast South Dakota.

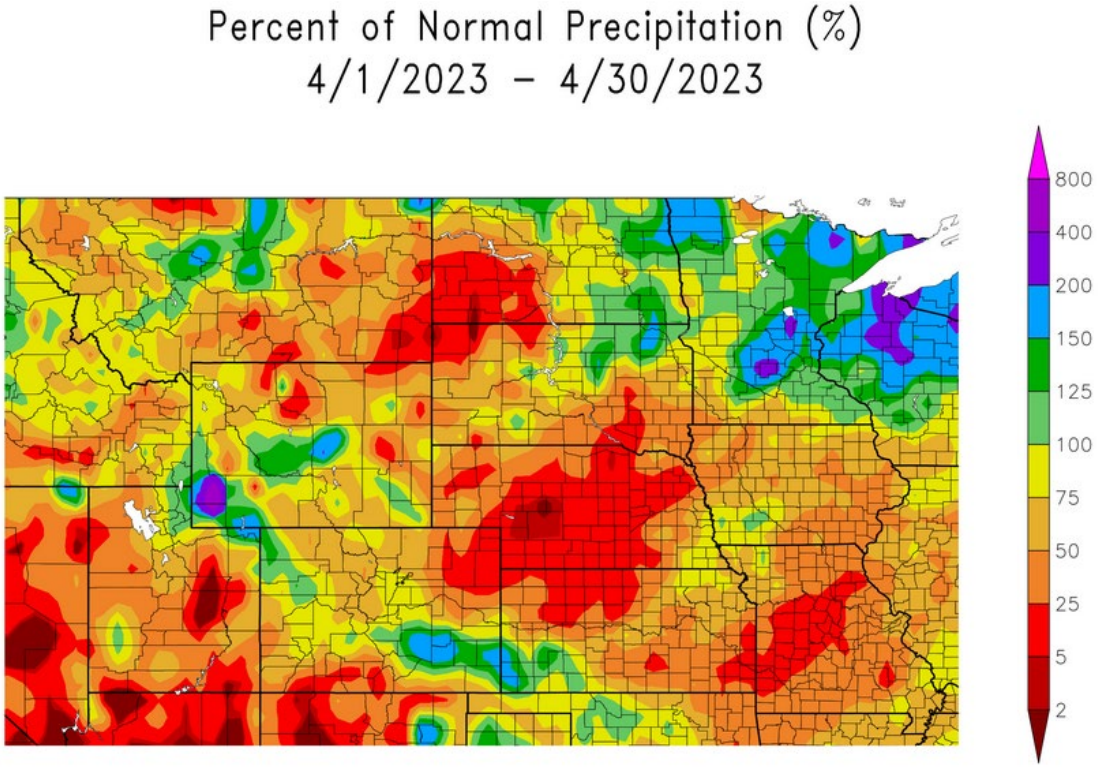


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

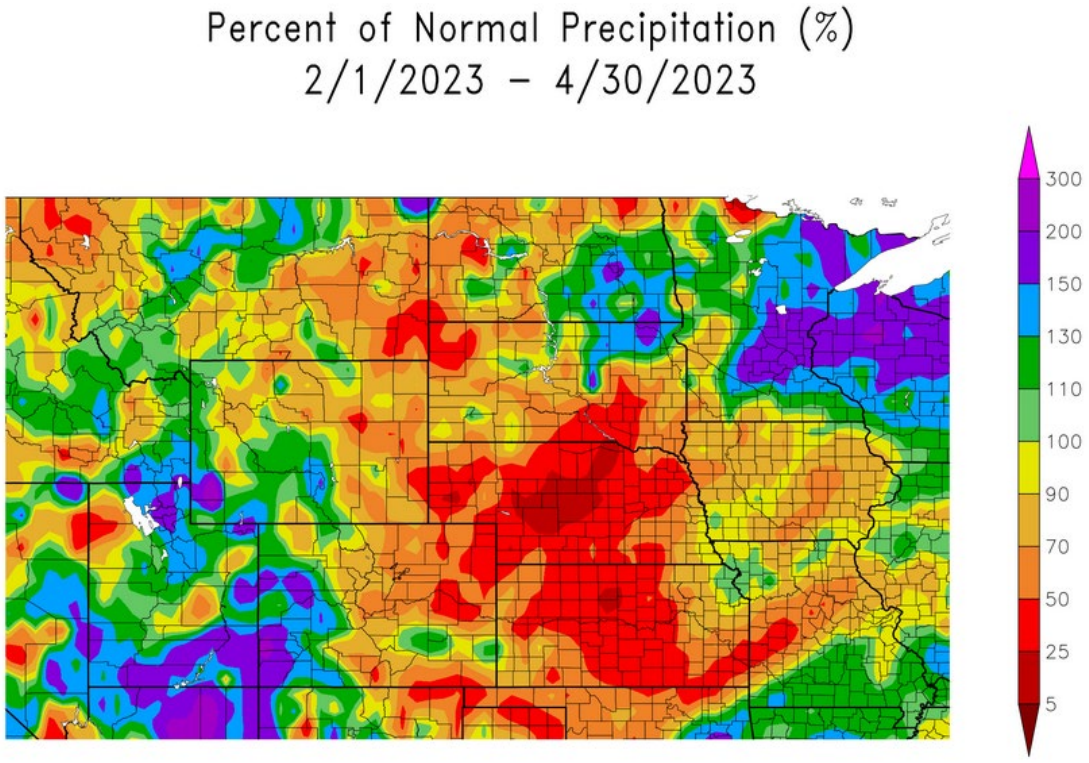


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

April temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate below-normal temperatures across the Basin. Areas of North Dakota saw temperatures colder than 10 degrees below normal. February-March-April temperature departures are shown in **Figure 6**. The three-month average temperature departures were below normal for the Basin, except for in eastern Kansas and Missouri.

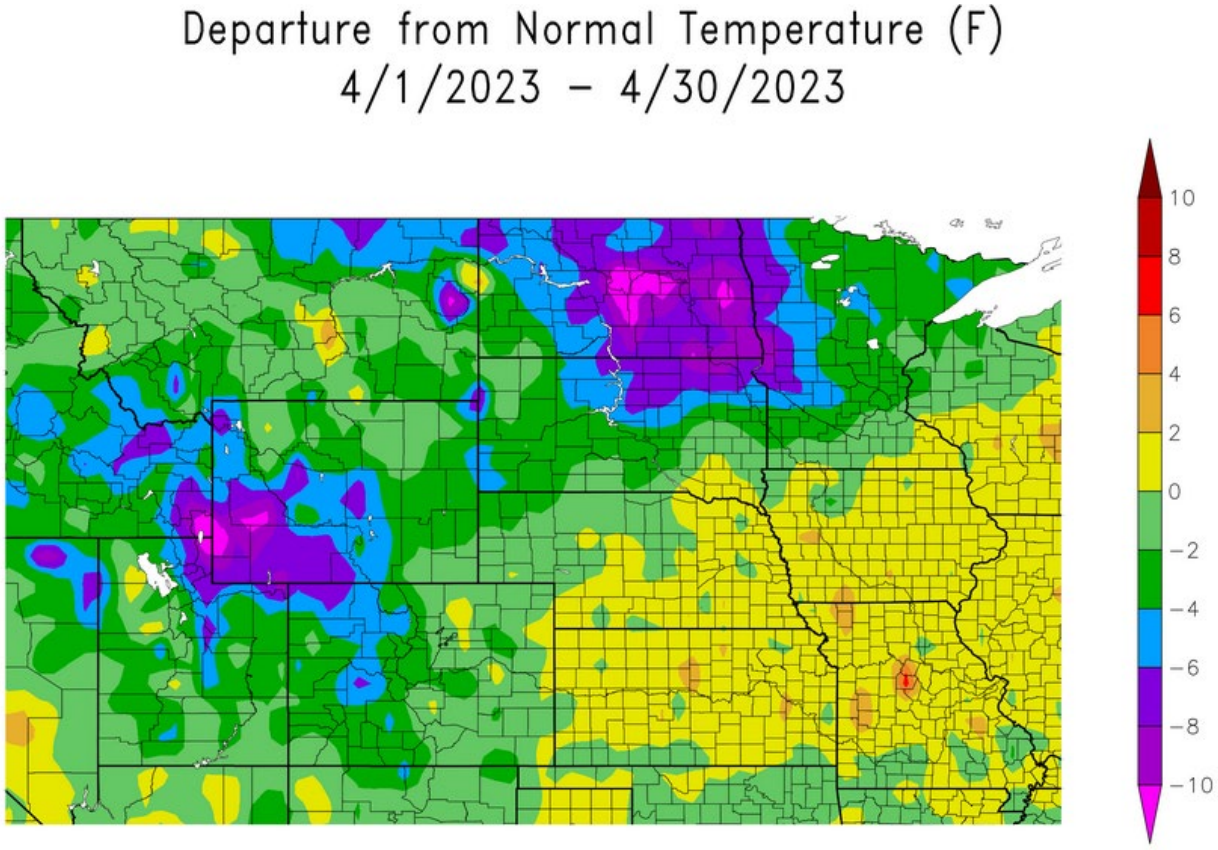


Figure 5. HPRCC Previous Month Departure from Normal Temperature

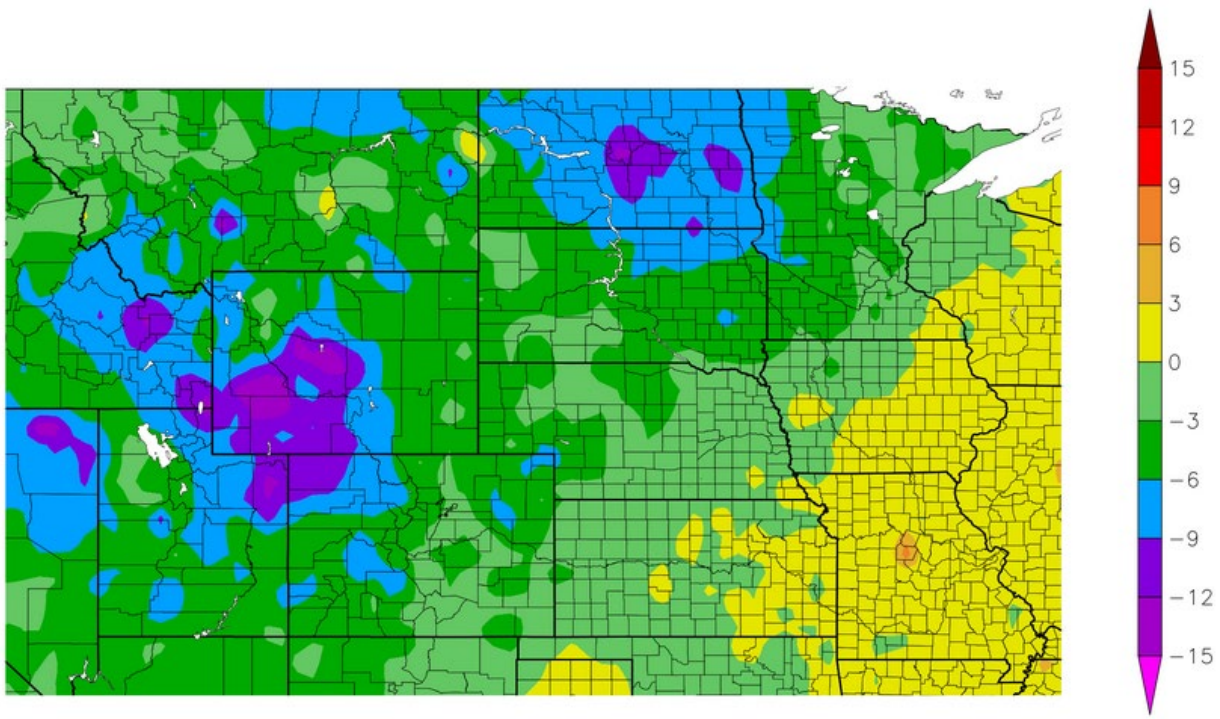


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of April is shown in **Figure 7**. Soil moisture is below normal in eastern Montana and the western Dakotas, and well below normal in Nebraska and Kansas. Soils dried out some during April over a large portion of the upper Basin, despite the plains snowmelt.

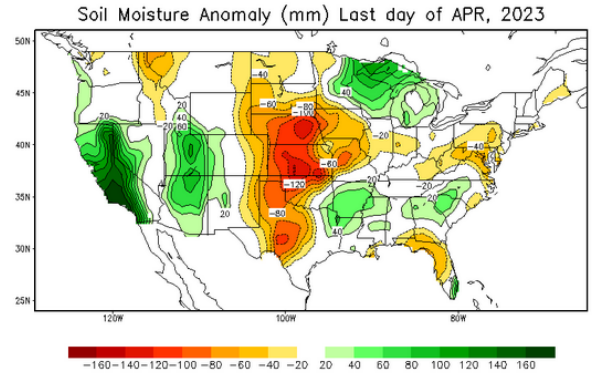
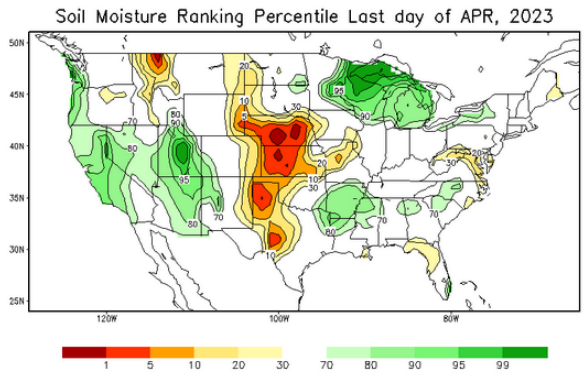
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
March 1, 2023	
	

Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. 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 (available here) from May 1, shown in **Figure 8**, shows no plains snowmelt remaining.

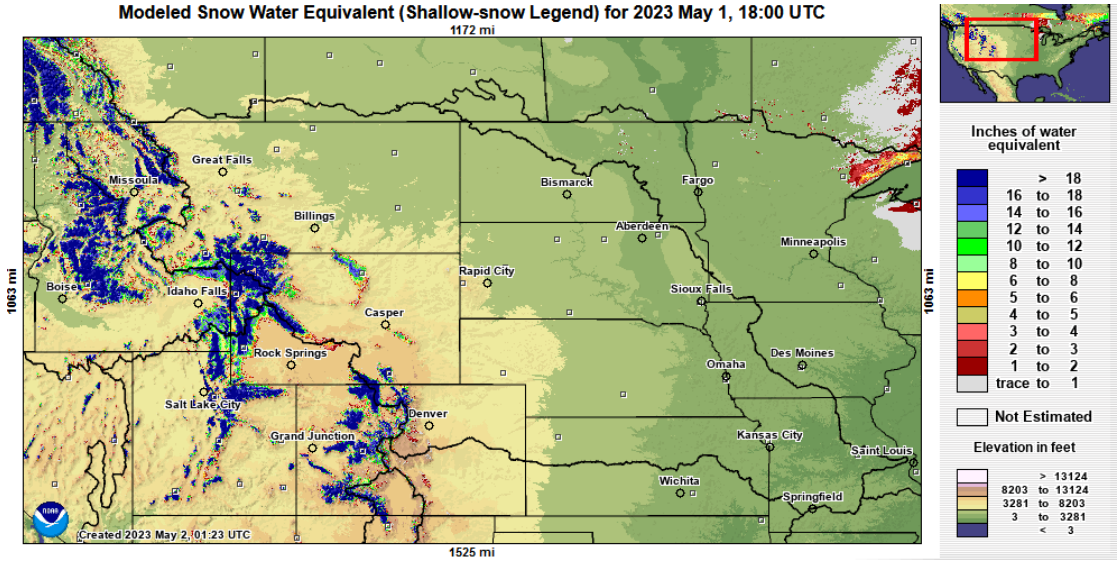


Figure 8. NOHRSC Modeled Snow Water Equivalent

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. May, June, and July runoff in the Fort Peck and Garrison reaches has a small correlation to the April 1 snowpack, because approximately 96 percent of the mountain snowpack has accumulated by April 1. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 9** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line).

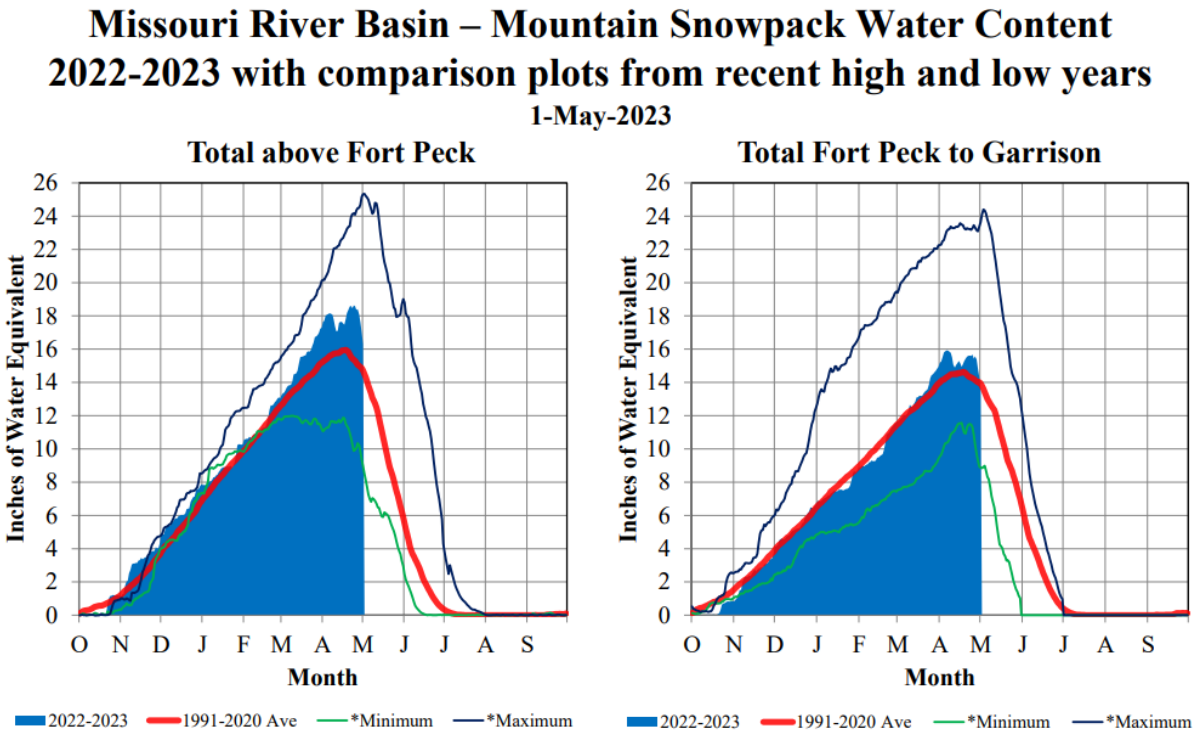


Figure 9. Mountain Snowpack Water Content

Mountain snowpack has peaked above normal in both reaches. The Fort Peck reach peaked at 117% of normal on April 24 and has 88% of the peak remaining on May 1. The Garrison reach peaked at 109% of normal on April 6 and has 85% of the peak remaining on May 1.

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

The latest ENSO Outlook indicates ENSO-neutral conditions are currently present. These conditions are expected to persist through spring and early summer, with a 62% chance of El Niño conditions developing by the end of July.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for May (**Figure 10**) indicates equal chances for below-normal, normal, or above-normal temperatures over most of the Basin, with an increased chance for above-normal temperatures in western Montana and Wyoming. The precipitation outlook (**Figure 10**) indicates increased chances for below-normal precipitation in North Dakota, South Dakota, Nebraska, Iowa, and Missouri, with equal chances in Montana, Wyoming, Colorado, and most of Kansas.

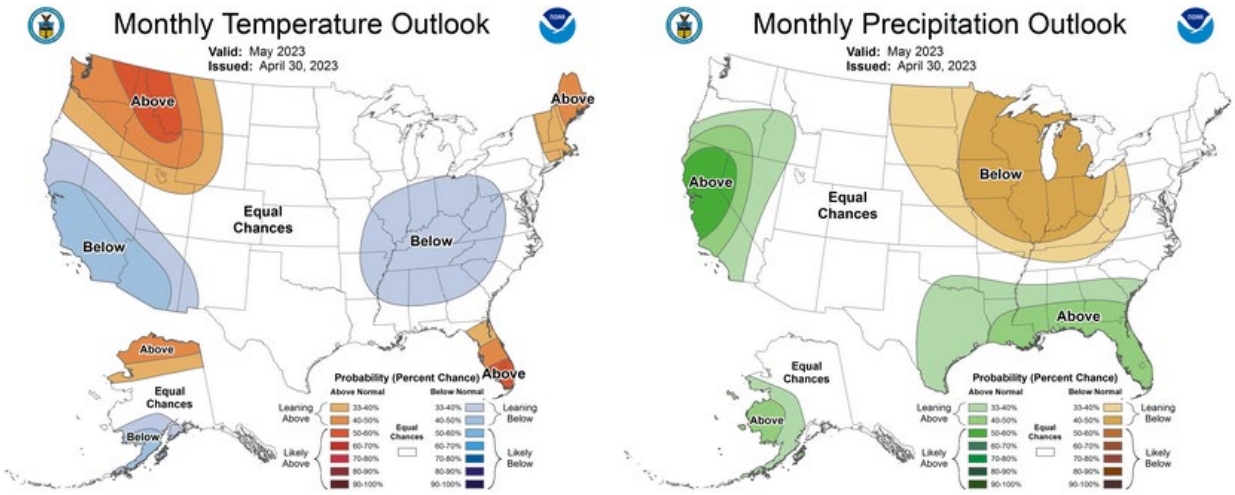


Figure 10. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 11**. The June-July-August temperature outlook indicates increased chances for above-normal temperatures in western Montana, Wyoming, and Colorado, with equal chances for the rest of the Basin. The precipitation outlook for the same period indicates equal chances for most of the Basin.

The September-October-November outlooks show equal chances for below-normal, normal, or above-normal temperatures and precipitation across most of the Basin. Western Montana, Wyoming, and Colorado have increased chances for above-normal temperatures through November. No precipitation indicators are shown for precipitation in the December 2023-January 2024-February 2024 outlook either. The increased chance for above-normal temperatures shifts East to the Dakotas, eastern Nebraska, Iowa, and Missouri over the winter.

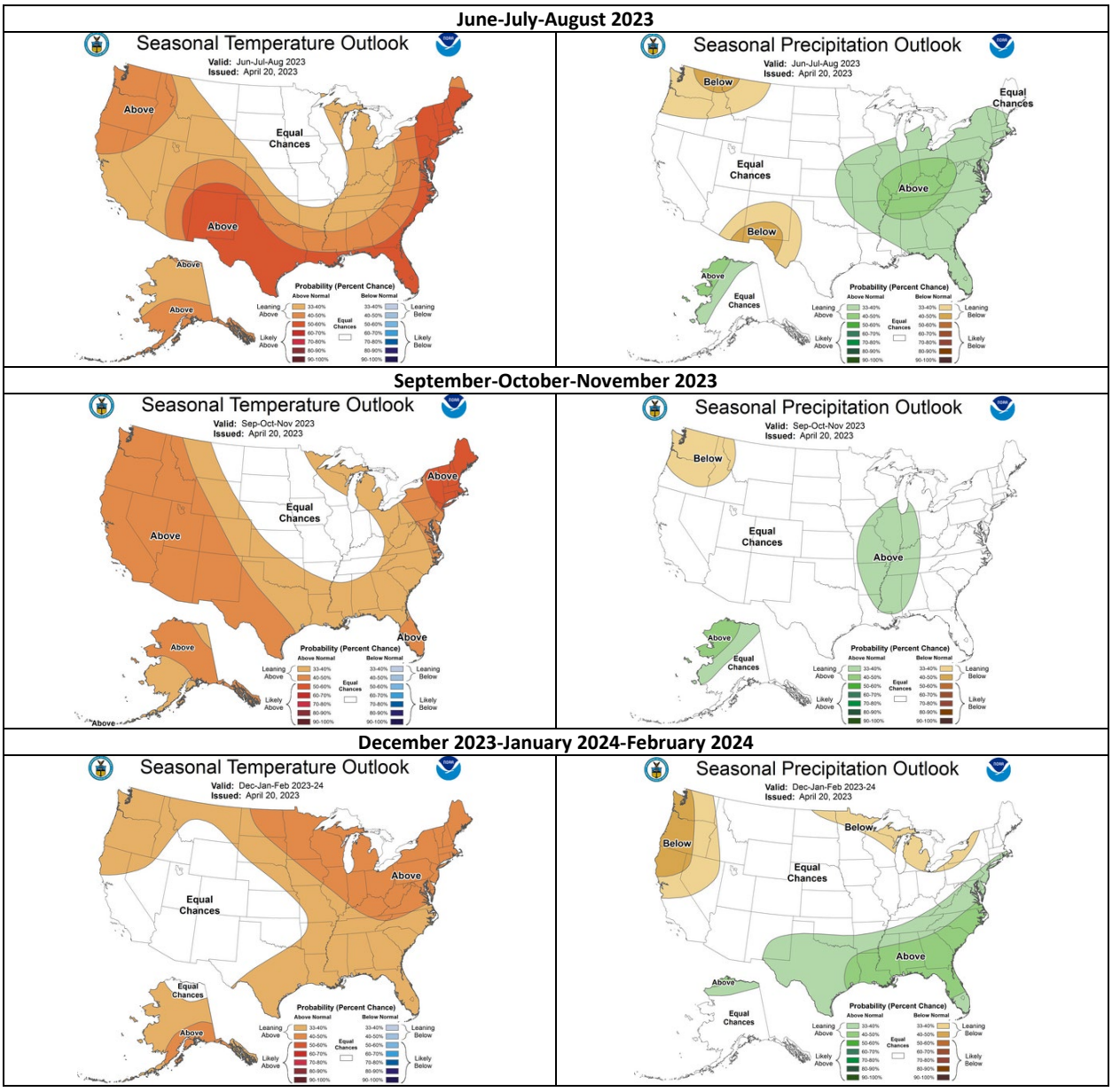


Figure 11. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given these conditions, runoff for the remainder of the year is forecasted to be near normal, but will greatly depend on precipitation received over the next 8 months.

In summary, the 2023 calendar year runoff forecast is **26.9 MAF, 105% of average**.

NRCS Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: May 03, 2023 03:05:18 PM
   - Based on May 01, 2023 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Lake Sherburne Inflow (2)	MAY-JUL	74	82	93	82	66	55	90
	MAY-SEP	87	83	108	95	79	66	105
St. Mary R at Intl Boundary (2)	MAY-JUL	350	84	455	390	305	245	415
	MAY-SEP	400	85	520	450	350	280	470
Lima Reservoir Inflow (2)	MAY-JUL	74	185	99	84	64	49	40
	MAY-SEP	84	168	111	95	73	57	50
Clark Canyon Inflow (2)	MAY-JUL	68	213	110	85	51	26	32
	MAY-SEP	83	224	130	102	64	36	37
Jefferson R nr Three Forks (2)	MAY-JUL	705	131	1000	825	585	410	540
	MAY-SEP	835	149	1150	960	710	525	560
Hebgen Lake Inflow (2)	MAY-JUL	380	133	455	410	350	305	285
	MAY-SEP	490	127	580	525	455	400	385
Ennis Lake Inflow (2)	MAY-JUL	680	132	795	725	635	565	515
	MAY-SEP	855	131	995	910	800	715	655
Missouri R at Toston (2)	MAY-JUL	1760	116	2350	2000	1520	1170	1520
	MAY-SEP	2170	128	2810	2430	1910	1530	1700
Smith R bl Eagle Ck (2)	MAY-JUL	100	125	146	119	81	54	80
	MAY-SEP	111	128	162	131	91	60	87
Gibson Reservoir Inflow (2)	MAY-JUL	325	97	390	350	300	260	335
	MAY-SEP	360	96	435	390	330	285	375
Marias R nr Shelby (2)	MAY-JUL	285	100	430	345	225	139	285
	MAY-SEP	290	100	450	355	225	132	290

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	MAY-JUL	59	104	67	62	56	51	57
	MAY-SEP	75	101	85	79	71	65	74
Wind R Ab Bull Lake Ck (2)	MAY-JUL	445	99	550	485	405	340	450
	MAY-SEP	470	107	585	515	425	355	440
Bull Lake Ck nr Lenore (2)	MAY-JUL	150	111	176	161	139	124	135
	MAY-SEP	180	110	210	192	168	150	163
Boysen Reservoir Inflow (2)	MAY-JUL	735	108	975	835	635	495	680
	MAY-SEP	795	110	1040	895	695	550	725
Greybull R at Meeteetse	MAY-JUL	146	107	199	167	125	93	137
	MAY-SEP	195	103	255	220	171	135	190
Shell Ck nr Shell	MAY-JUL	49	88	65	55	43	33	56
	MAY-SEP	60	88	77	67	53	43	68
Bighorn R at Kane (2)	MAY-JUL	980	106	1400	1150	810	565	925
	MAY-SEP	1050	110	1480	1220	875	620	955
NF Shoshone R at Wapiti	MAY-JUL	435	102	525	470	400	345	425
	MAY-SEP	485	100	585	525	445	385	485
SF Shoshone R nr Valley	MAY-JUL	200	95	245	220	181	154	210
	MAY-SEP	230	92	280	250	210	178	250
Buffalo Bill Reservoir Inflow (2)	MAY-JUL	625	101	770	685	565	480	620
	MAY-SEP	685	101	840	750	620	530	680
Bighorn R nr St. Xavier (2)	MAY-JUL	1460	99	2000	1680	1240	925	1480
	MAY-SEP	1540	96	2110	1770	1310	965	1610
Little Bighorn R nr Hardin	MAY-JUL	94	104	137	112	76	51	90
	MAY-SEP	109	101	158	129	89	60	108
Tongue R nr Dayton (2)	MAY-JUL	85	102	109	95	75	61	83

	MAY-SEP	98	102	125	109	87	71	96
Tongue River Reservoir Inflow (2)	MAY-JUL	194	97	275	225	161	113	200
	MAY-SEP	220	98	305	255	185	134	225
NF Powder R nr Hazelton	MAY-JUL	9.4	98	12.6	10.7	8.1	6.2	9.6
	MAY-SEP	10.1	96	13.5	11.5	8.7	6.7	10.5
Powder R at Moorhead	MAY-JUL	177	110	295	225	129	58	161
	MAY-SEP	193	112	315	240	144	72	173
Powder R nr Locate	MAY-JUL	189	103	315	240	137	61	184
	MAY-SEP	205	103	340	260	151	71	199

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	MAY-JUL	3.8	100	6.7	5.0	2.6	0.92	3.8
Pactola Reservoir Inflow (2)	MAY-JUL	16.6	85	30	22	11.1	3.1	19.5

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	MAY-JUL	255	150	335	285	225	176	170
	MAY-SEP	285	145	370	320	250	199	196
Encampment R nr Encampment (2)	MAY-JUL	199	166	240	215	183	159	120
	MAY-SEP	210	169	250	225	193	168	124
Rock Ck ab King Canyon Cnl nr Arlington	MAY-JUL	52	111	62	56	48	42	47
	MAY-SEP	55	110	65	59	51	45	50
Seminoe Reservoir Inflow (2)	MAY-JUL	805	140	1030	895	715	580	575
	MAY-SEP	870	139	1110	965	775	635	625
Sweetwater R nr Alcova	MAY-JUL	69	186	92	78	60	46	37
	MAY-SEP	75	183	100	85	65	50	41
La Prele Ck nr Douglas	MAY-JUL	19.4	145	28	23	15.9	10.7	13.4
	MAY-SEP	20	155	28	23	16.6	11.7	12.9
North Platte R bl Glendo Reservoir (2)	MAY-JUL	935	147	1240	1060	810	630	635
	MAY-SEP	975	148	1290	1100	850	665	660
North Platte R bl Guernsey Reservoir (2)	MAY-JUL	950	153	1260	1080	820	630	620
	MAY-SEP	985	152	1300	1110	855	665	650
Laramie R and Pioneer Cnl nr Woods Lg (2)	MAY-JUL	124	112	160	138	110	88	111
	MAY-SEP	136	113	174	151	121	98	120
Little Laramie R nr Filmore	MAY-JUL	56	114	72	62	50	40	49
	MAY-SEP	61	115	77	68	54	45	53

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
June 2023 Calendar Year Runoff Forecast
June 2, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 4.9 MAF, or 144% of average, for the basin above Sioux City, and 4.3 MAF, or 142% of average, above Gavins Point. Runoff was above-average or well above-average in all reaches except the Fort Randall reach, due to above-normal precipitation in some areas of the Basin and faster-than-normal melting of the mountain snowpack.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **26.8 MAF, 104% of average** and about the same as last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **23.8 MAF, 103% 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 31.7 MAF upper basic forecast to the 22.4 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for May 30, 2023 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 62% of the Basin, with about 7% of that being Extreme or

Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of August, indicates drought conditions are likely to persist or develop in areas of South Dakota, eastern Nebraska, and Iowa, but drought removal or improvement is likely over most of the upper Basin.

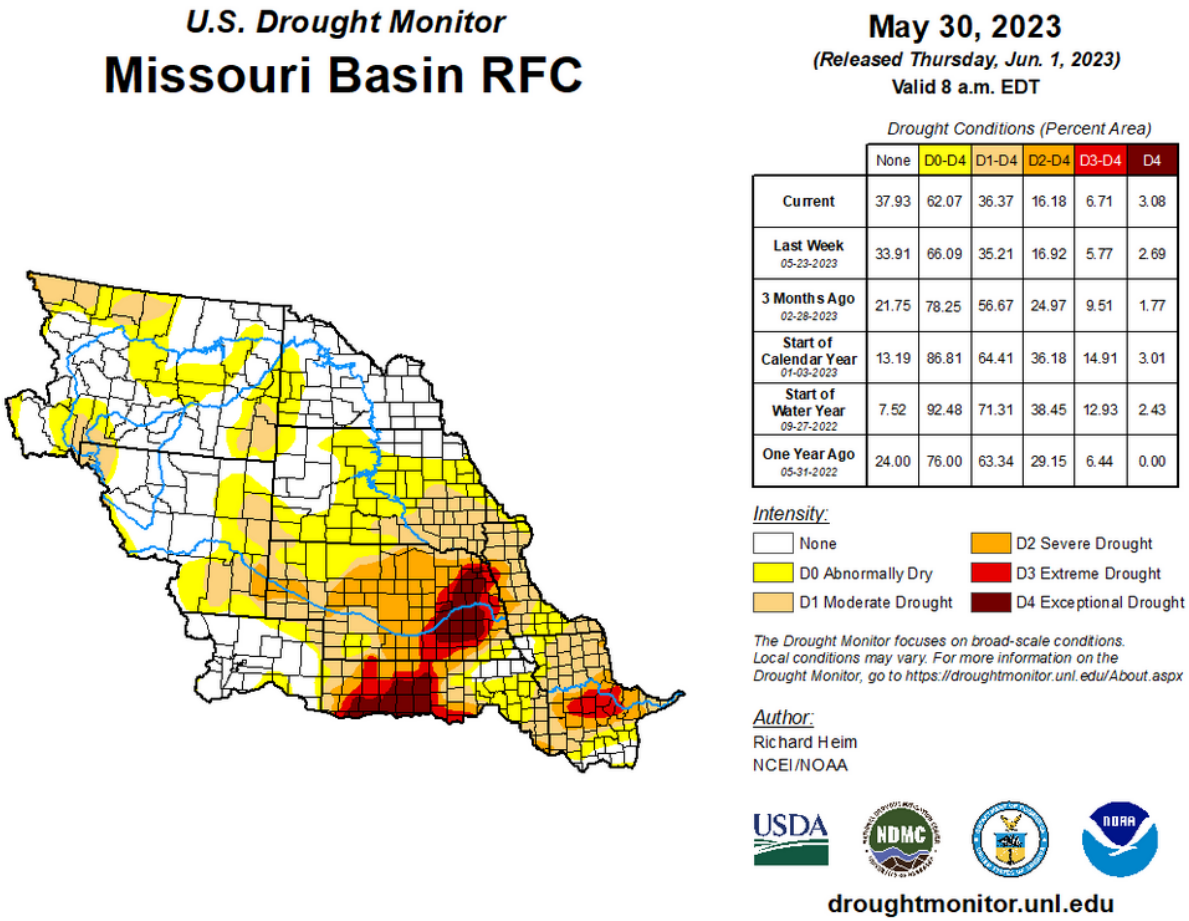


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

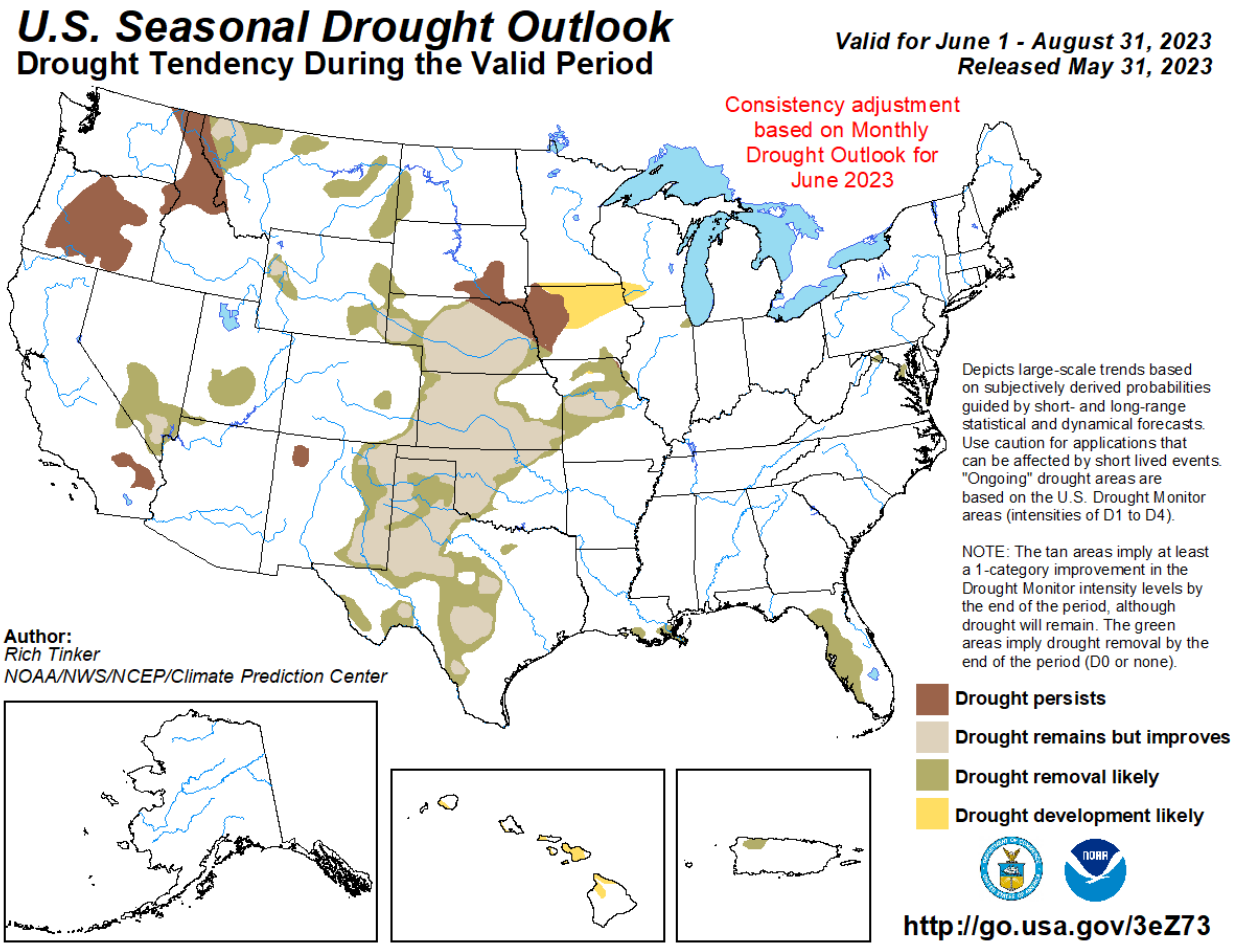


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The May precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was below normal over most of the Basin during May, except for a north-south stretch over eastern Montana, the western Dakotas, western Nebraska, and eastern Colorado that had up to 300 percent of normal precipitation.

Precipitation as a percent of normal for the March-April-May period (**Figure 4**) was below normal throughout most of the Basin, with pockets of slightly-above-normal precipitation in Montana, North Dakota, South Dakota, western Nebraska, and Colorado.

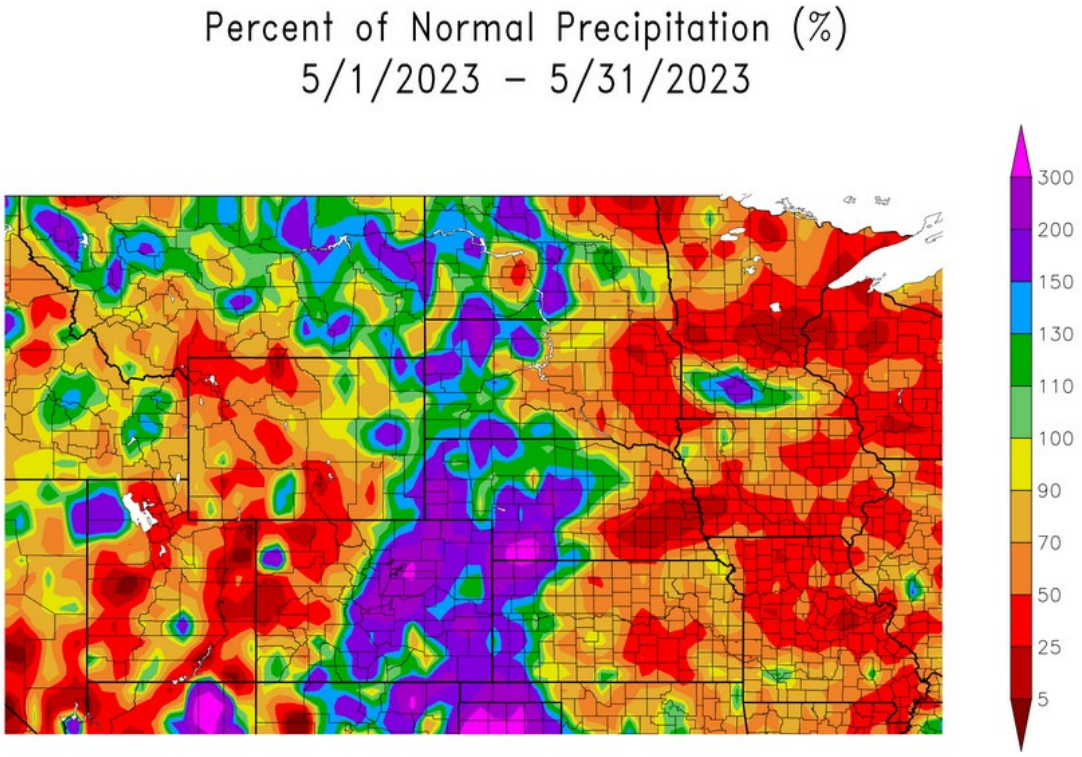


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

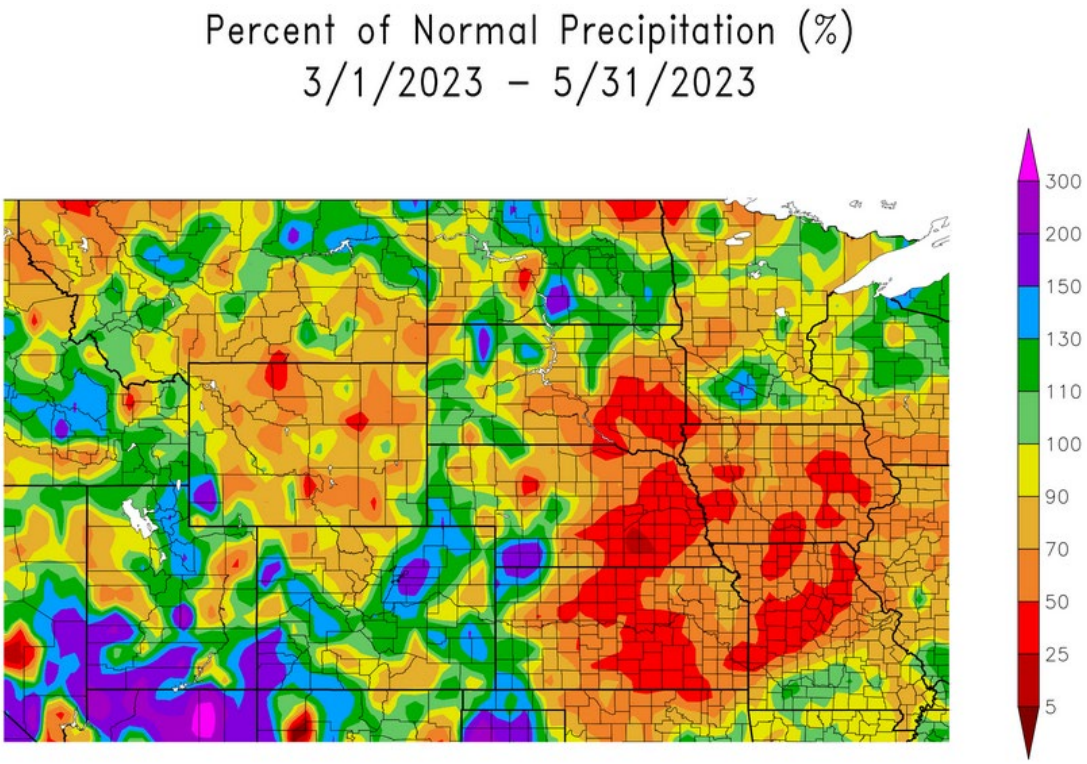


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

May temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate above-normal temperatures across the Basin. Areas along the Canadian border saw temperatures as high as 10 degrees above normal. March-April-May temperature departures are shown in **Figure 6**. The three-month average temperature departures were below normal across the upper Basin.

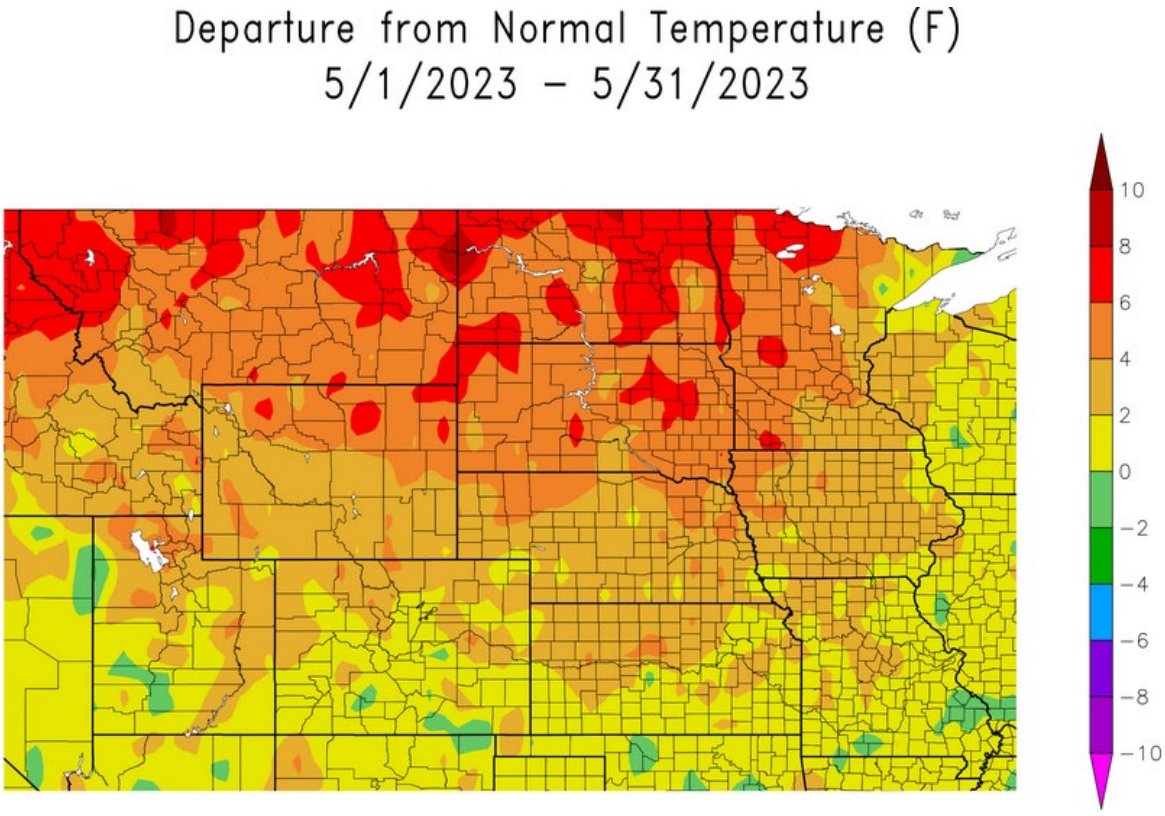


Figure 5. HPRCC Previous Month Departure from Normal Temperature

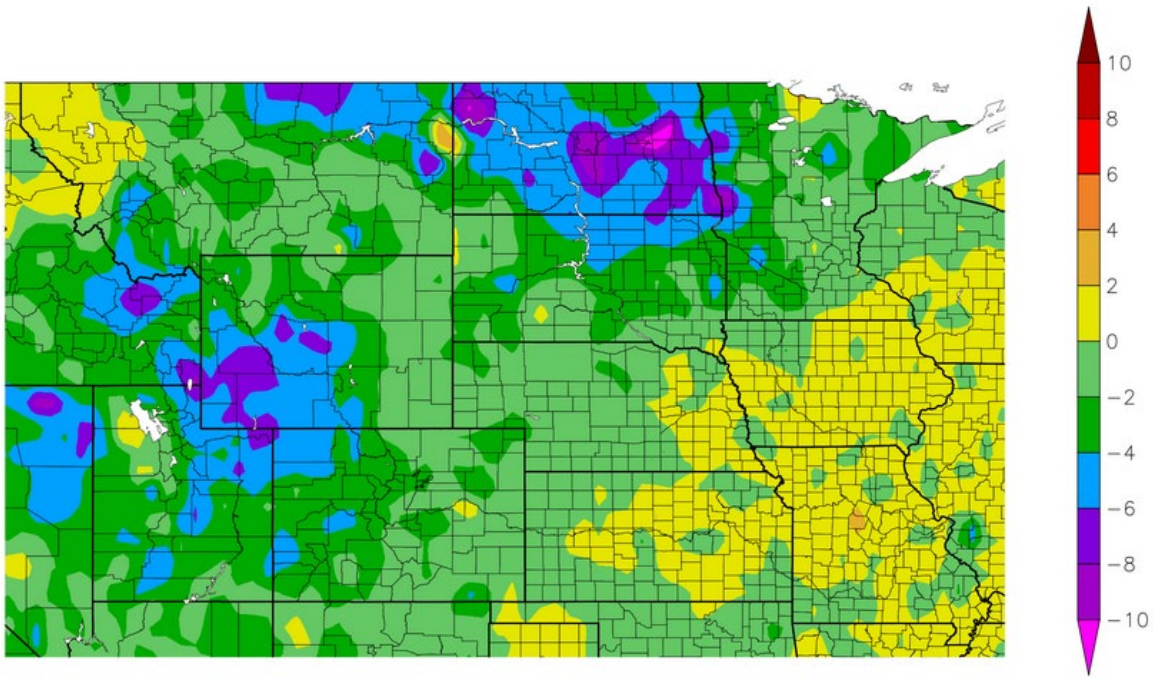


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of May is shown in **Figure 7**. Soil moisture is below normal in the eastern Dakotas, Wyoming, and across the lower Basin. Soil moisture percentiles are near normal for much of the upper Basin.

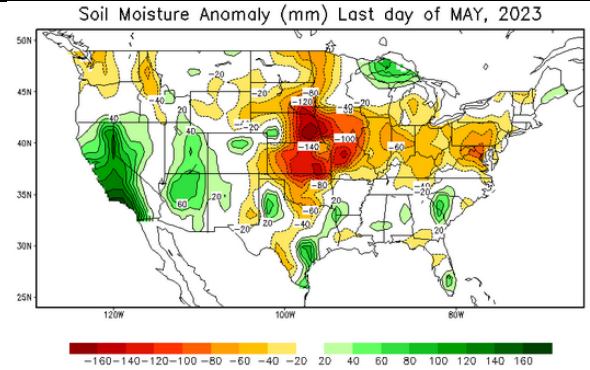
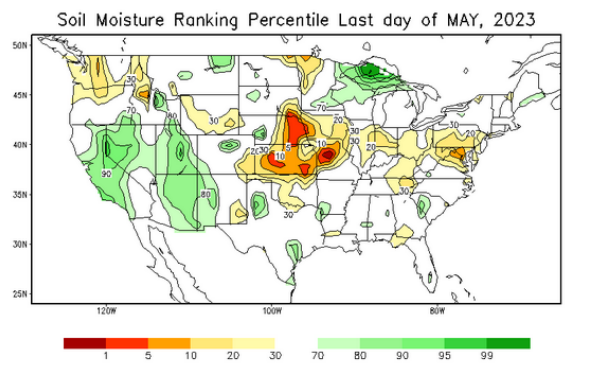
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
March 1, 2023	
	

Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. At this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack is not a factor in the June runoff forecast.

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. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 8** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line).

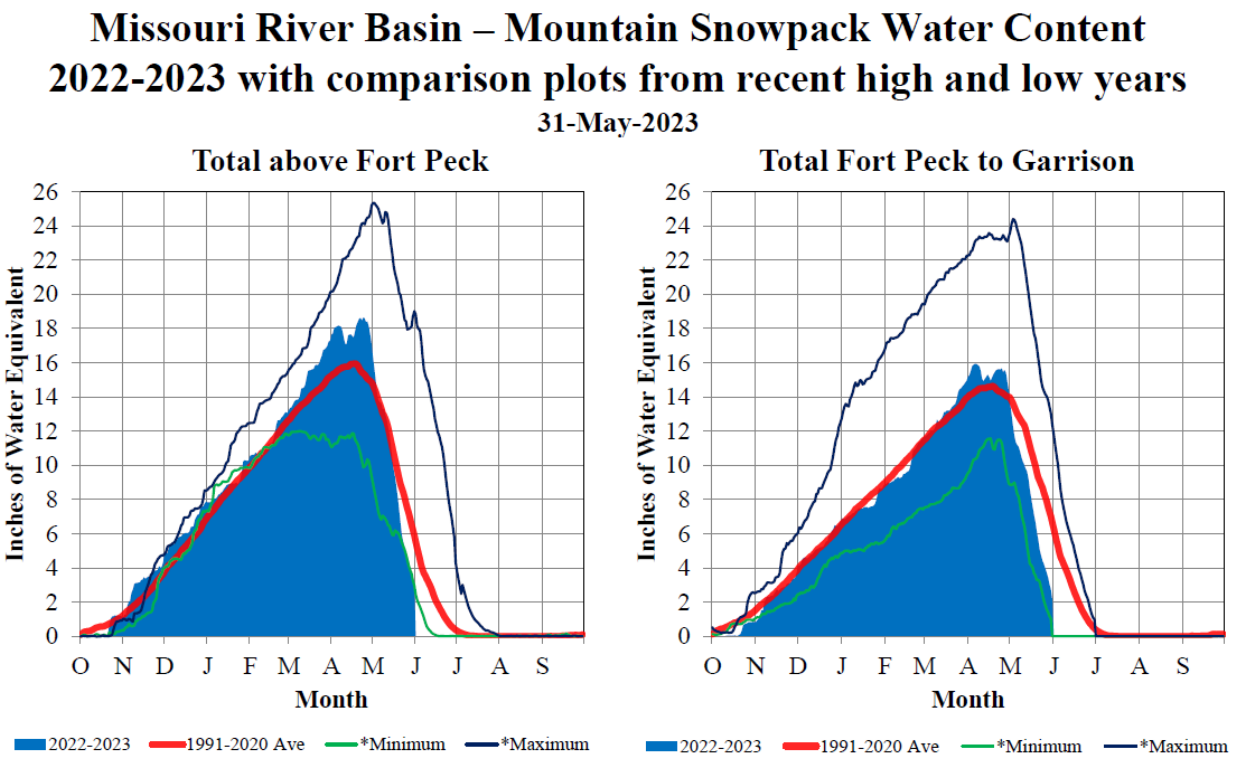


Figure 8. Mountain Snowpack Water Content

Mountain snowpack has peaked above normal in both reaches. The Fort Peck reach peaked at 117% of normal on April 24 and has 16% of the peak remaining on May 31. The Garrison reach peaked at 109% of normal on April 6 and has 13% of the peak remaining on May 31. Snowpack is melting off much faster than normal in both reaches.

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

The latest ENSO Outlook indicates ENSO-neutral conditions are currently present. These conditions are expected to transition to El Niño conditions over the next couple of months, with a greater than 90% chance of El Niño conditions persisting through the winter.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for June (**Figure 9**) indicates increased chances for above-normal temperatures across most of the Basin, with increased chances for below-normal temperatures in Colorado. The precipitation outlook (**Figure 9**) indicates increased chances for below-normal precipitation in eastern North Dakota, eastern South Dakota, and Iowa; increased chances for above-normal precipitation in Montana, Wyoming, and Colorado; and equal chances in between.

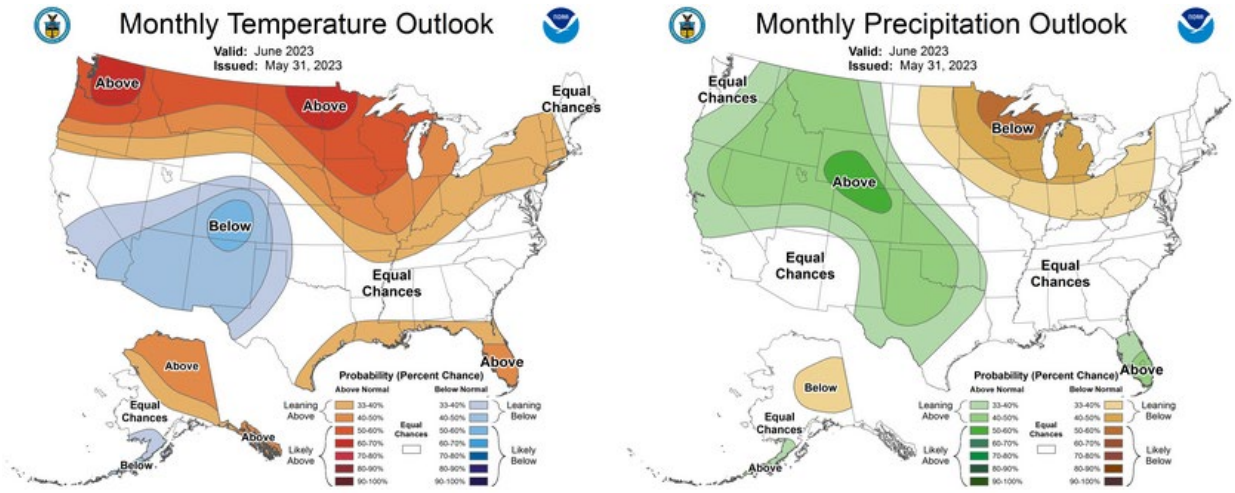


Figure 9. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 10**. The July-August-September temperature outlook indicates increased chances for above-normal temperatures in western Montana, Wyoming, and Colorado, with equal chances for the rest of the Basin. The precipitation outlook for the same period indicates equal chances for most of the Basin.

The October-November-December outlooks show equal chances for below-normal, normal, or above-normal temperatures and precipitation across the entire Basin.

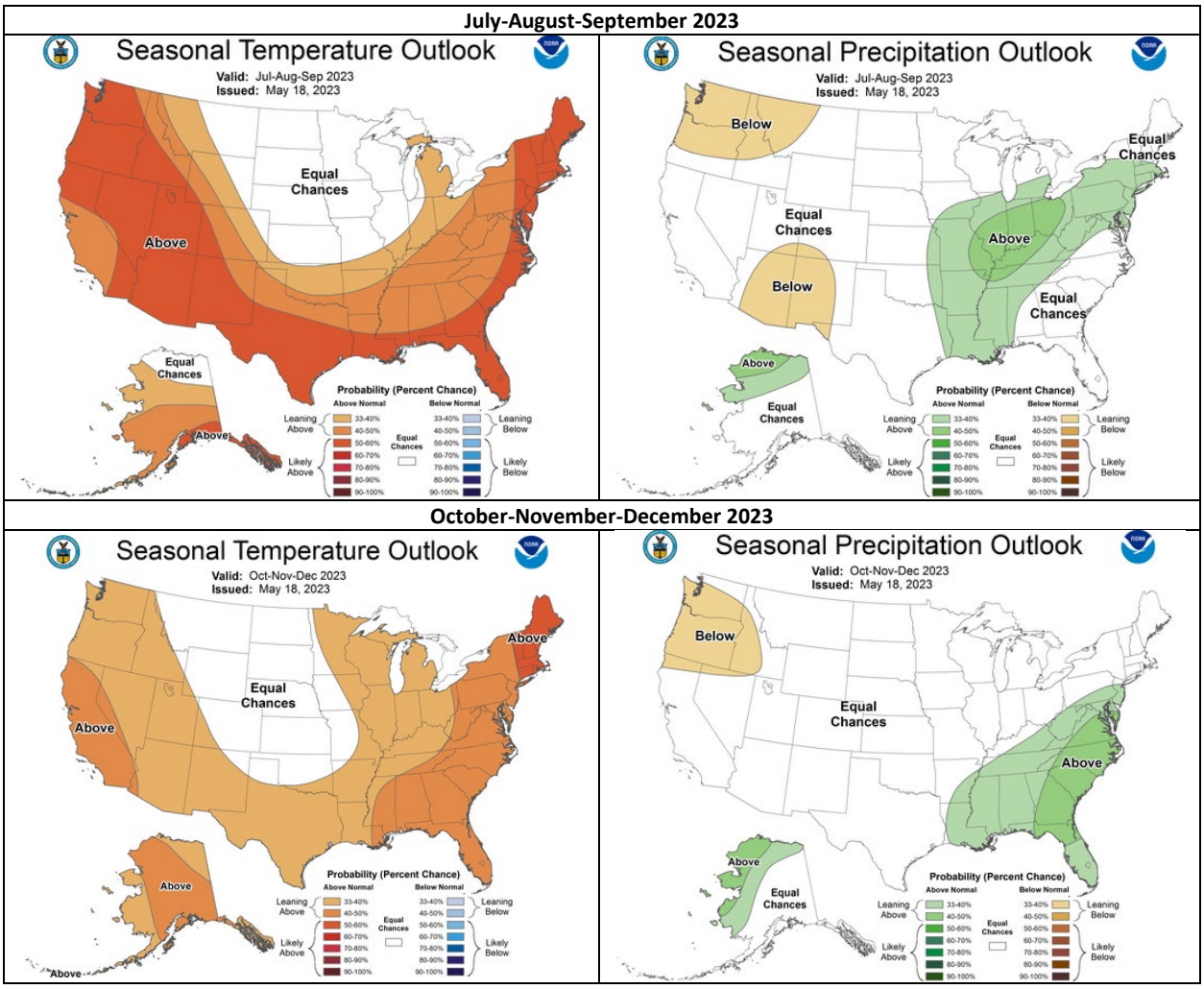


Figure 10. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given the conditions described in the preceding sections, runoff for the remainder of the year is forecasted to be near normal, but will greatly depend on precipitation received over the next 7 months.

In summary, the 2023 calendar year runoff forecast is **26.8 MAF, 104% of average**.

NRCS Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: June 06, 2023 10:35:57 AM
   - Based on June 01, 2023 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Lake Sherburne Inflow (2)	JUN-JUL	35	67	52	42	28	18.4	52
	JUN-SEP	48	73	68	56	40	28	66
St. Mary R at Intl Boundary (2)	JUN-JUL	179	69	275	220	140	82	260
	JUN-SEP	235	71	345	280	188	122	330
Lima Reservoir Inflow (2)	JUN-JUL	34	131	51	41	27	16.8	26
	JUN-SEP	43	123	63	51	35	23	35
Clark Canyon Inflow (2)	JUN-JUL	34	351	64	46	22	3.8	9.7
	JUN-SEP	45	238	82	60	30	8.0	18.9
Jefferson R nr Three Forks (2)	JUN-JUL	365	124	550	440	290	181	295
	JUN-SEP	405	127	625	495	315	184	320
Hebgen Lake Inflow (2)	JUN-JUL	169	109	210	186	152	127	155
	JUN-SEP	265	106	320	290	240	210	250
Ennis Lake Inflow (2)	JUN-JUL	335	108	425	370	300	245	310
	JUN-SEP	460	101	575	510	415	350	455
Missouri R at Toston (2)	JUN-JUL	860	92	1210	1000	720	510	935
	JUN-SEP	1070	95	1510	1250	895	635	1130
Smith R bl Eagle Ck (2)	JUN-JUL	54	120	95	71	37	12.8	45
	JUN-SEP	63	121	108	81	45	18.2	52
Gibson Reservoir Inflow (2)	JUN-JUL	150	85	210	175	125	89	176
	JUN-SEP	180	80	255	210	150	107	225
Marias R nr Shelby (2)	JUN-JUL	85	56	191	128	42	1.00	153
	JUN-SEP	89	66	210	138	39	1.00	135

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	JUN-JUL	40	83	47	43	37	33	48
	JUN-SEP	53	82	63	57	49	43	65
Wind R Ab Bull Lake Ck (2)	JUN-JUL	260	74	345	295	225	174	350
	JUN-SEP	270	75	385	315	225	155	360
Bull Lake Ck nr Lenore (2)	JUN-JUL	89	86	109	97	81	69	103
	JUN-SEP	116	89	143	127	105	89	130
Boysen Reservoir Inflow (2)	JUN-JUL	455	100	610	520	390	300	455
	JUN-SEP	465	96	660	545	385	270	485
Greybull R at Meeteetse	JUN-JUL	95	93	135	111	79	55	102
	JUN-SEP	138	90	186	157	119	90	153
Shell Ck nr Shell	JUN-JUL	24	71	34	28	19.8	13.5	34
	JUN-SEP	35	74	47	40	30	23	47
Bighorn R at Kane (2)	JUN-JUL	555	82	815	660	450	295	675
	JUN-SEP	570	77	880	695	445	260	740
NF Shoshone R at Wapiti	JUN-JUL	255	81	320	280	230	192	315
	JUN-SEP	300	81	370	330	270	230	370
SF Shoshone R nr Valley	JUN-JUL	135	84	174	151	119	96	160
	JUN-SEP	162	84	205	180	144	117	194
Buffalo Bill Reservoir Inflow (2)	JUN-JUL	375	82	480	420	330	270	460
	JUN-SEP	430	83	550	480	380	310	520
Bighorn R nr St. Xavier (2)	JUN-JUL	815	78	1170	960	670	460	1050
	JUN-SEP	830	75	1260	1000	655	400	1110
Little Bighorn R nr Hardin	JUN-JUL	43	78	71	54	32	14.9	55
	JUN-SEP	54	79	87	68	40	21	68
Tongue R nr Dayton (2)	JUN-JUL	36	75	50	42	31	23	48

	JUN-SEP	47	76	63	53	41	31	62
Tongue River Reservoir Inflow (2)	JUN-JUL	86	70	131	104	68	41	123
	JUN-SEP	105	73	159	127	83	51	144
NF Powder R nr Hazelton	JUN-JUL	3.9	89	6.1	4.8	3.0	1.65	4.4
	JUN-SEP	4.6	87	7.0	5.6	3.6	2.2	5.3
Powder R at Moorhead	JUN-JUL	87	99	158	116	58	16.2	88
	JUN-SEP	104	98	180	135	73	28	106
Powder R nr Locate	JUN-JUL	99	100	185	134	64	13.0	99
	JUN-SEP	117	97	210	156	78	22	121

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	JUN-JUL	2.6	108	4.0	3.2	2.0	1.21	2.4
Pactola Reservoir Inflow (2)	JUN-JUL	10.8	105	20	14.7	6.9	1.13	10.3

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	JUN-JUL	124	102	172	143	105	76	122
	JUN-SEP	146	102	197	167	125	95	143
Encampment R nr Encampment (2)	JUN-JUL	84	127	103	92	76	65	66
	JUN-SEP	93	127	114	101	85	72	73
Rock Ck ab King Canyon Cnl nr Arlington	JUN-JUL	25	83	31	27	22	18.7	30
	JUN-SEP	27	82	33	29	24	20	33
Seminoe Reservoir Inflow (2)	JUN-JUL	360	101	475	405	315	245	355
	JUN-SEP	410	103	530	460	360	290	400
Sweetwater R nr Alcova	JUN-JUL	24	104	34	28	20	13.9	23
	JUN-SEP	28	108	41	33	23	15.6	26
La Prele Ck nr Douglas	JUN-JUL	3.2	119	7.1	4.6	2.1	0.84	2.7
	JUN-SEP	3.9	103	8.5	5.6	3.9	1.10	3.8
North Platte R bl Glendo Reservoir (2)	JUN-JUL	345	95	485	400	290	205	365
	JUN-SEP	365	94	510	425	305	220	390
North Platte R bl Guernsey Reservoir (2)	JUN-JUL	340	96	485	400	280	197	355
	JUN-SEP	355	93	505	415	295	205	380
Laramie R and Pioneer Cnl nr Woods Lg (2)	JUN-JUL	62	86	81	70	54	42	72
	JUN-SEP	71	88	92	80	63	51	81
Little Laramie R nr Filmore	JUN-JUL	28	80	36	31	24	19.5	35
	JUN-SEP	31	79	40	35	28	22	39

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
July 2023 Calendar Year Runoff Forecast
July 5, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 6.7 MAF, or 122% of average, for the basin above Sioux City, and 6.4 MAF, or 123% of average, above Gavins Point. Runoff was above-average in all reaches except the Fort Randall and Sioux City reaches due to above-normal precipitation and faster-than-normal melting of the mountain snowpack.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **29.2 MAF, 114% of average** and 2.4 MAF higher than last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **26.5 MAF, 114% 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 32.2 MAF upper basic forecast to the 26.5 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.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for July 4 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 45% of the Basin, with about 9% of that being Extreme or

Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of September, indicates drought removal or improvement is likely over most of the areas impacted by dryness.

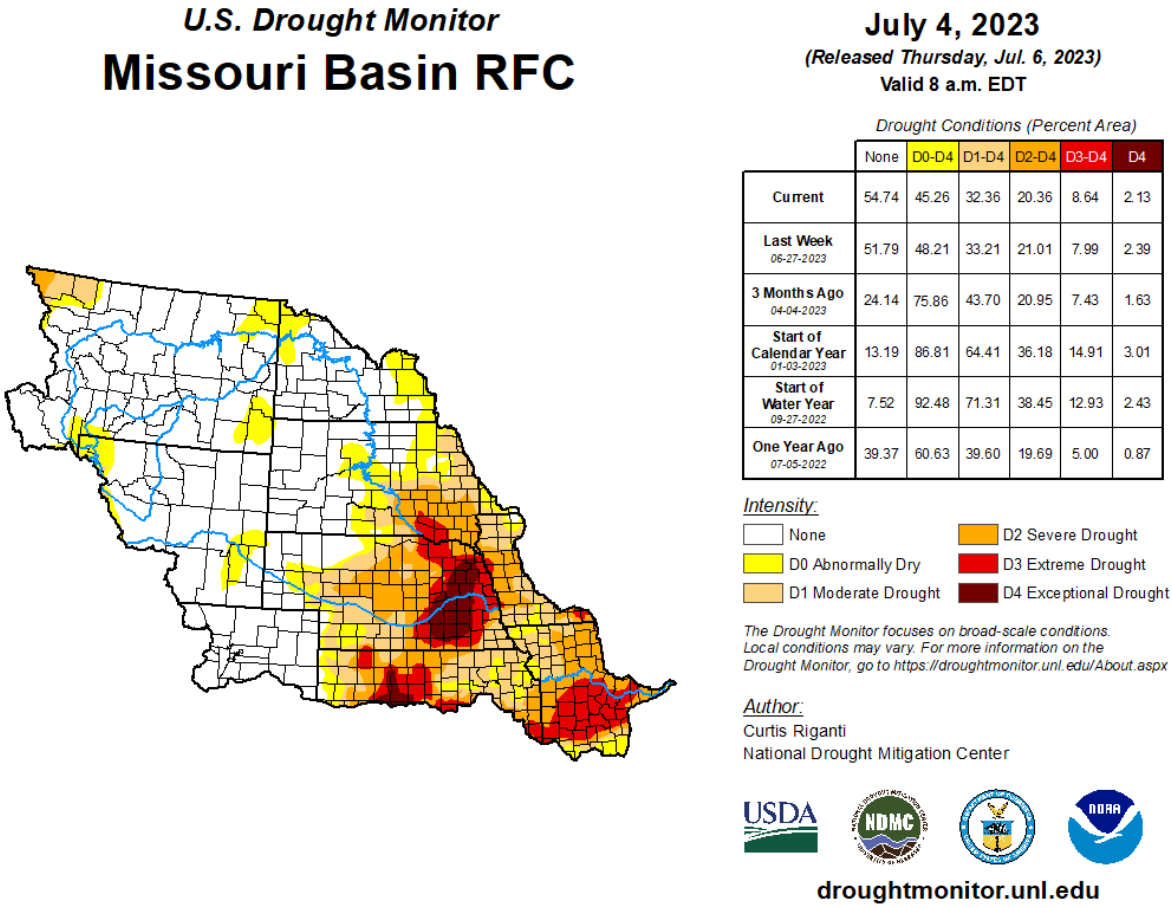


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

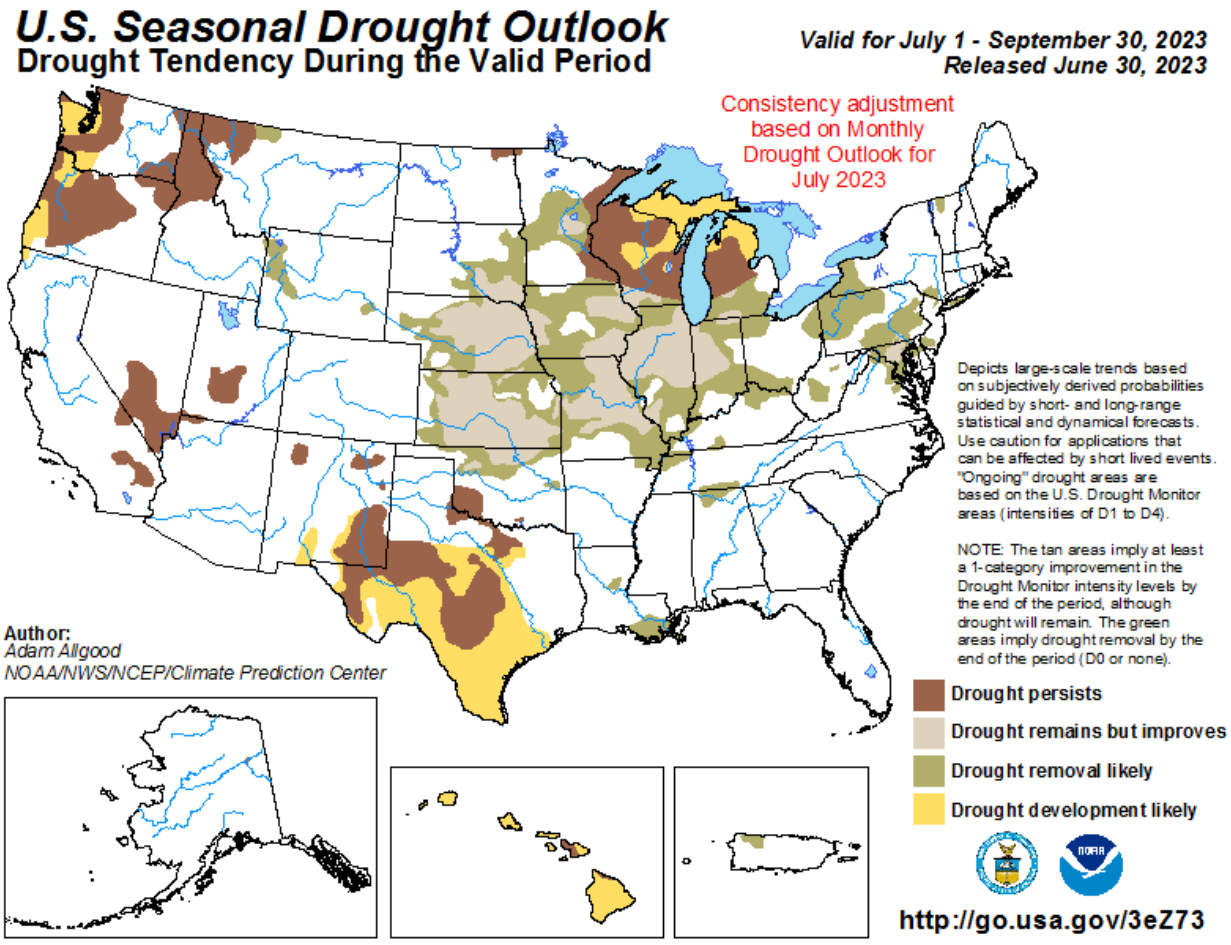


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The June precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was above normal or well above normal in southern Montana, Wyoming, and into southwestern North Dakota and northwestern South Dakota. Precipitation was normal to below normal in most of the rest of the Basin.

Precipitation as a percent of normal for the April-May-June period (**Figure 4**) was normal or above normal in most of Montana, Wyoming, western South Dakota, and southern and central North Dakota. Precipitation was below normal in parts of North Dakota, eastern South Dakota, and into the lower Basin.

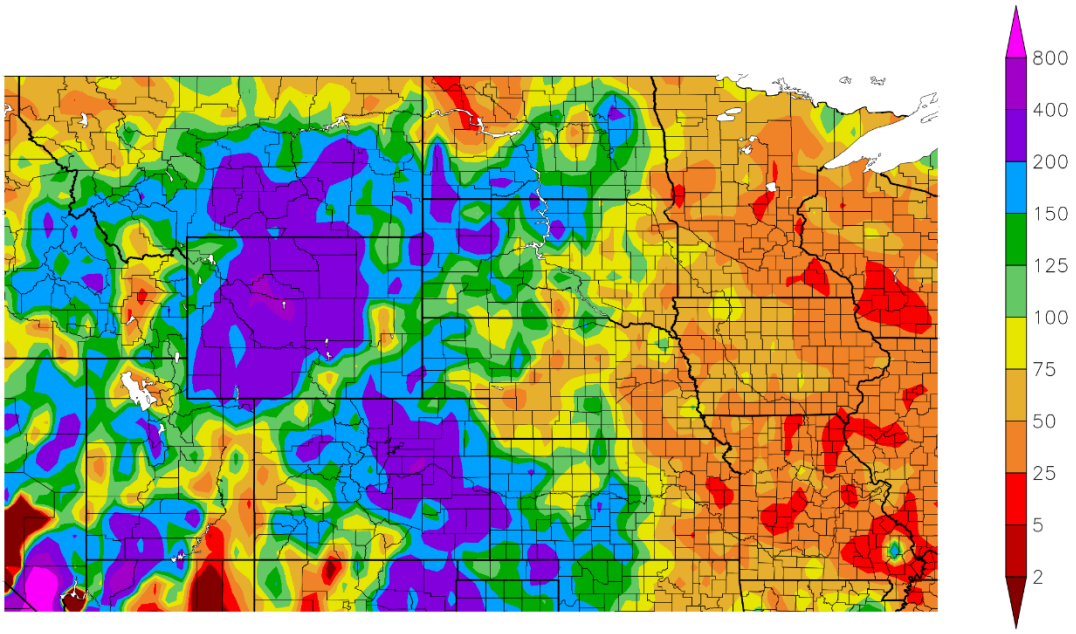


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

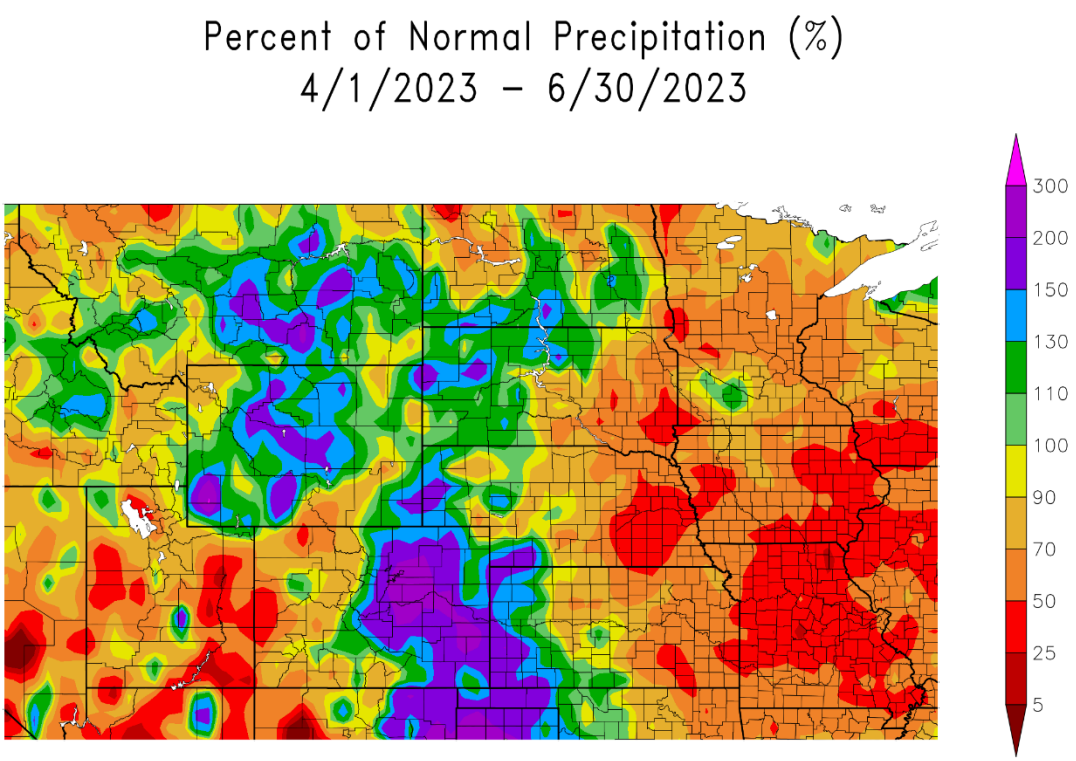


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

June temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate above normal temperatures across most of the Basin. April-May-June temperature departures are shown in **Figure 6**. The three-month average temperature departures were above normal or normal across the Basin.

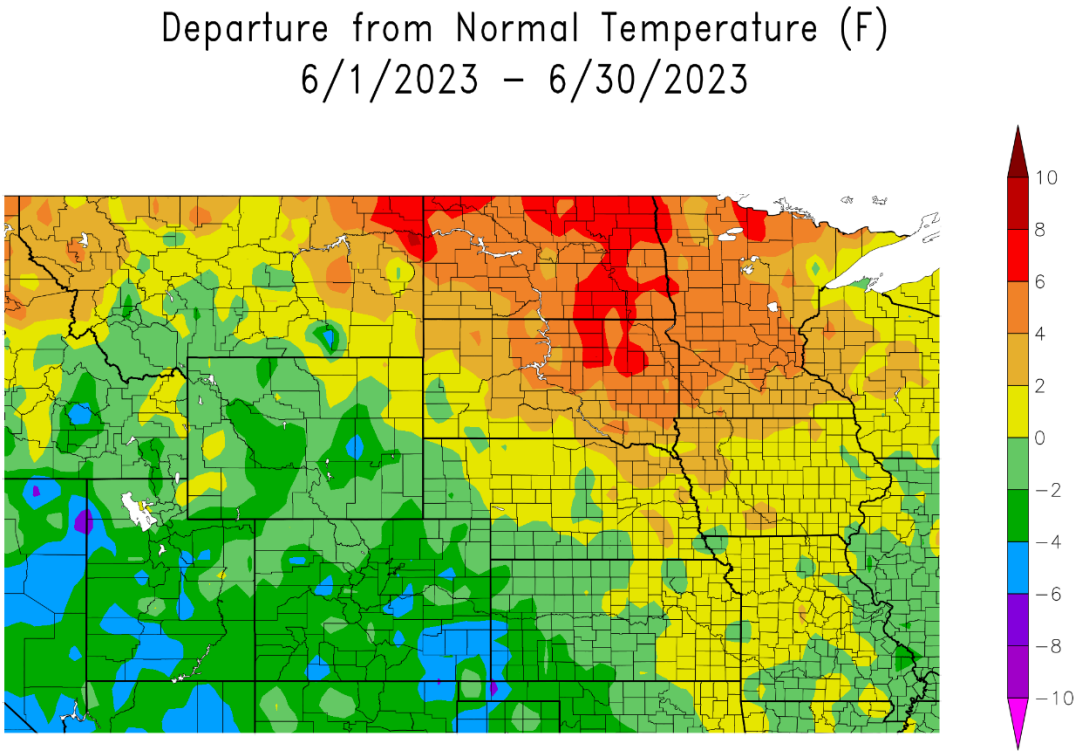


Figure 5. HPRCC Previous Month Departure from Normal Temperature

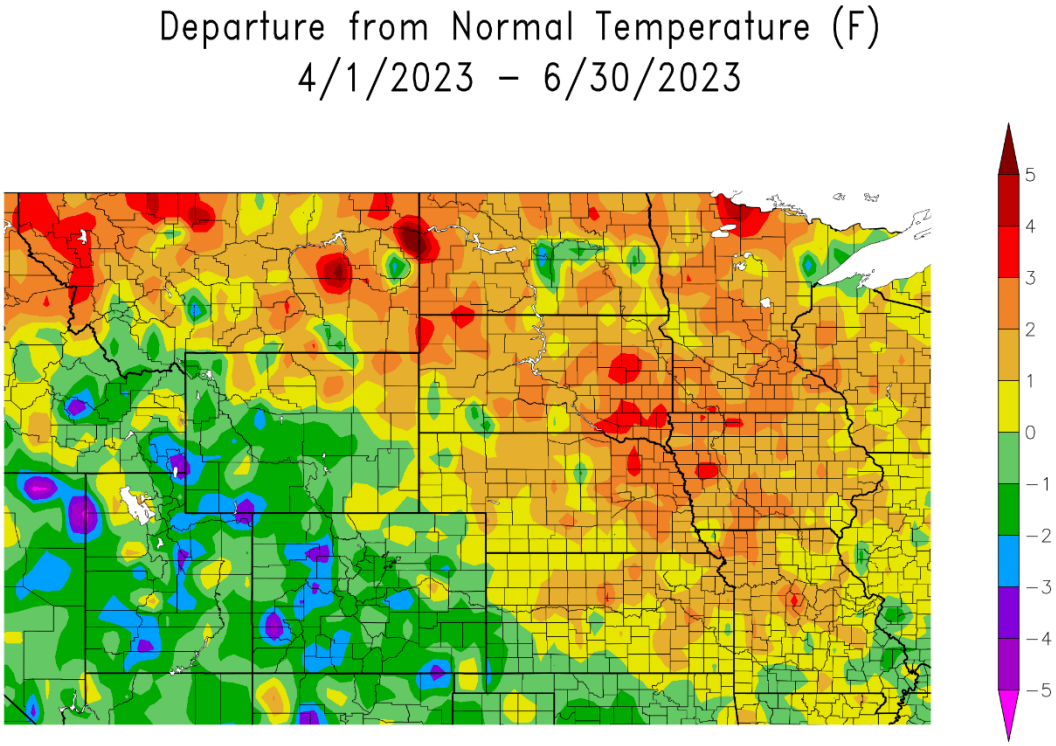


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of June is shown in **Figure 7**. Soil moisture is below normal in eastern South Dakota and much of the lower Basin, and is above normal in south-central Montana and into some parts of southwestern North Dakota and northwestern South Dakota.

Soil Moisture Anomaly (mm)	Soil Moisture Percentile
June 30, 2023	

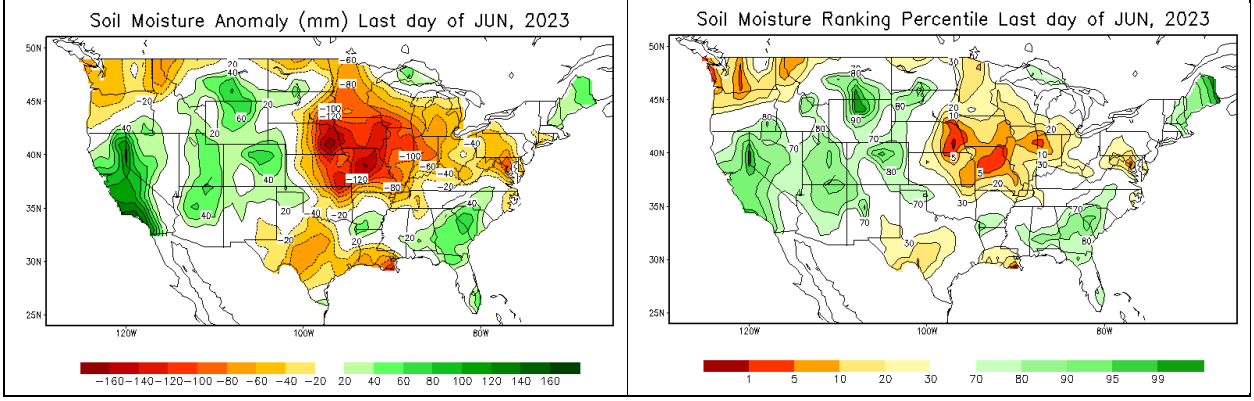


Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. At this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

Plains snowpack is not a factor in the July runoff forecast.

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. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 8** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line).

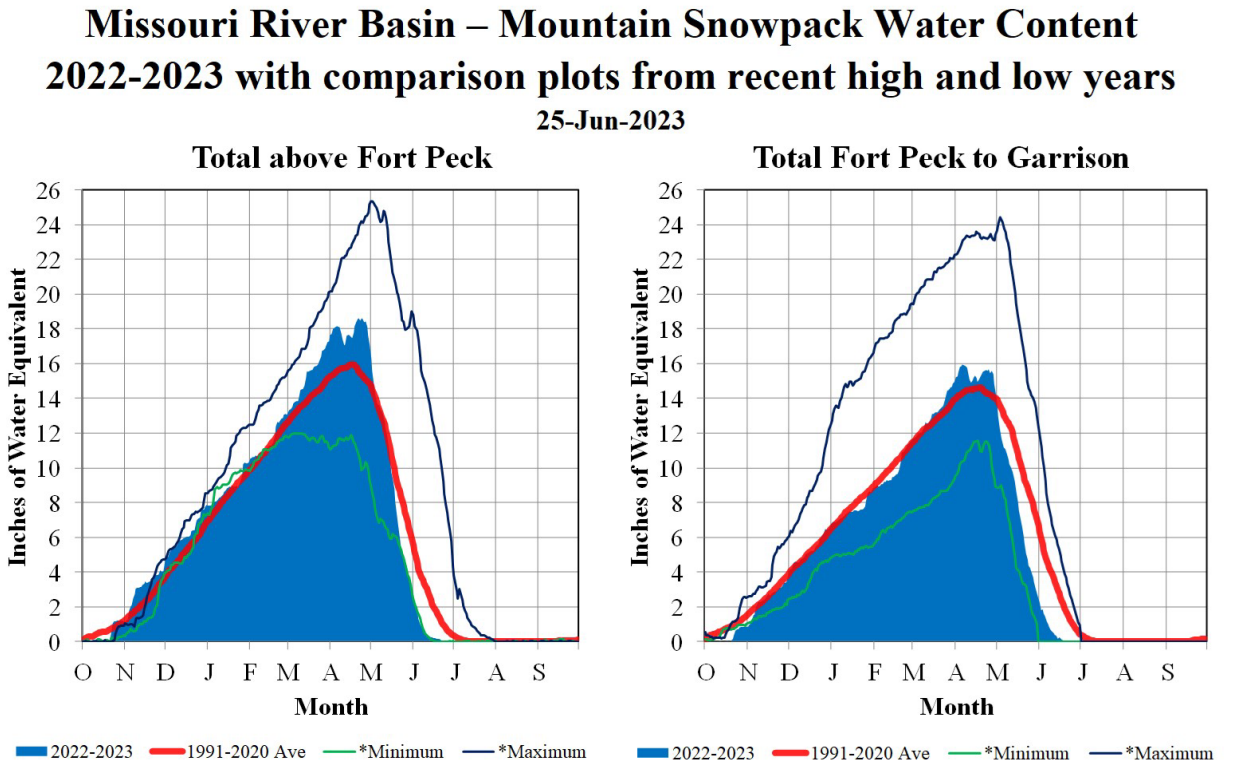


Figure 8. Mountain Snowpack Water Content

Mountain snowpack peaked in the Fort Peck reach on April 24 at 18.6” SWE and 117% of the normal peak. The Garrison reach peaked on April 6 at 15.9” SWE and 109% of the normal peak. As of June 25, all mountain snowpack has melted in both reaches.

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above-normal snowfall across the northern Rockies.

The latest ENSO Outlook indicates weak El Niño conditions are currently present. These conditions are expected to gradually strengthen into winter.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for July (**Figure 9**) indicates equal chances for below-normal, normal, or above-normal temperatures across most of the Basin. The precipitation outlook (**Figure 9**) indicates increased chances for above-normal precipitation in the lower Basin and into southern South Dakota, with equal chances for above-normal, normal, or below-normal precipitation in the rest of the Basin.

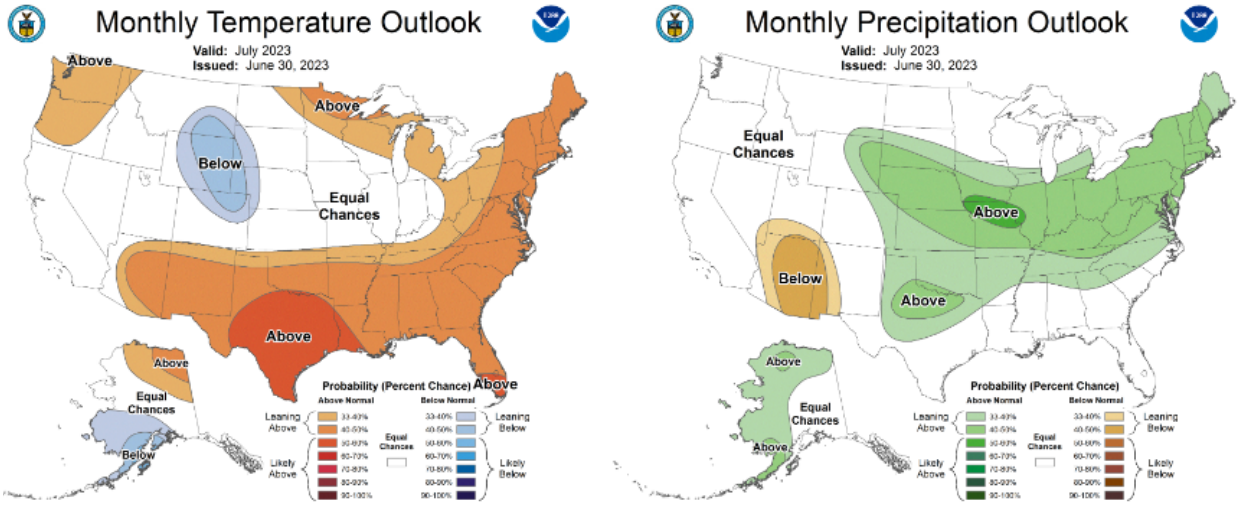


Figure 9. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 10**. The July-August-September temperature outlook indicates equal chances for most of the Basin. The precipitation outlook for the same period indicates increased chances for above-normal precipitation in southern Montana, Wyoming, South Dakota, and into the lower Basin, with equal chances for the rest of the Basin.

The October-November-December outlooks show equal chances for below-normal, normal, or above-normal temperatures and precipitation across the entire Basin.

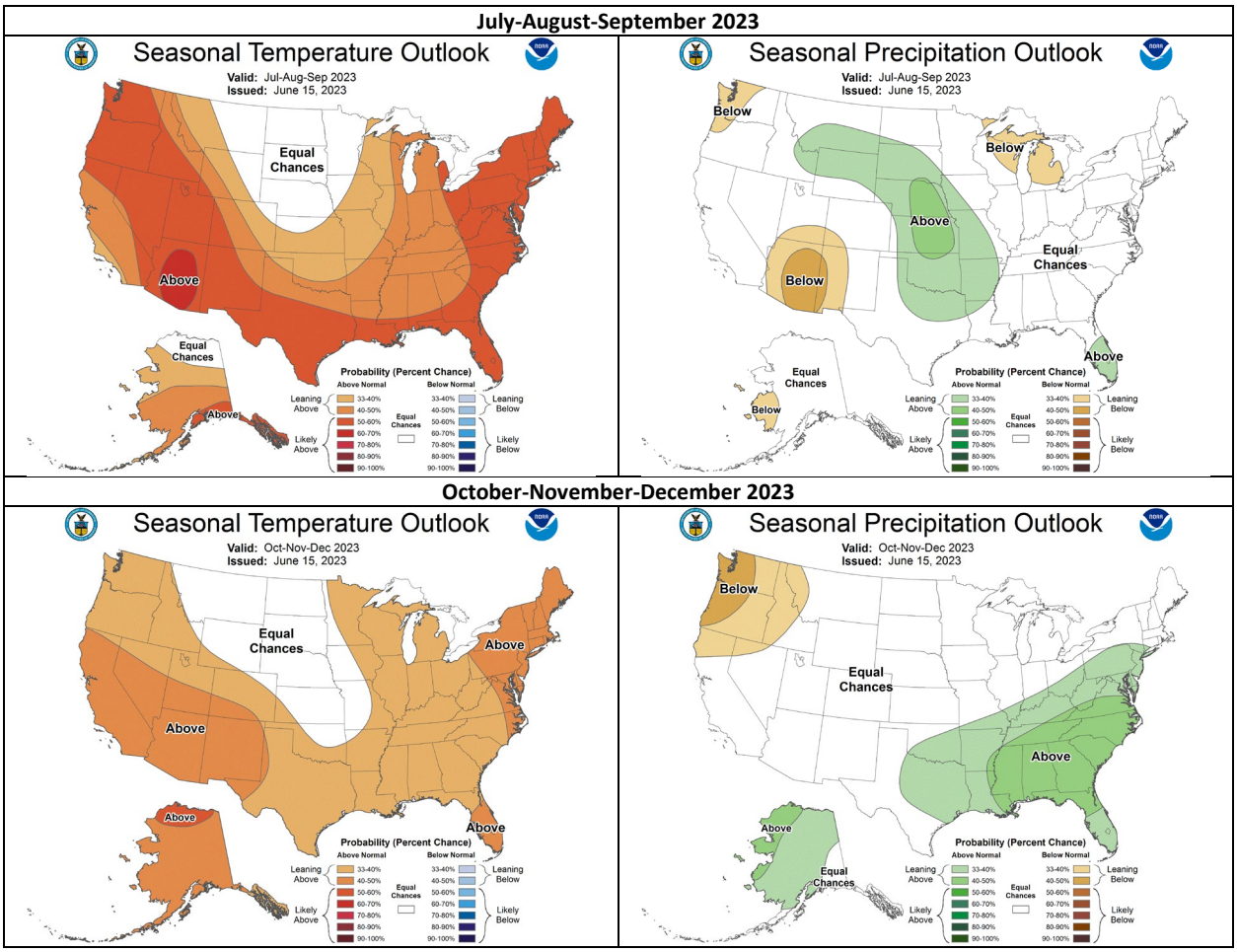


Figure 10. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given the conditions described in the preceding sections, runoff for the remainder of the year is forecasted to be near normal but will depend on precipitation received over the next 6 months.

In summary, the 2023 calendar year runoff forecast is **29.2 MAF, 114% of average**.

Upper Missouri River Basin
August 2023 Calendar Year Runoff Forecast
August 1, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 3.3 MAF, or 99% of average, for the basin above Sioux City, and 3.0 MAF, or 98% of average, above Gavins Point. Runoff was near or above average in all reaches except the Fort Peck reach, which was 68% of average.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **28.5 MAF, 111% of average** and 0.7 MAF lower than last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **25.7 MAF, 111% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 5 months, expected inflow could range from the 29.9 MAF upper basic forecast to the 27.2 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.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for July 4 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 46% of the Basin, with about 6% of that being Extreme or Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of

October, indicates drought removal or improvement is likely over most of the areas impacted by dryness except the northern tier of the Basin.

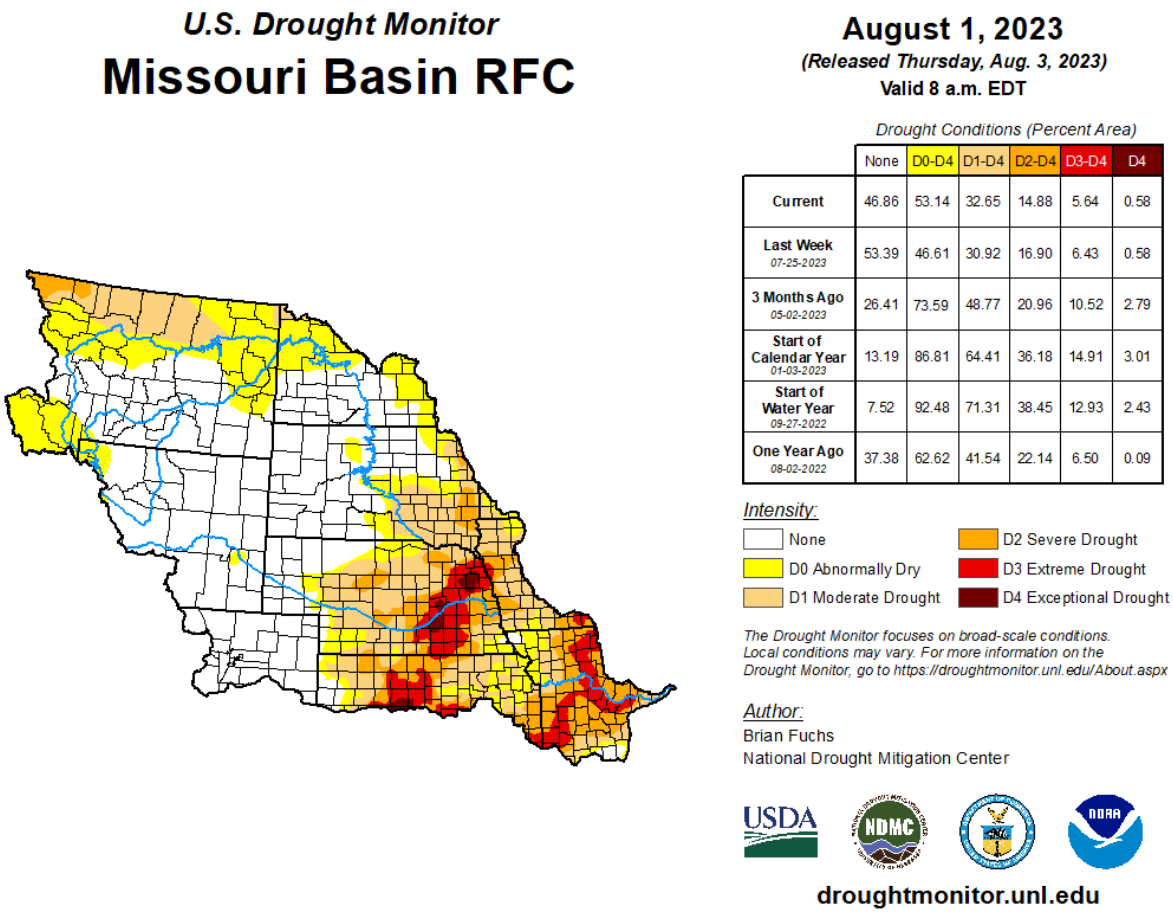


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

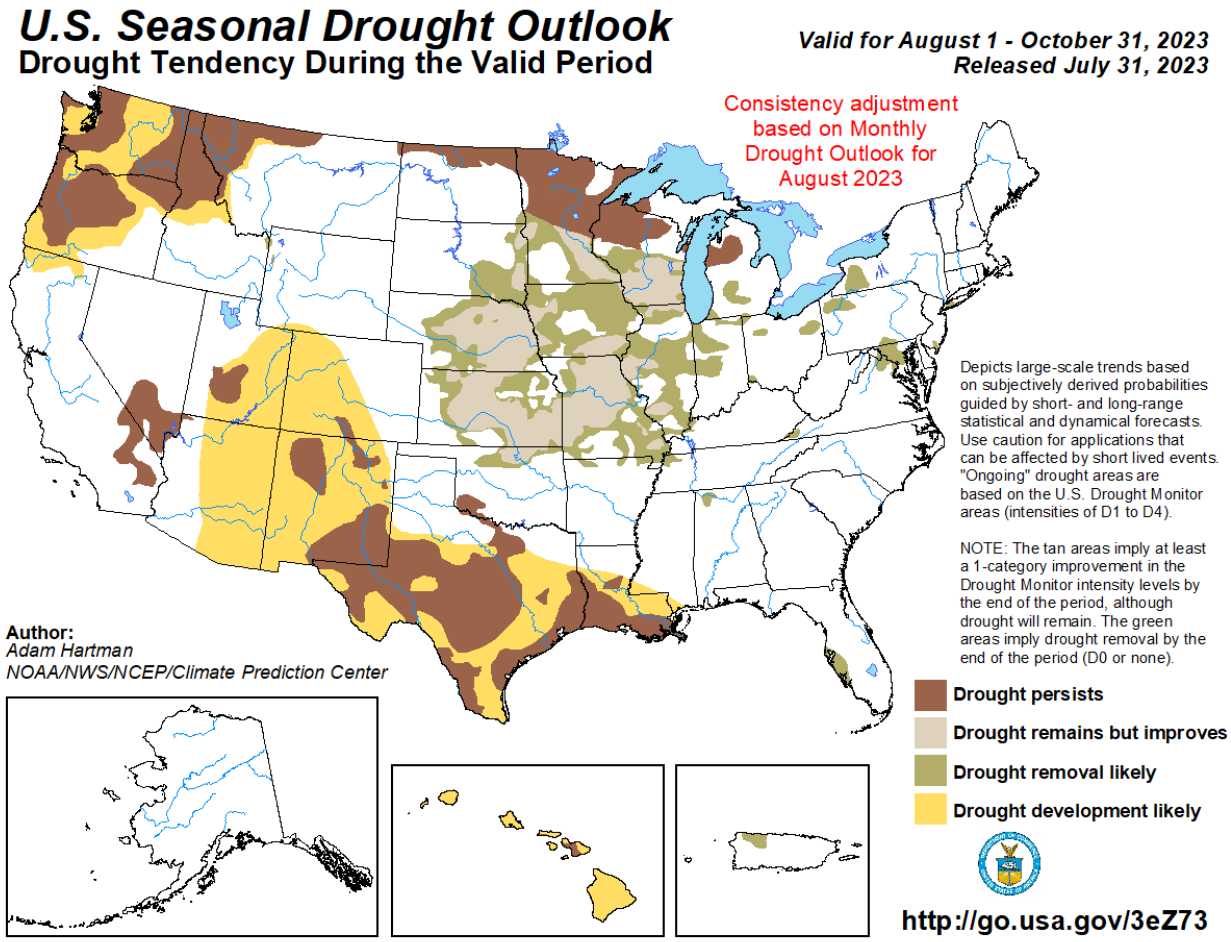


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The July precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was below normal over most of the upper Basin last month except for small pockets across Wyoming, southern South Dakota, and northern Nebraska. The lower Basin saw a mix of above- and below-normal precipitation.

Precipitation as a percent of normal for the May-June-July period (**Figure 4**) was below normal across northern Montana, northern North Dakota, and over the eastern side of the Basin. Normal to above-normal precipitation occurred in the rest of the Basin.

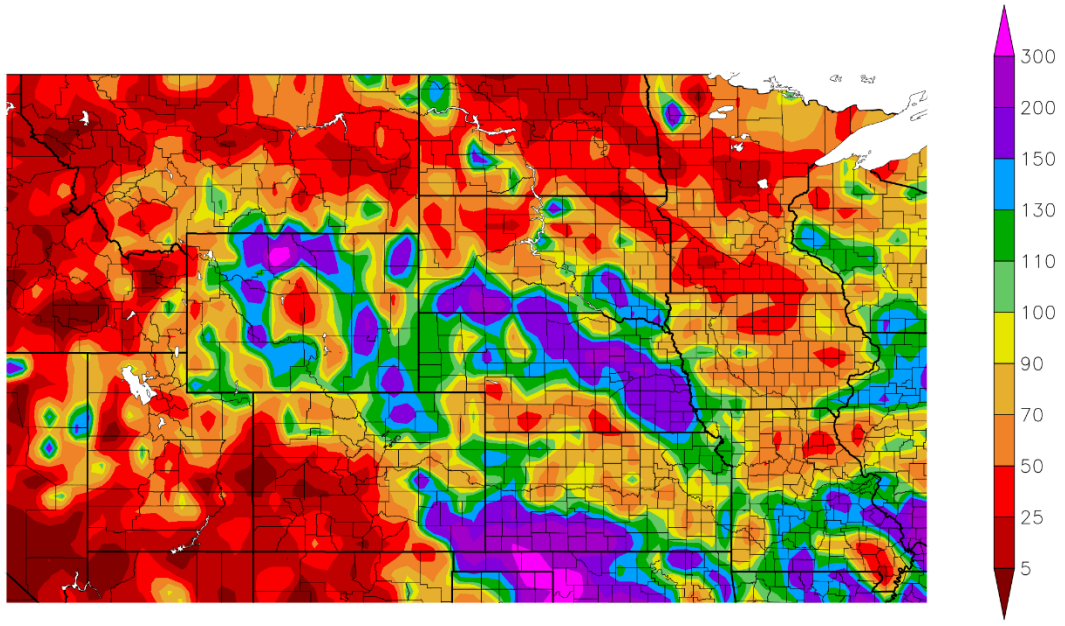


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

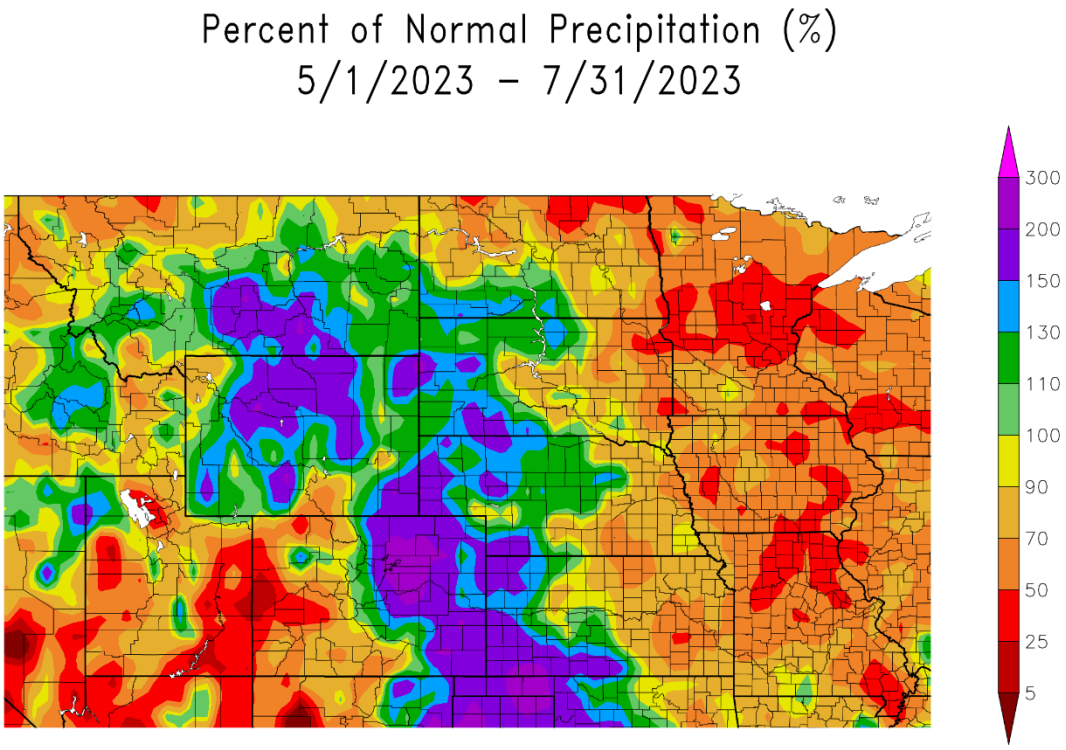


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

July temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate normal to below normal temperatures across most of the Basin. May-June-July temperature departures are shown in **Figure 6**. The three-month average temperature departures were above normal in the upper Basin and normal over the lower Basin.

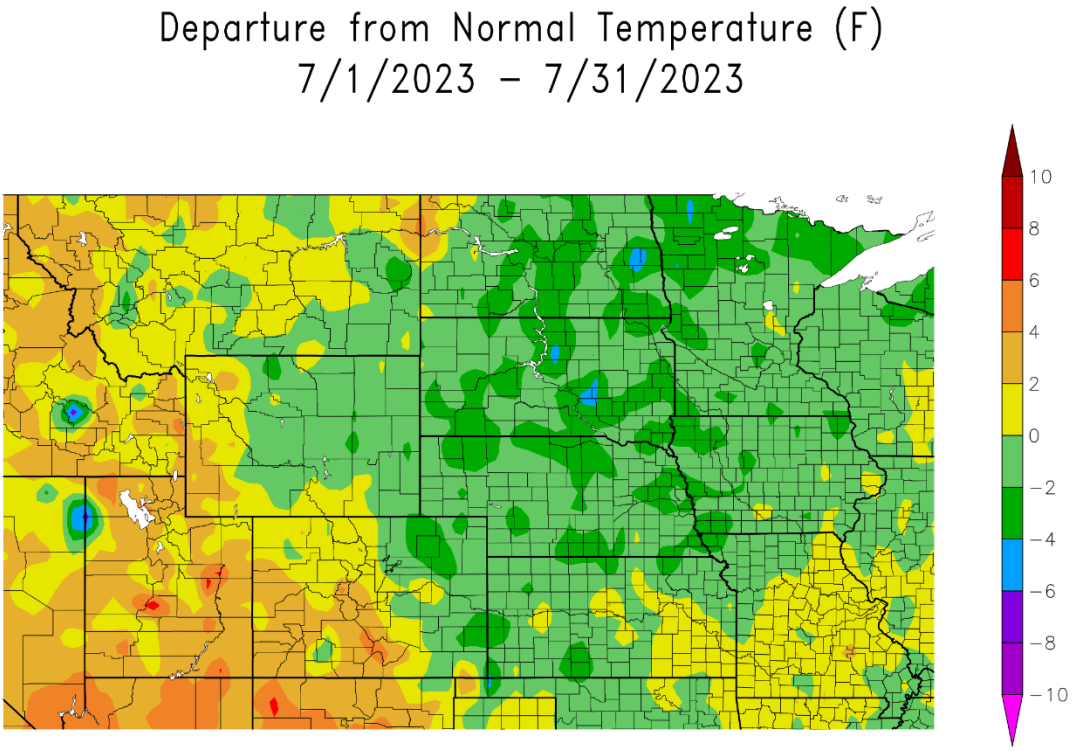


Figure 5. HPRCC Previous Month Departure from Normal Temperature

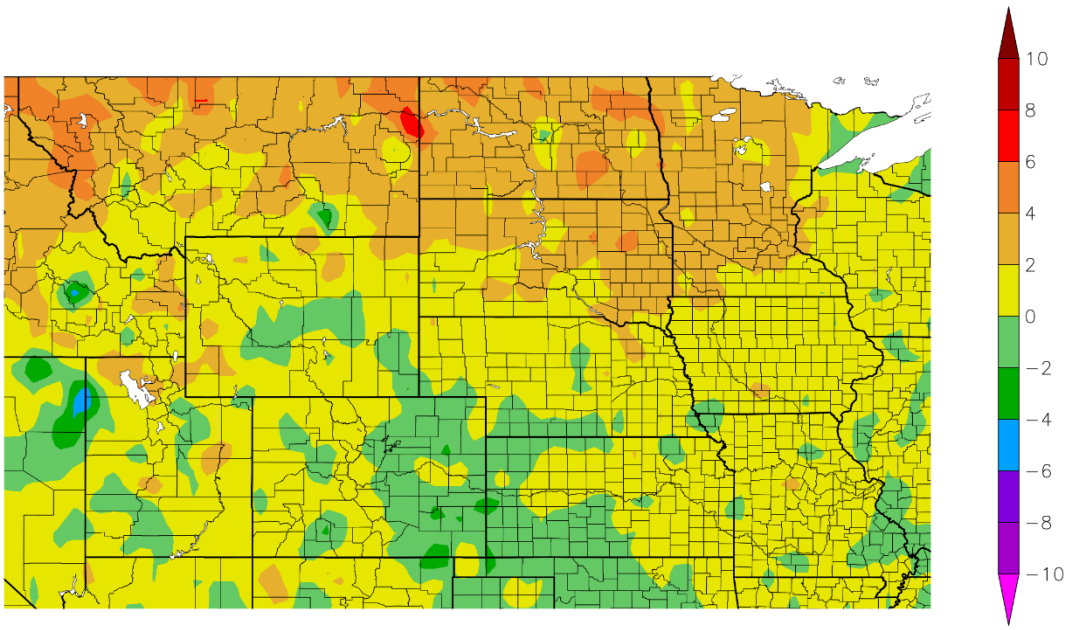


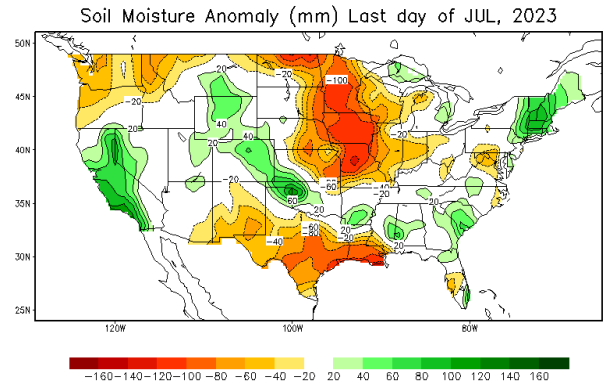
Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of July is shown in **Figure 7**. Soil moisture is below normal in the northern and eastern sides of the Basin as well as the lower Basin. Soil conditions are above normal along the Montana-Wyoming border and into western South Dakota.

Soil Moisture Anomaly (mm)	Soil Moisture Percentile
July 31, 2023	



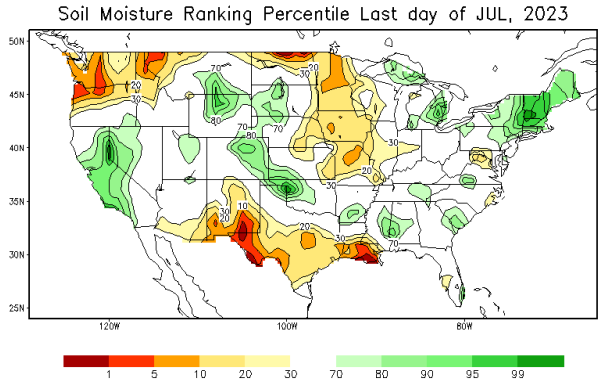


Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. Plains snowpack is not a factor in the August runoff forecast.

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. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 8** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line). Mountain snowpack peaked in the Fort Peck reach on April 24 at 18.6” SWE and 117% of the normal peak. The Garrison reach peaked on April 6 at 15.9” SWE and 109% of the normal peak. As of June 25, all mountain snowpack has melted in both reaches.

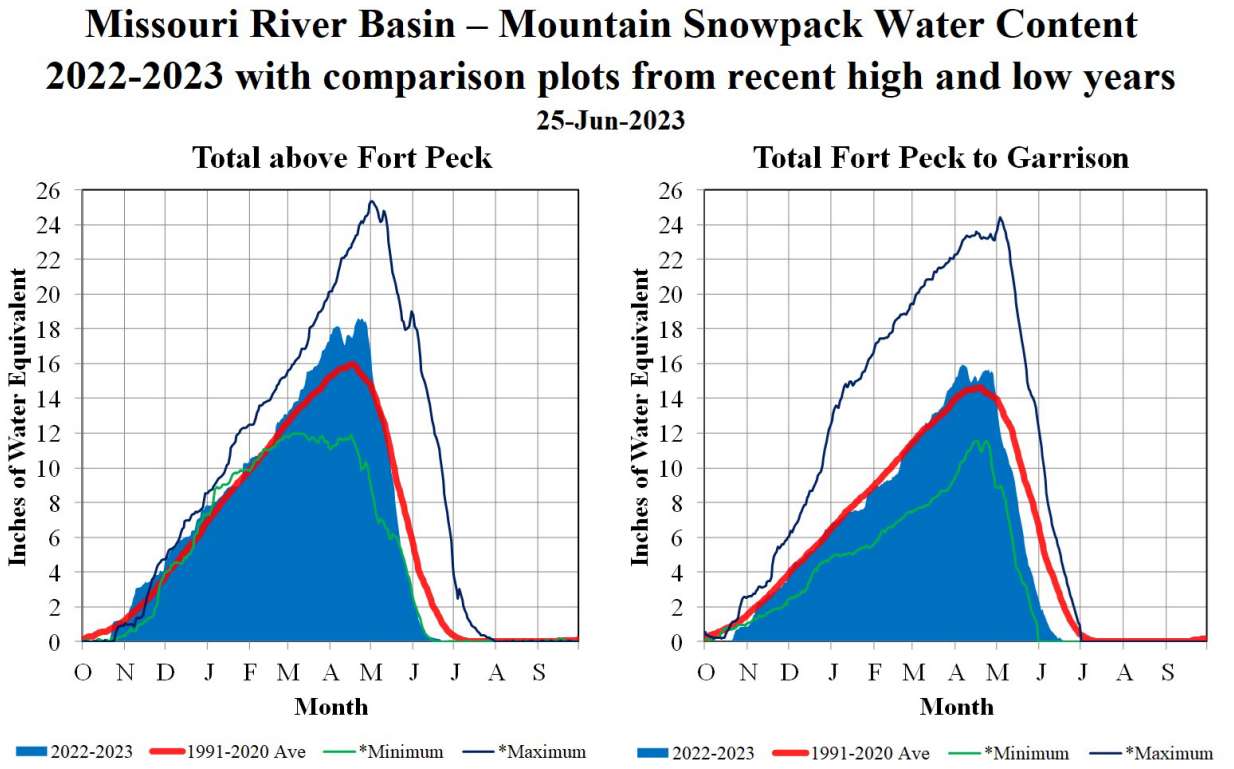


Figure 8. Mountain Snowpack Water Content

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

El Niño conditions are currently present. According to the latest ENSO outlook, these conditions are expected to continue through the winter.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for August (**Figure 9**) indicates equal chances for below-normal, normal, or above-normal temperatures across most of the Basin and increased chances for below-normal temperatures in Wyoming, western South Dakota, and southeastern Montana. The precipitation outlook (**Figure 9**) indicates increased chances for above-normal precipitation in most of the Basin except for North Dakota, northwestern Montana, and northwestern South Dakota, which all show equal chances for below-normal, normal, or above-normal precipitation.

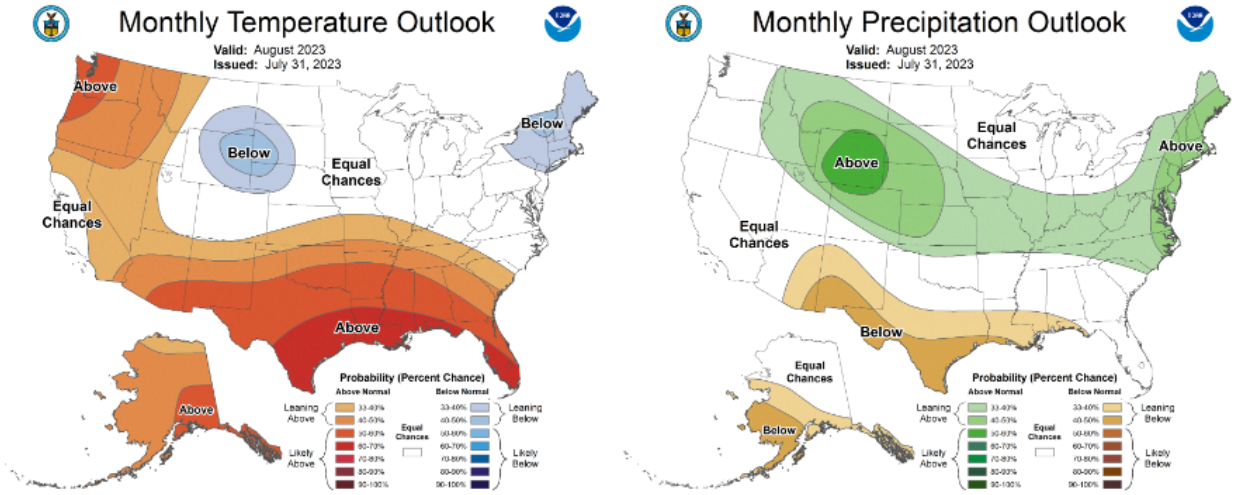


Figure 9. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 10**. The August-September-October temperature outlook indicates equal chances for the upper Basin and increased chances for below-normal temperatures in parts of the lower Basin. The precipitation outlook for the same period indicates increased chances for above-normal precipitation in parts of the lower Basin with equal chances for the rest of the Basin.

The October-November-December outlooks show equal chances for below-normal, normal, or above-normal temperatures and precipitation across the entire Basin.

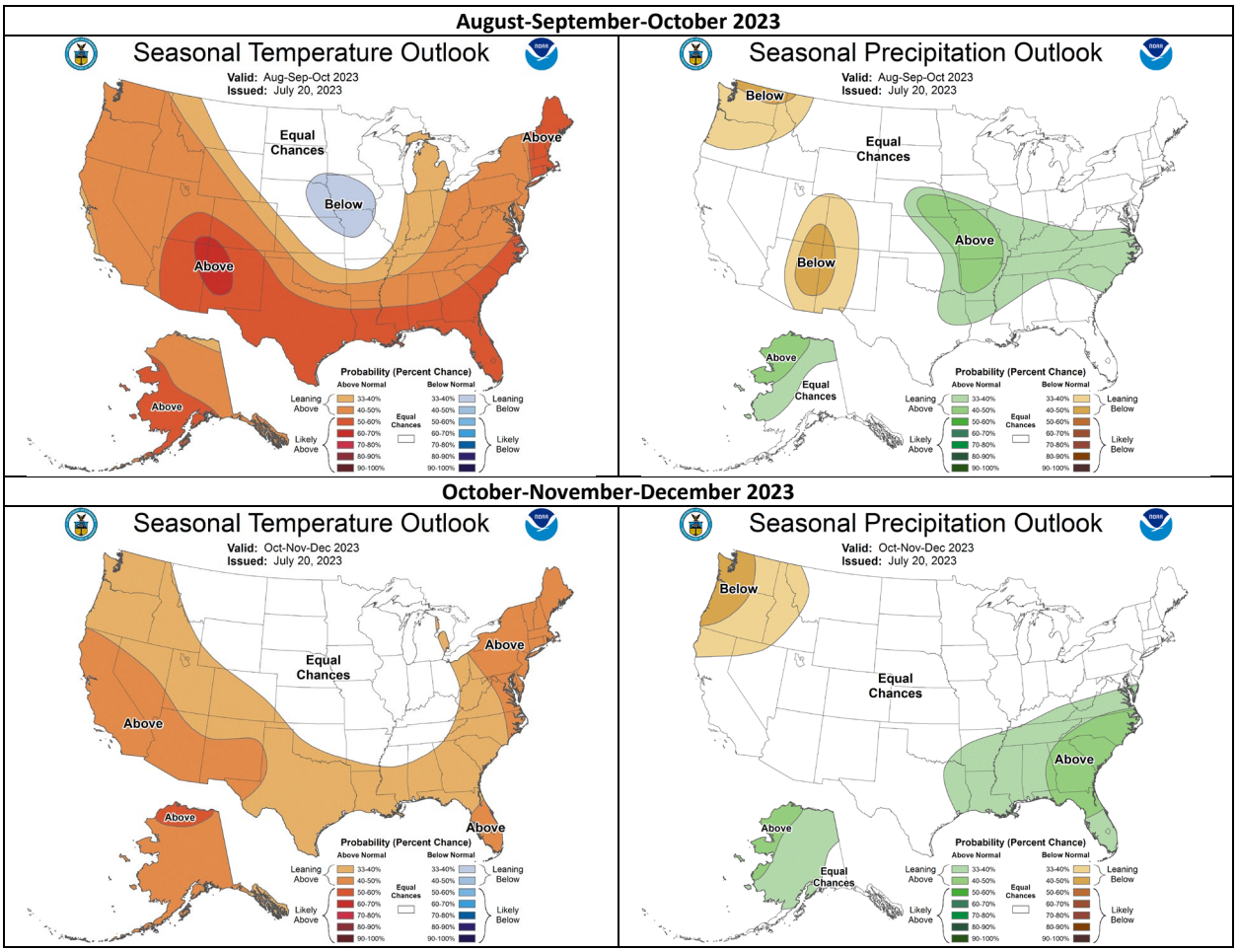


Figure 10. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given the conditions described in the preceding sections, runoff for the remainder of the year is forecasted to be near normal but will depend on precipitation received over the next 6 months.

In summary, the 2023 calendar year runoff forecast is **28.5 MAF, 111% of average**.

Upper Missouri River Basin
September 2023 Calendar Year Runoff Forecast
September 1, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 1.7 MAF, or 121% of average, for the Basin above Sioux City, and 1.4 MAF, or 118% of average, above Gavins Point. Runoff was 0.5 MAF more than forecasted for August. Runoff was below-average in the Fort Peck reach, slightly-below to near-average in the Garrison and Oahe reaches, and well-above-average in the lower three reaches.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **29.1 MAF, 113% of average** and 0.6 MAF higher than last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **26.3 MAF, 113% 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 30.1 MAF upper basic forecast to the 28.2 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.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for August 29 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 42% of the Basin, with about 5% of that being Extreme or

Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of November, indicates drought conditions are likely to persist in all areas of the Basin currently experiencing drought. In addition, widespread drought conditions are likely to develop over the remainder of the lower Basin extending up into eastern South Dakota.

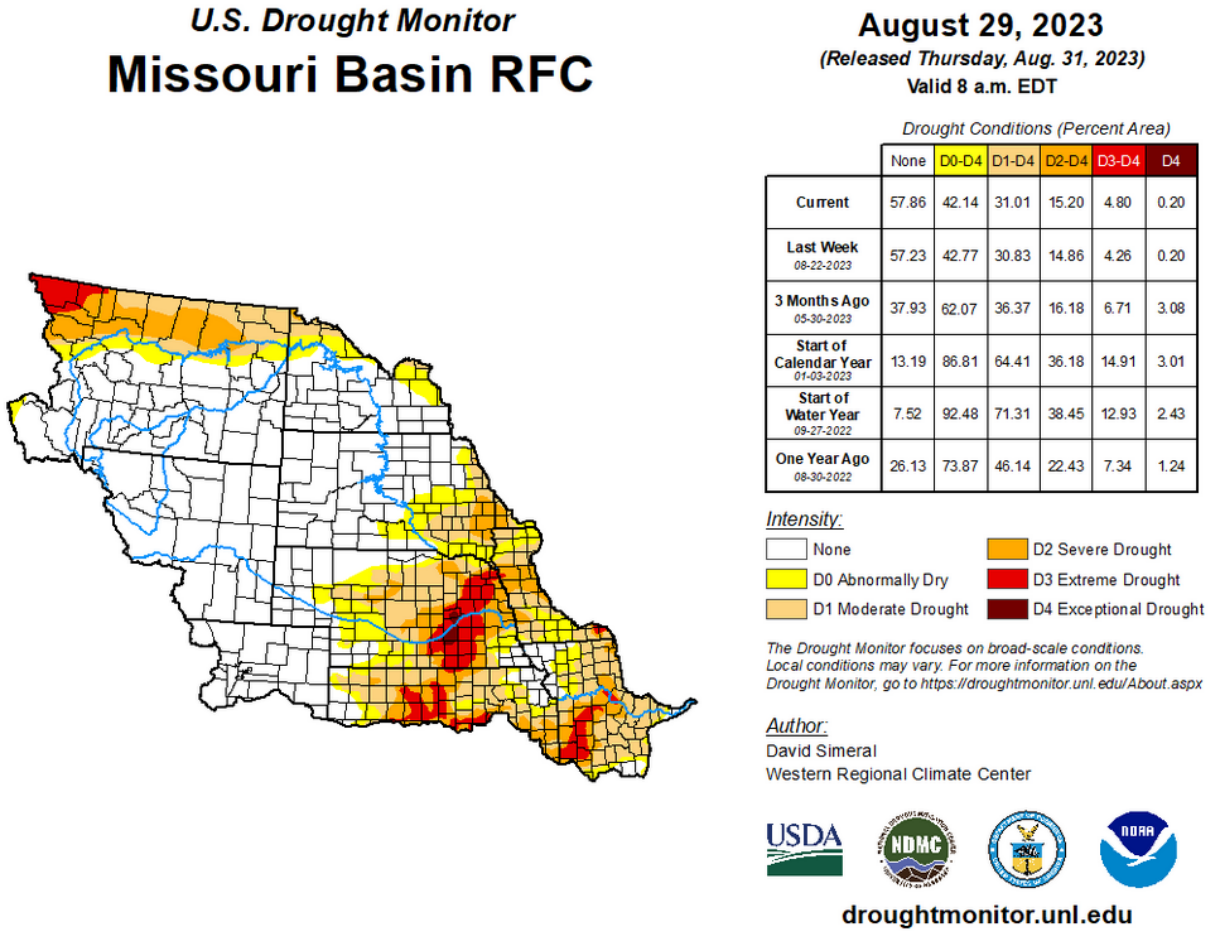


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

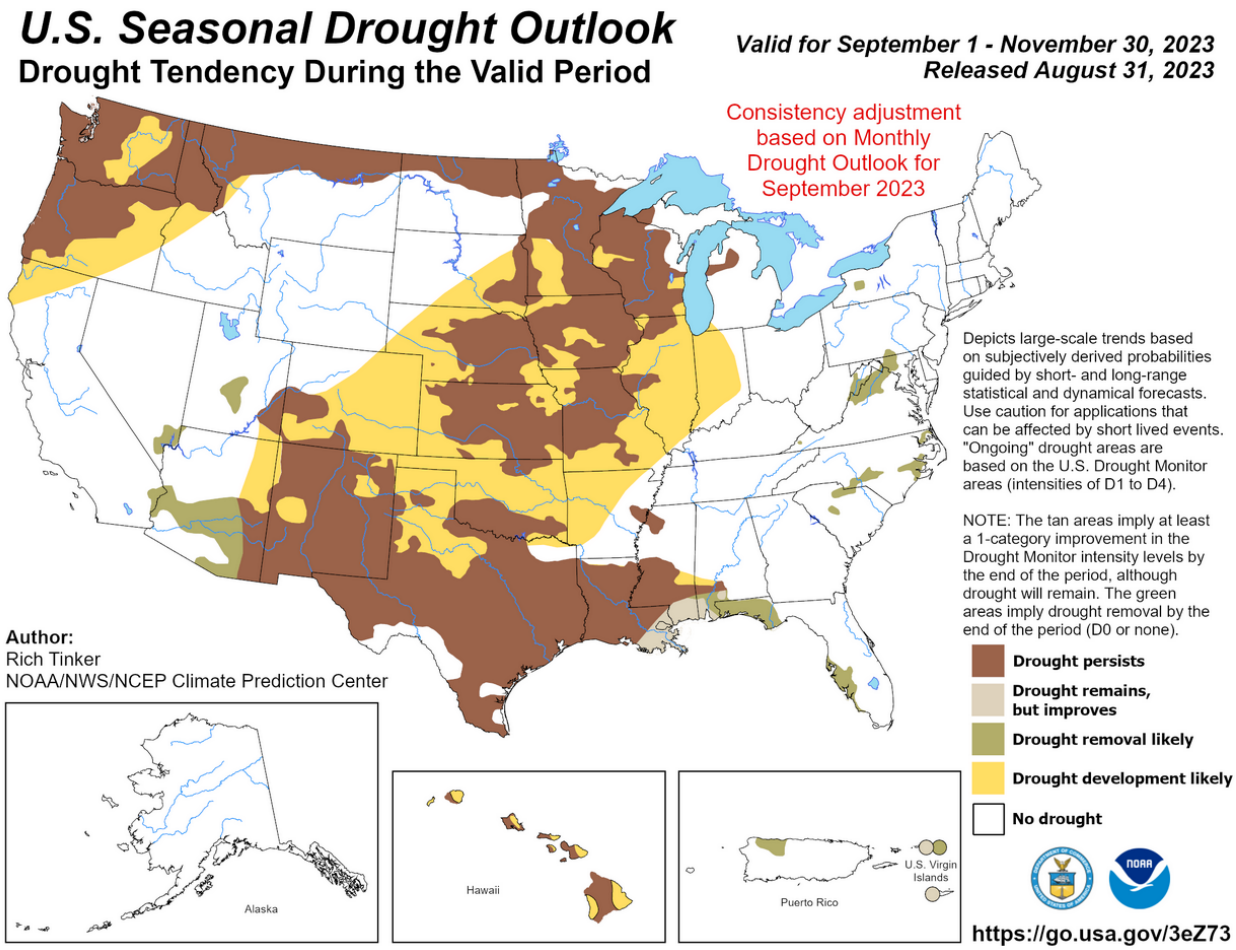


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The August precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was mixed over the Basin last month, with every state experiencing areas of above- and below-normal precipitation.

Precipitation as a percent of normal for the June-July-August period (**Figure 4**) was well below normal across northern Montana, northern North Dakota, and over the eastern side of the Basin extending into central Nebraska. Near-normal to above-normal precipitation occurred in the rest of the Basin with most of Wyoming and southern Montana seeing 150-300 percent of normal precipitation.

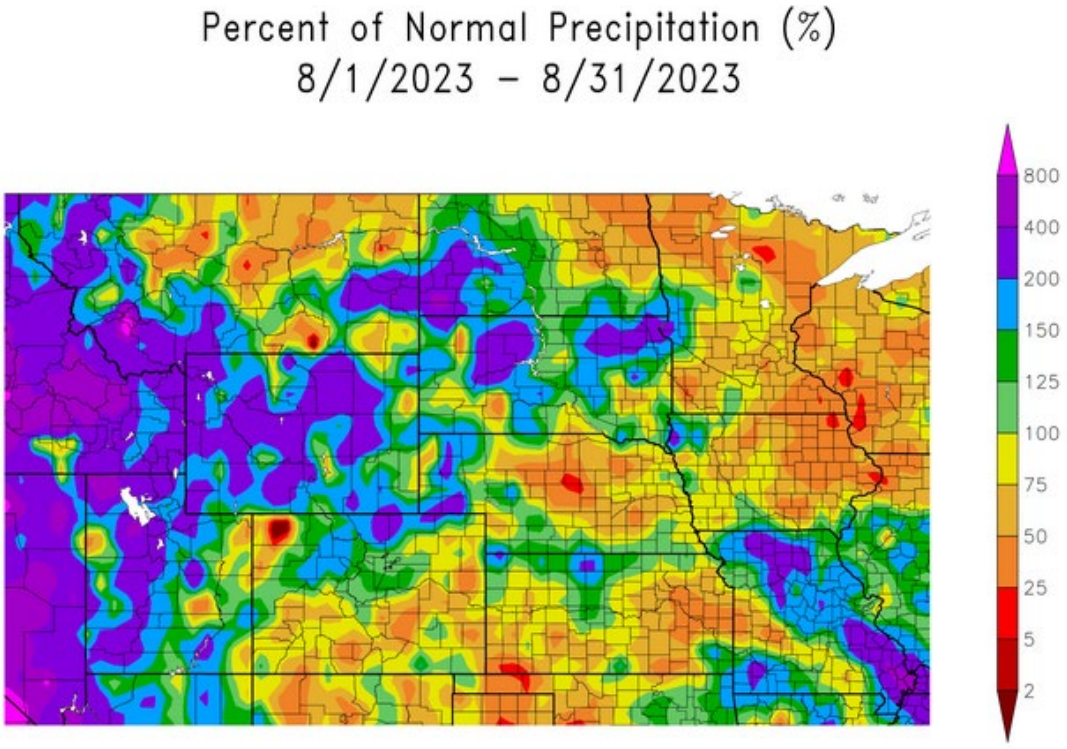


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

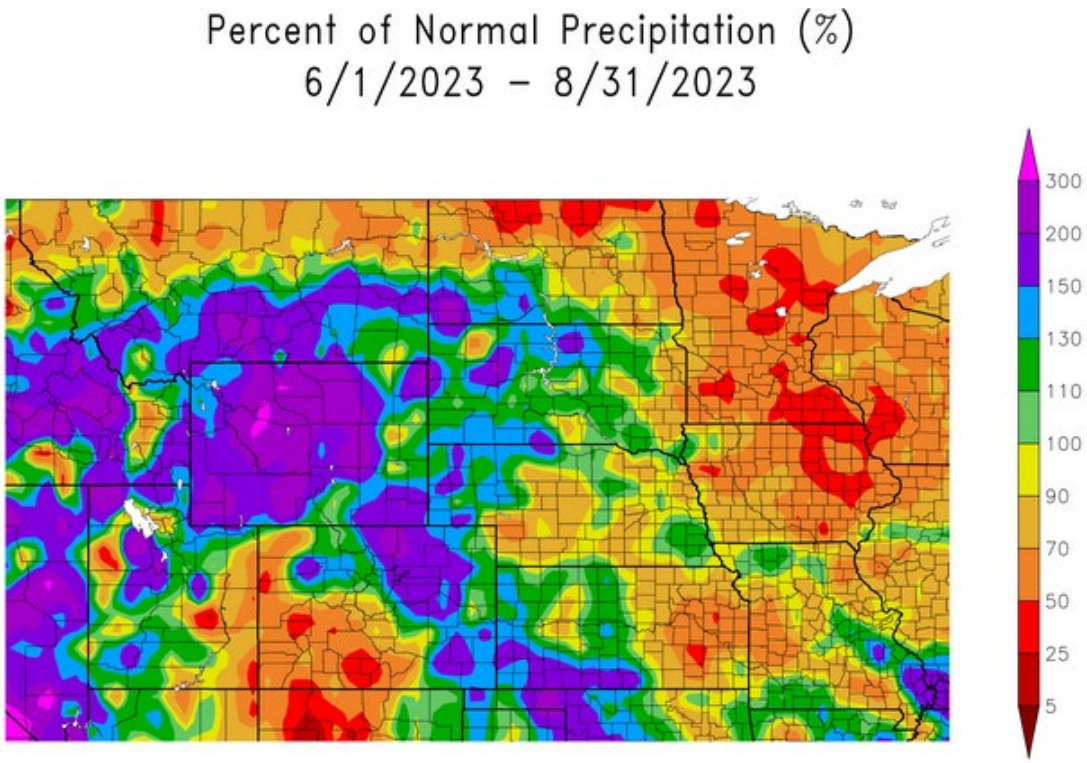


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

August temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate normal to above-normal temperatures across most of the Basin. June-July-August temperature departures are shown in **Figure 6**. The three-month average temperature departures were generally near normal across the Basin, with warmer temperature departures along northern portions of the Basin.

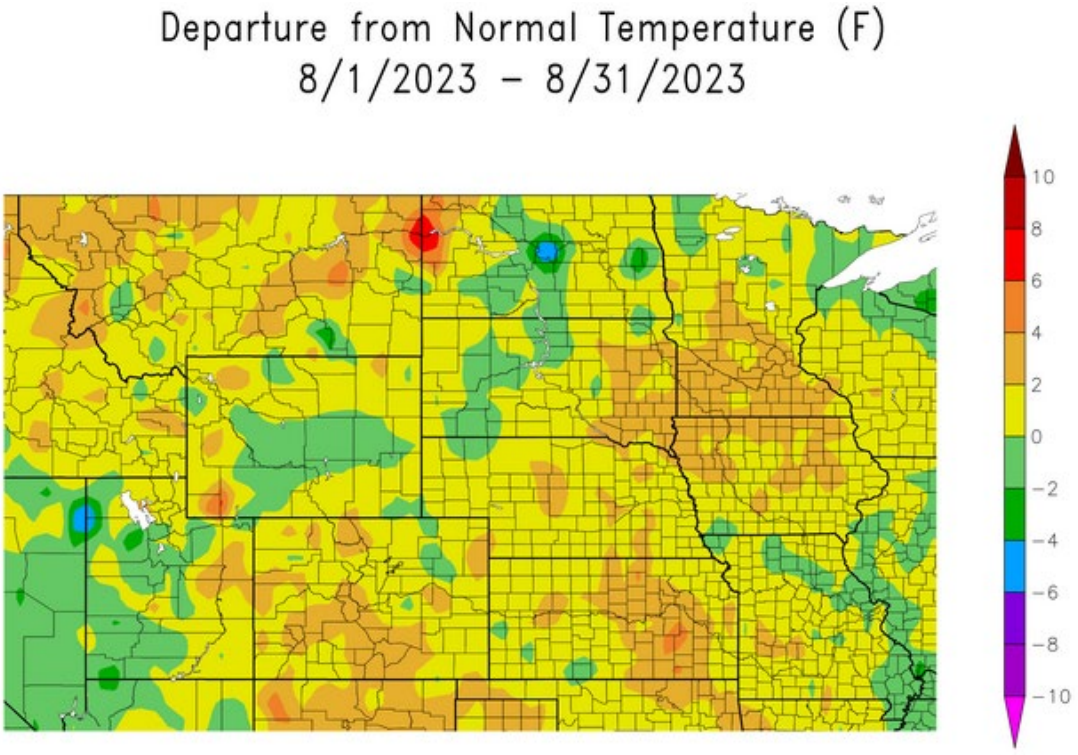


Figure 5. HPRCC Previous Month Departure from Normal Temperature

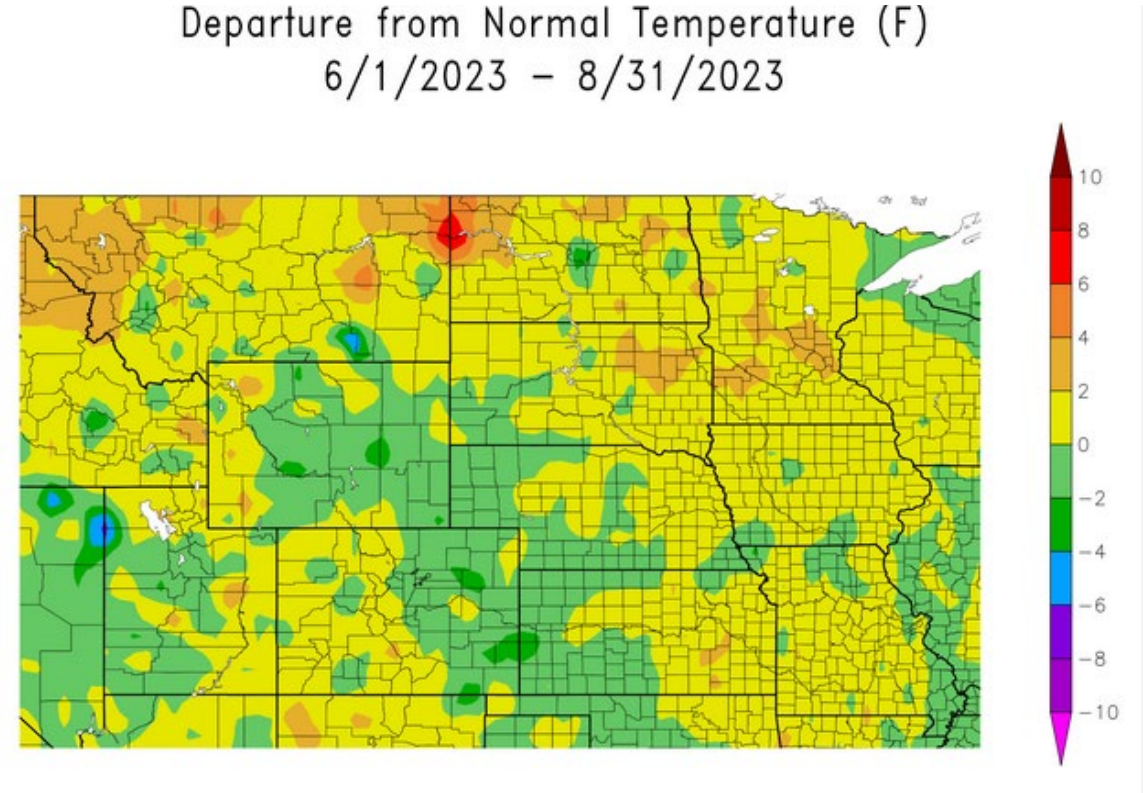


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of August is shown in **Figure 7**. Soil moisture is below normal in the northern and eastern sides of the Basin as well as the lower Basin. Soil conditions are above normal along the Montana-Wyoming border and into western South Dakota.

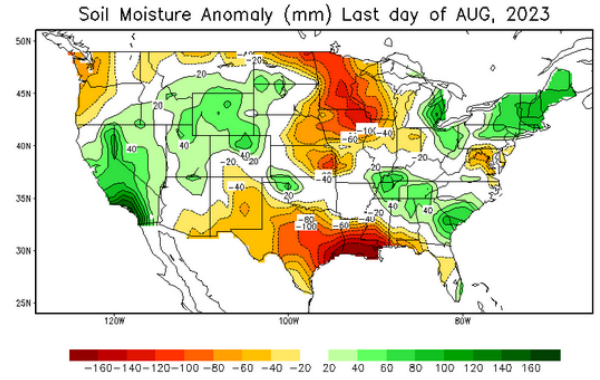
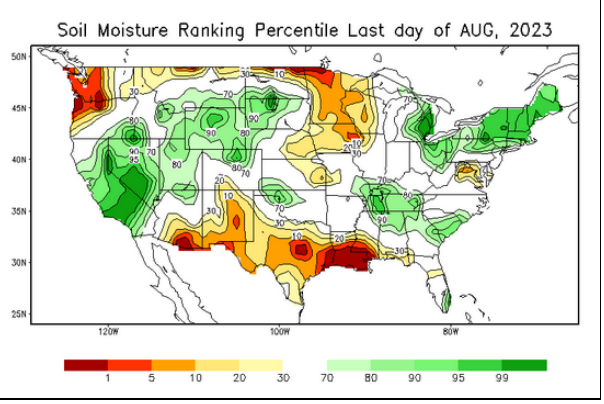
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
August 31, 2023	
	

Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. Plains snowpack is not a factor in the September runoff forecast.

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. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 8** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line). Mountain snowpack peaked in the Fort Peck reach on April 24 at 18.6” SWE and 117% of the normal peak. The Garrison reach peaked on April 6 at 15.9” SWE and 109% of the normal peak. As of June 25, all mountain snowpack has melted in both reaches.

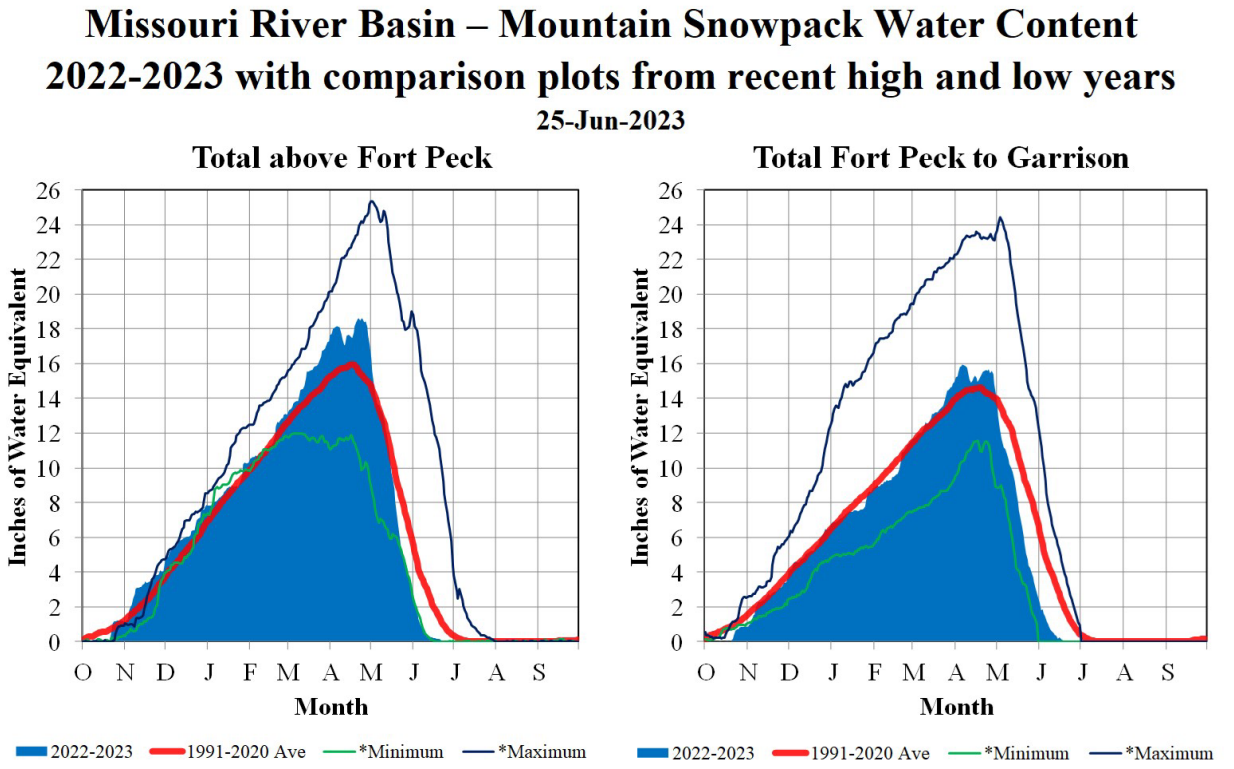


Figure 8. Mountain Snowpack Water Content

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

El Niño conditions are currently present. According to the latest ENSO outlook, these conditions have a greater than 95% chance of continuing through the winter.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for September (**Figure 9**) indicates increased chances of above-normal temperatures across the entire Basin. The precipitation outlook (**Figure 9**) indicates increased chances for below-normal precipitation in the lower Basin and eastern South Dakota, with equal chances for below-normal, normal, or above-normal precipitation in the remainder of the upper Basin.

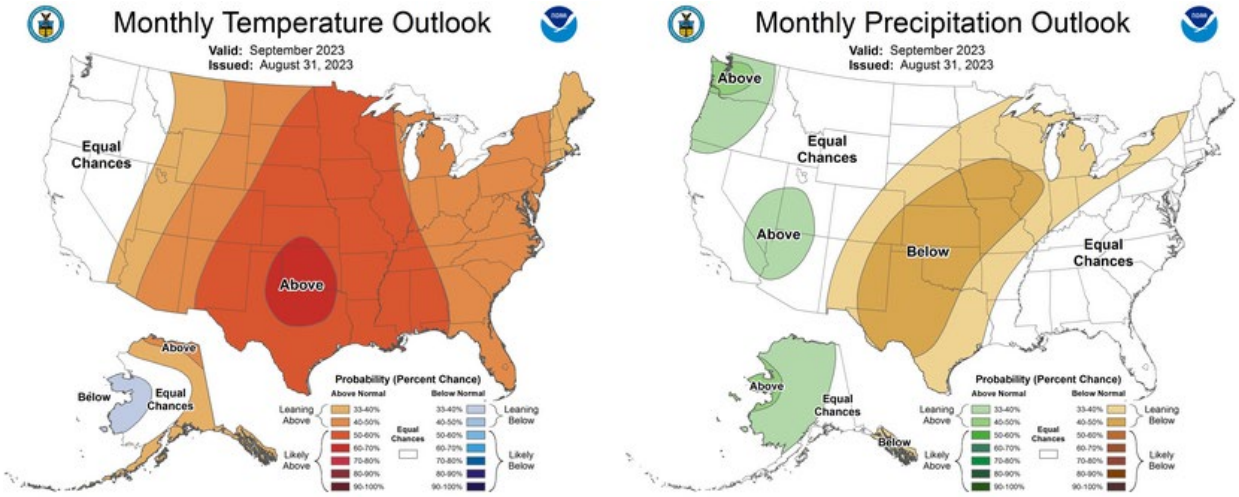


Figure 9. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 10**. The October-November-December temperature outlook indicates increased chances for above-normal temperatures in Montana, Wyoming, and Colorado, with equal chances elsewhere across the Basin. The precipitation outlook for the same period indicates equal chances for below-normal, normal, or above-normal precipitation across the entire Basin.

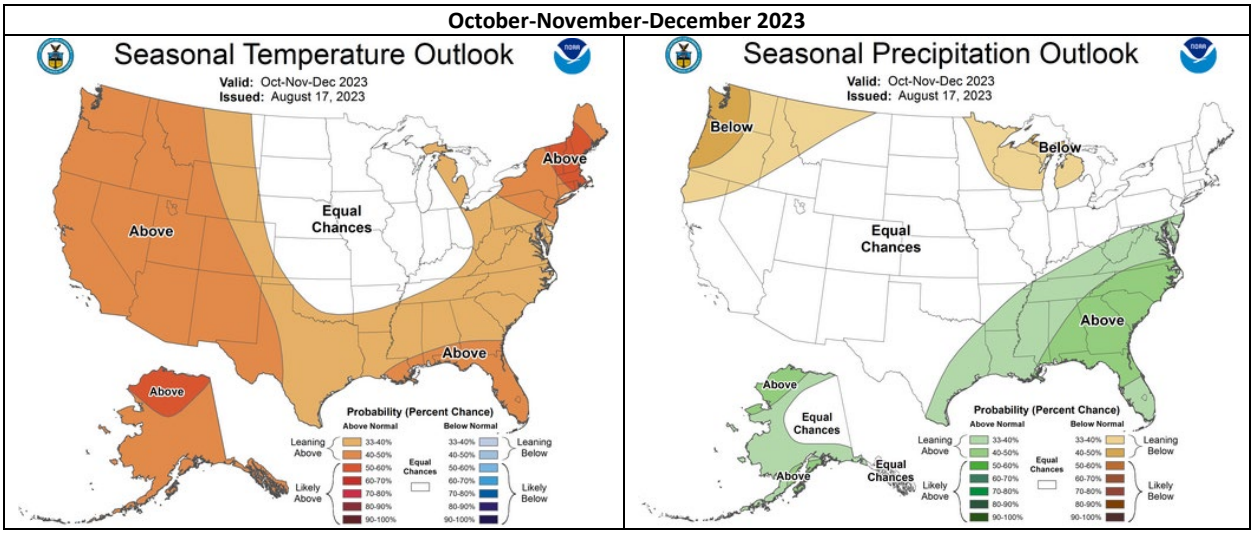


Figure 10. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given the conditions described in the preceding sections, runoff for the remainder of the year is forecasted to be near normal but will depend on precipitation received over the next 4 months.

In summary, the 2023 calendar year runoff forecast is **29.1 MAF, 113% of average**.

Upper Missouri River Basin
October 2023 Calendar Year Runoff Forecast
October 3, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 1.3 MAF, or 109% of average, for the Basin above Sioux City, and 1.2 MAF, or 113% of average, above Gavins Point. Runoff was 0.2 MAF more than forecasted for September. Runoff was above average or near average in all reaches except Sioux City, which was below average.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **29.1 MAF, 113% of average** and the same as last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **26.4 MAF, 114% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next three months, expected inflow could range from the 29.8 MAF upper basic forecast to the 28.5 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.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for September 26 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 42% of the Basin, with about 6% of that being Extreme or

Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of December, indicates drought conditions are likely to persist in most areas except potential improvement in central Nebraska and central Kansas.

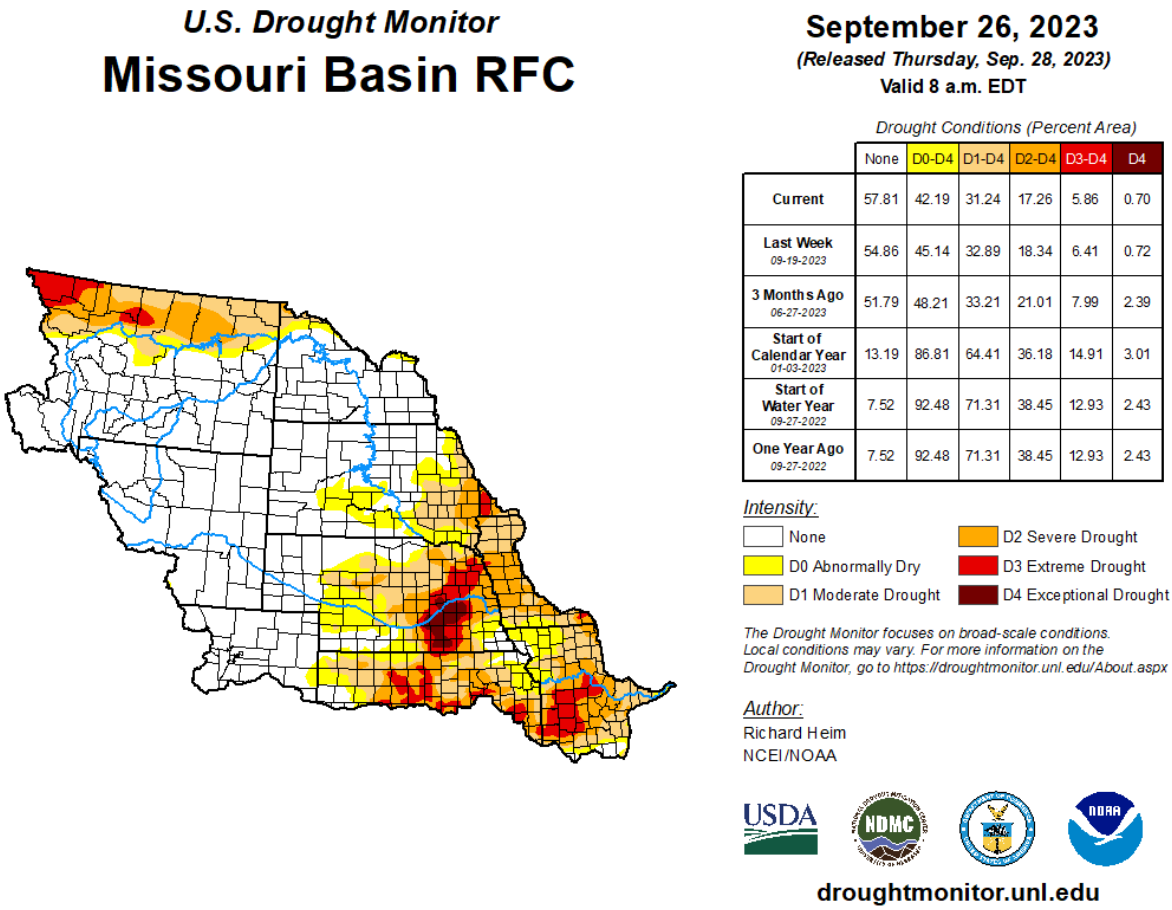


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

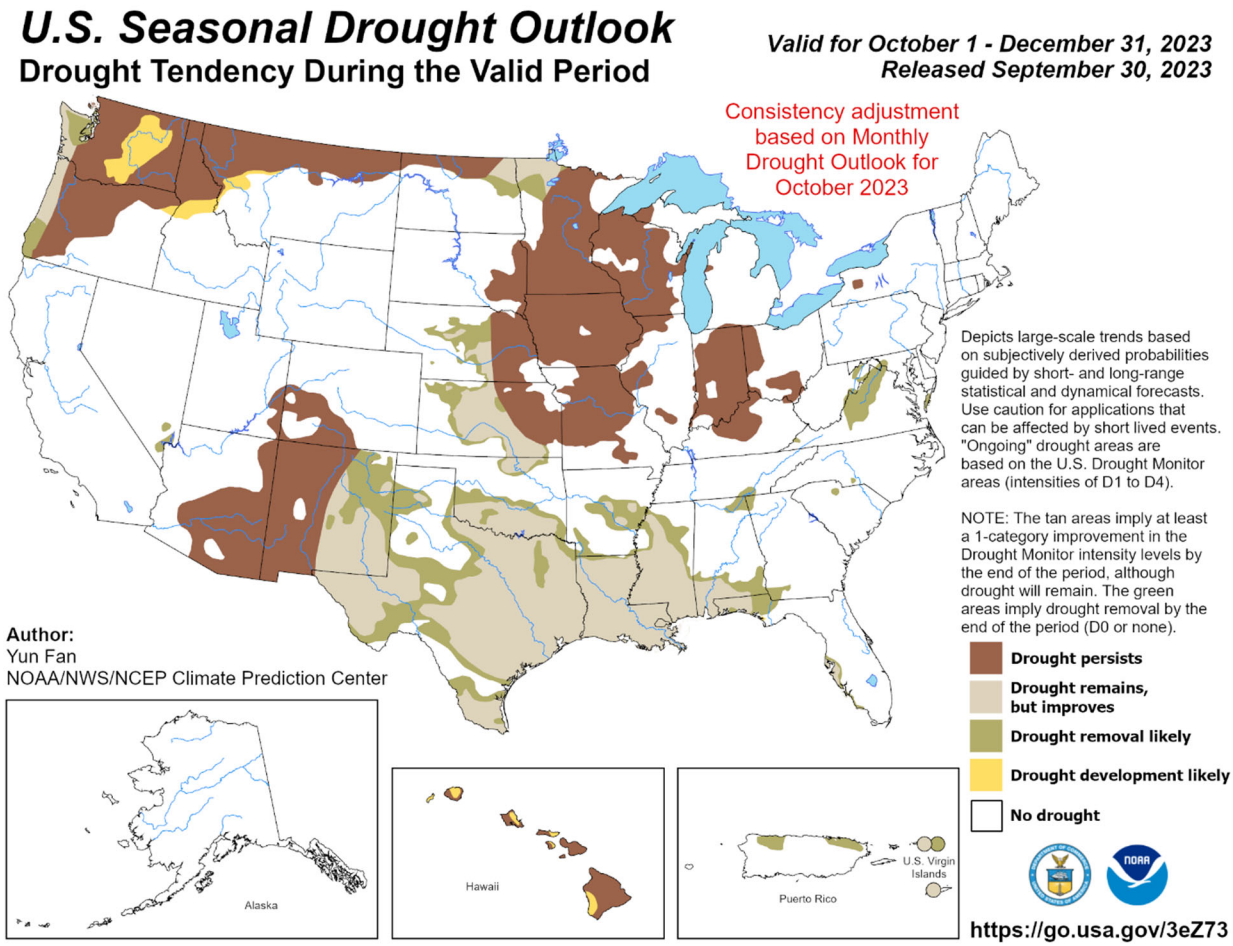


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The September precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was mixed over the Basin last month. Normal to above-normal precipitation fell in southern and central Montana, central North Dakota, western South Dakota, and northern Nebraska. The rest of the upper Basin and most of the lower Basin saw below-normal precipitation.

Precipitation as a percent of normal for the July-August-September period (**Figure 4**) was normal to slightly above normal in southern Montana, southeastern North Dakota, much of South Dakota and Wyoming, and parts of Nebraska. The rest of the Basin observed below-normal precipitation.

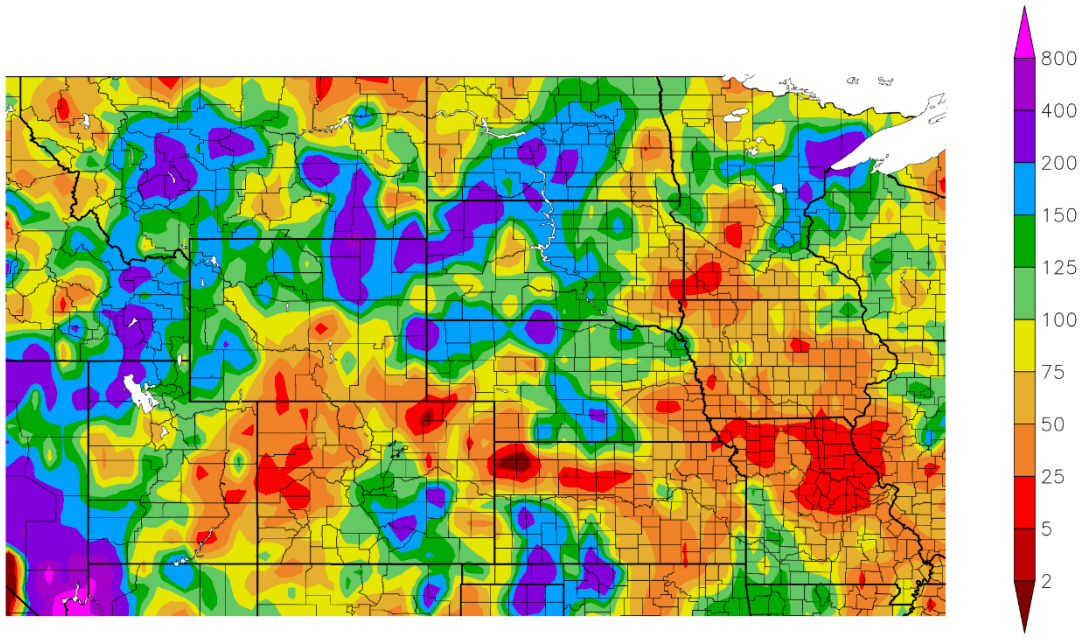


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

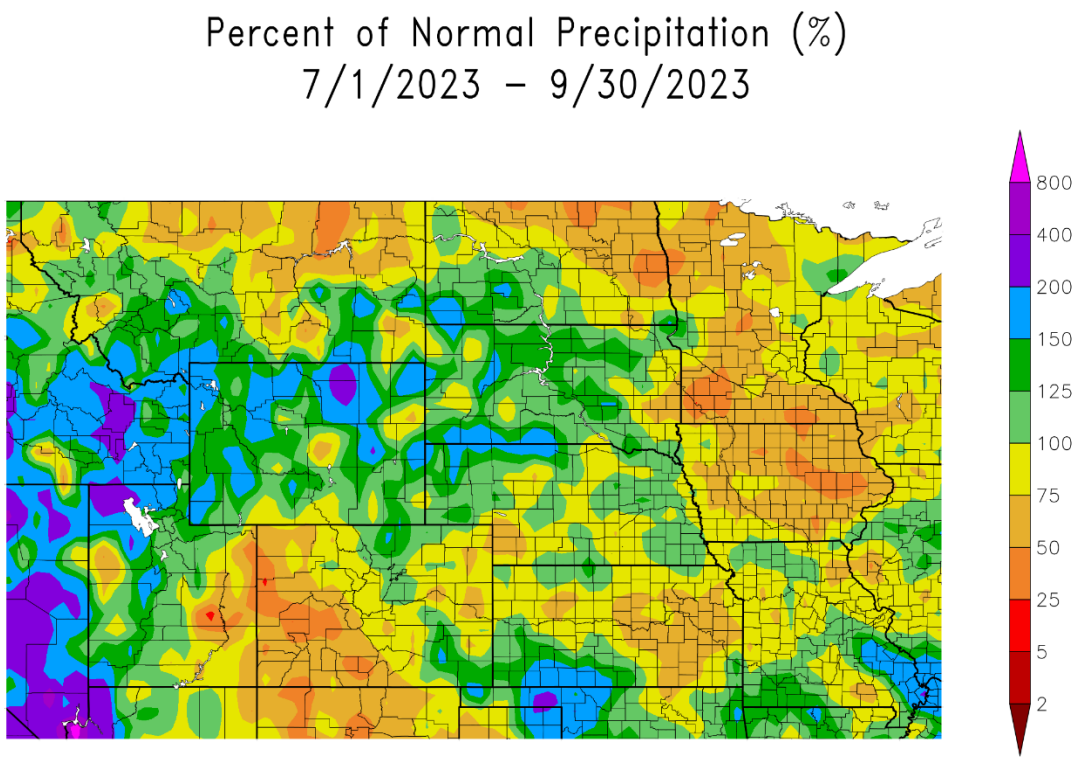


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

September temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate above-normal temperatures across most of the Basin. July-August-September temperature departures are shown in **Figure 6**. The three-month average temperature departures were generally near to slightly above normal across the Basin.

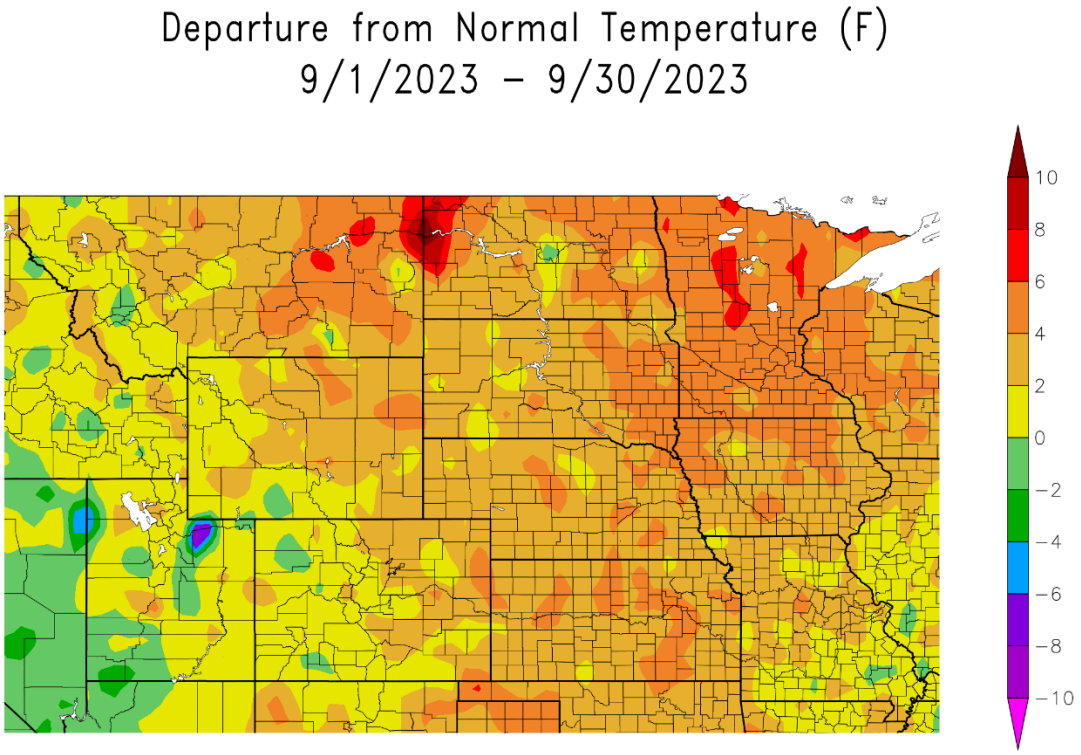


Figure 5. HPRCC Previous Month Departure from Normal Temperature

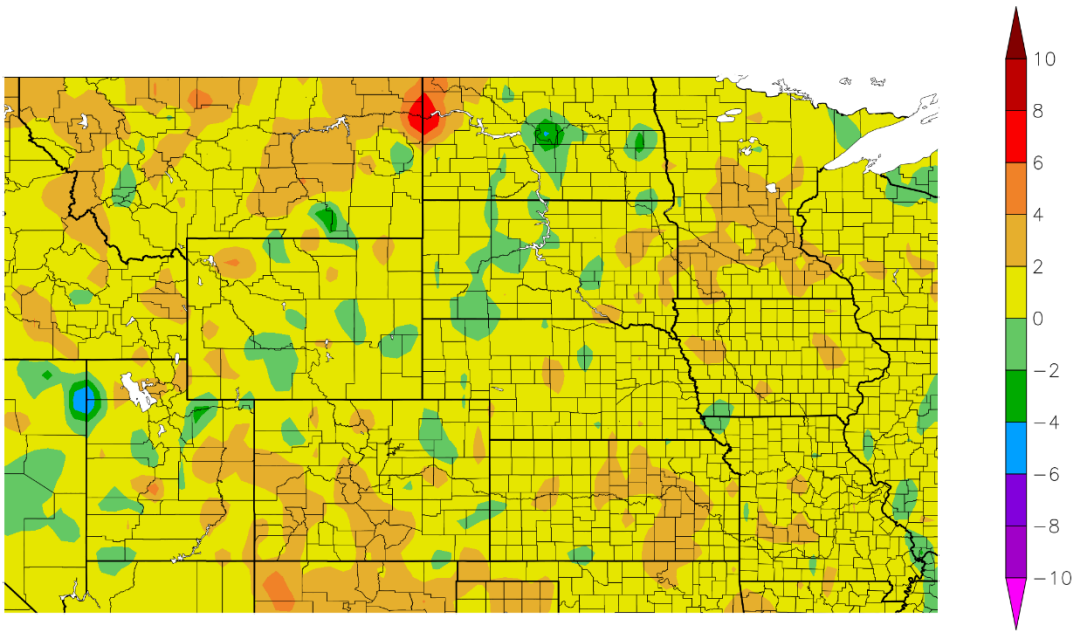


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of September is shown in **Figure 7**. Soil moisture is drier than normal in the areas of drought in the Basin: northern Montana, northern and eastern North Dakota, eastern South Dakota, and most of the lower Basin. Soil moisture conditions are wetter than normal in southern Montana into Wyoming as well as southwestern North Dakota and western South Dakota.

Soil Moisture Anomaly (mm)	Soil Moisture Percentile
September 30, 2023	

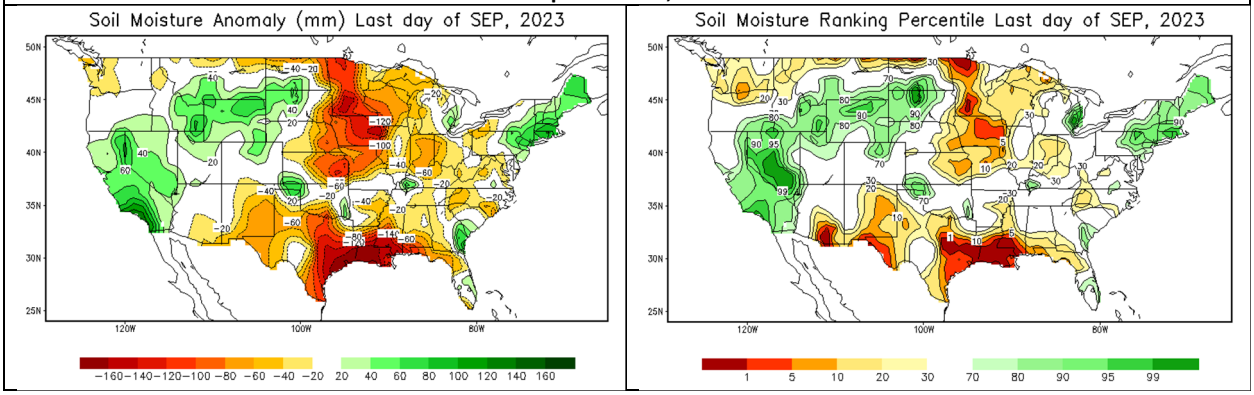


Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. Plains snowpack is not a factor in the October runoff forecast.

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. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 8** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line). Mountain snowpack peaked in the Fort Peck reach on April 24 at 18.6" SWE and 117% of the normal peak. The Garrison reach peaked on April 6 at 15.9" SWE and 109% of the normal peak. As of June 25, all mountain snowpack had melted in both reaches.

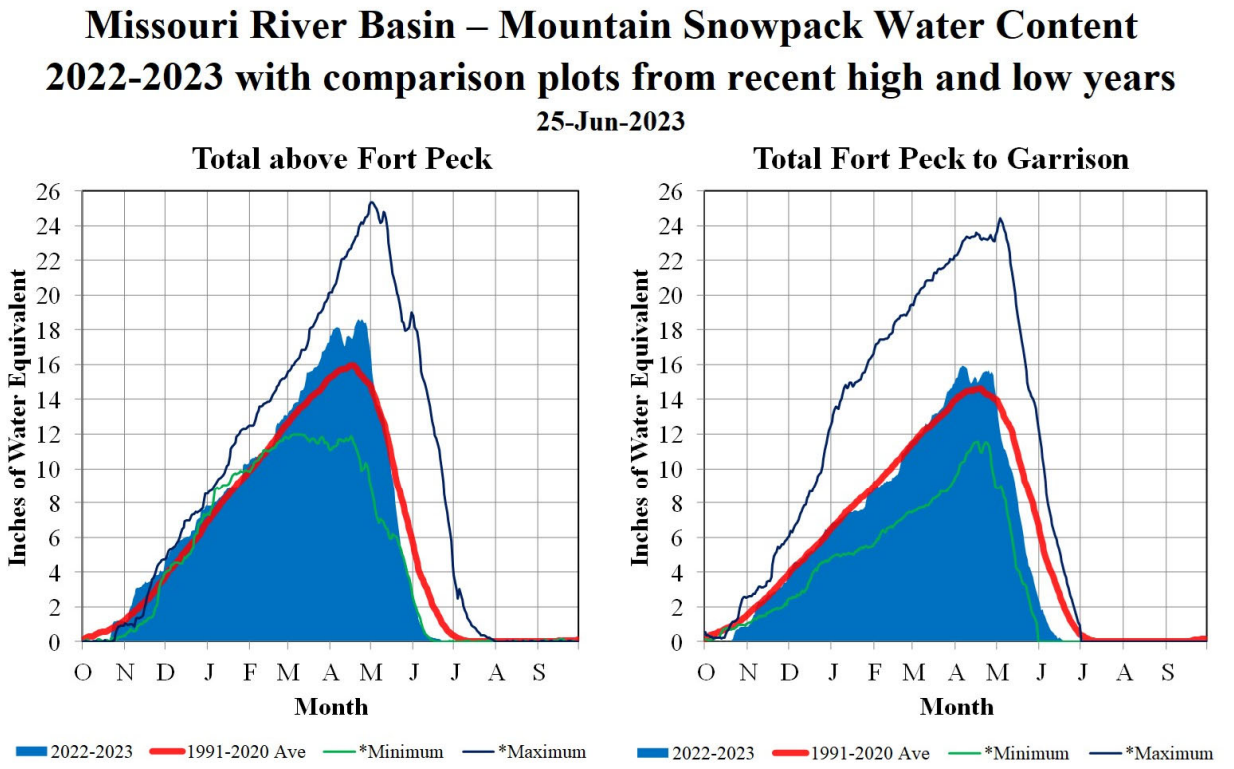


Figure 8. Mountain Snowpack Water Content

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

El Niño conditions are currently present. According to the latest ENSO outlook, these conditions have a greater than 95% chance of continuing through the winter.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The outlooks for October (**Figure**) indicate increased chances for above-normal precipitation and above-normal temperatures across most of the Basin except for the eastern edge of the Basin, which indicates equal chances for below-normal, normal, or above-normal precipitation.

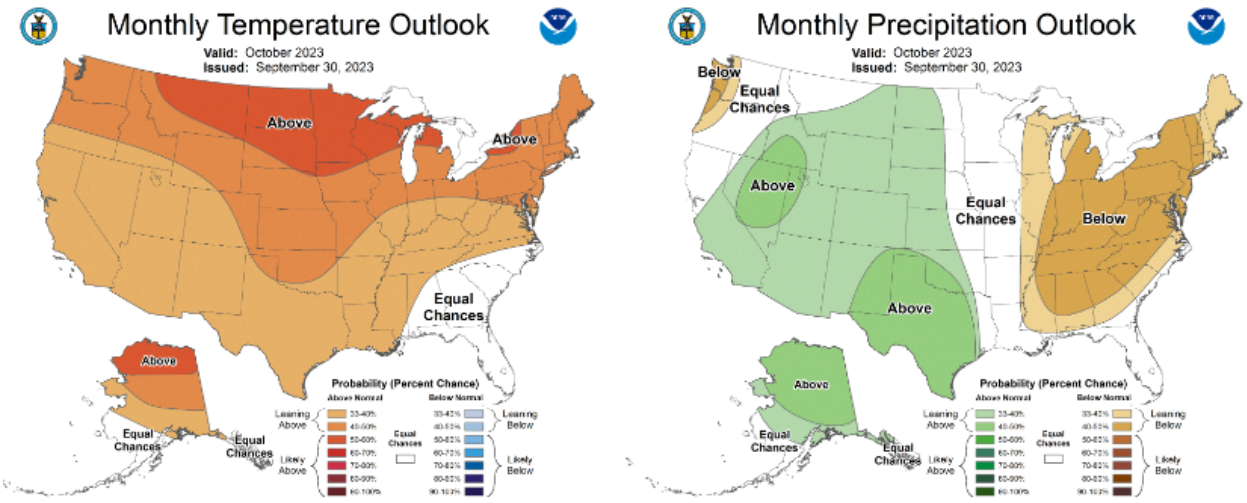


Figure 9. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure** . The October-November-December outlooks show equal chances for below-normal, normal, or above-normal temperature and precipitation across most of the Basin.

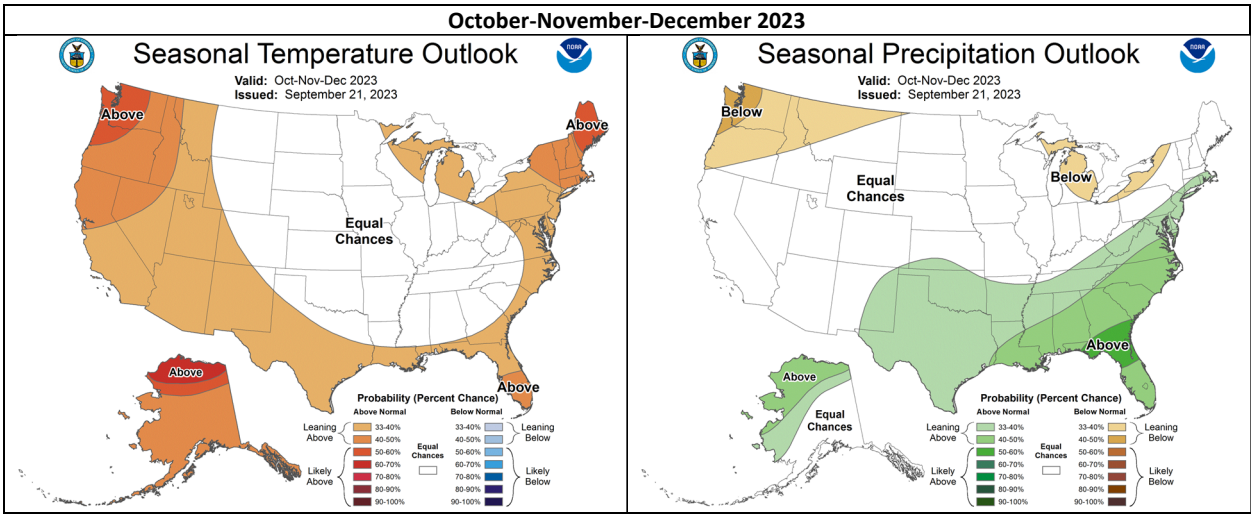


Figure 10. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given the conditions described in the preceding sections, runoff for the remainder of the year is forecasted to be near normal but will depend on precipitation received over the next three months.

In summary, the 2023 calendar year runoff forecast is **29.1 MAF, 113% of average**.

Upper Missouri River Basin
November 2023 Calendar Year Runoff Forecast
November 2, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 1.5 MAF, or 124% of average, for the Basin above Sioux City, and 1.4 MAF, or 130% of average, above Gavins Point. Runoff was 0.5 MAF more than forecasted for October. Runoff was above average in all reaches except Sioux City, which was below average.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **29.8 MAF, 116% of average** and 0.7 MAF more last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **27.1 MAF, 117% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next two months, expected inflow could range from the 30.2 MAF upper basic forecast to the 29.4 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for October 31 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 34% of the Basin, with about 2.5% of that being Extreme or Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of

January, indicates drought conditions are likely to persist in the upper Basin, with the potential for improvement in the lower Basin.

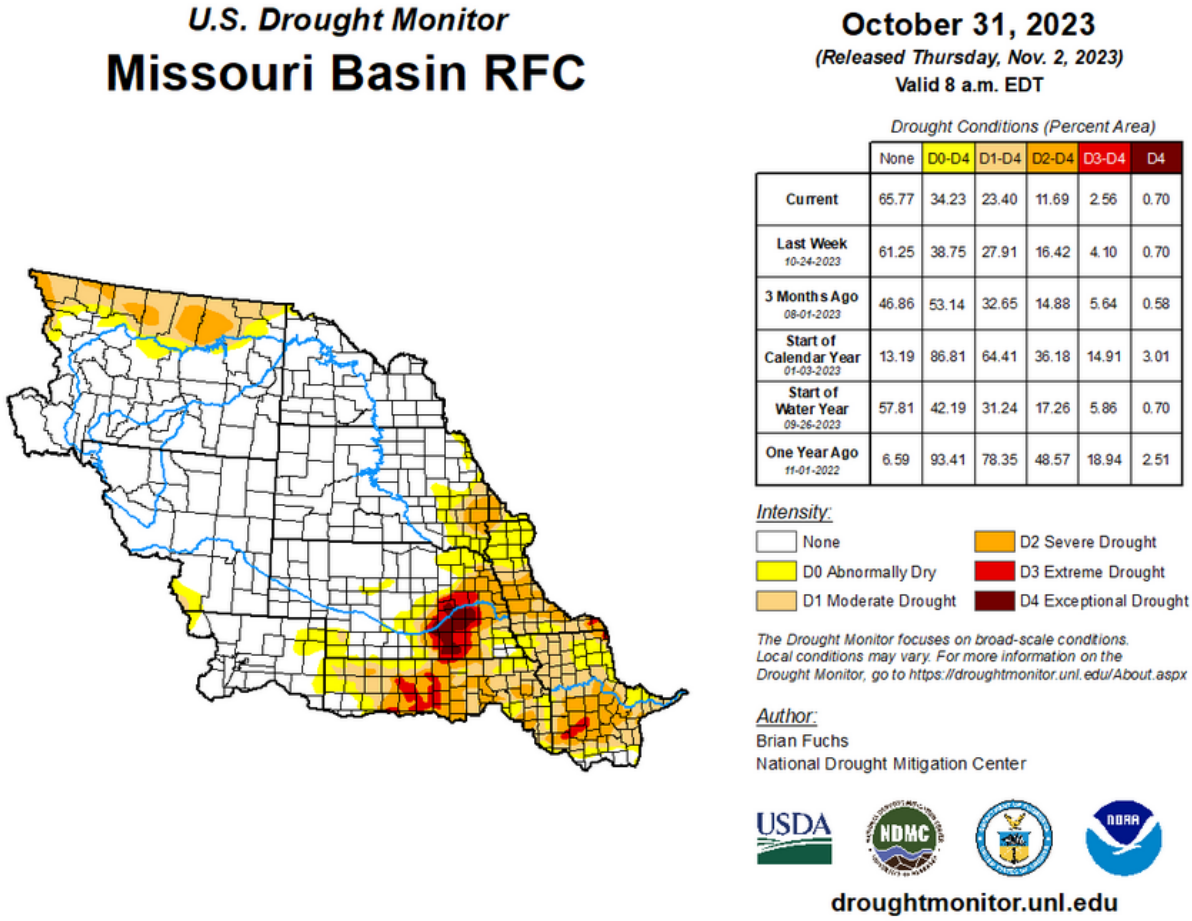


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

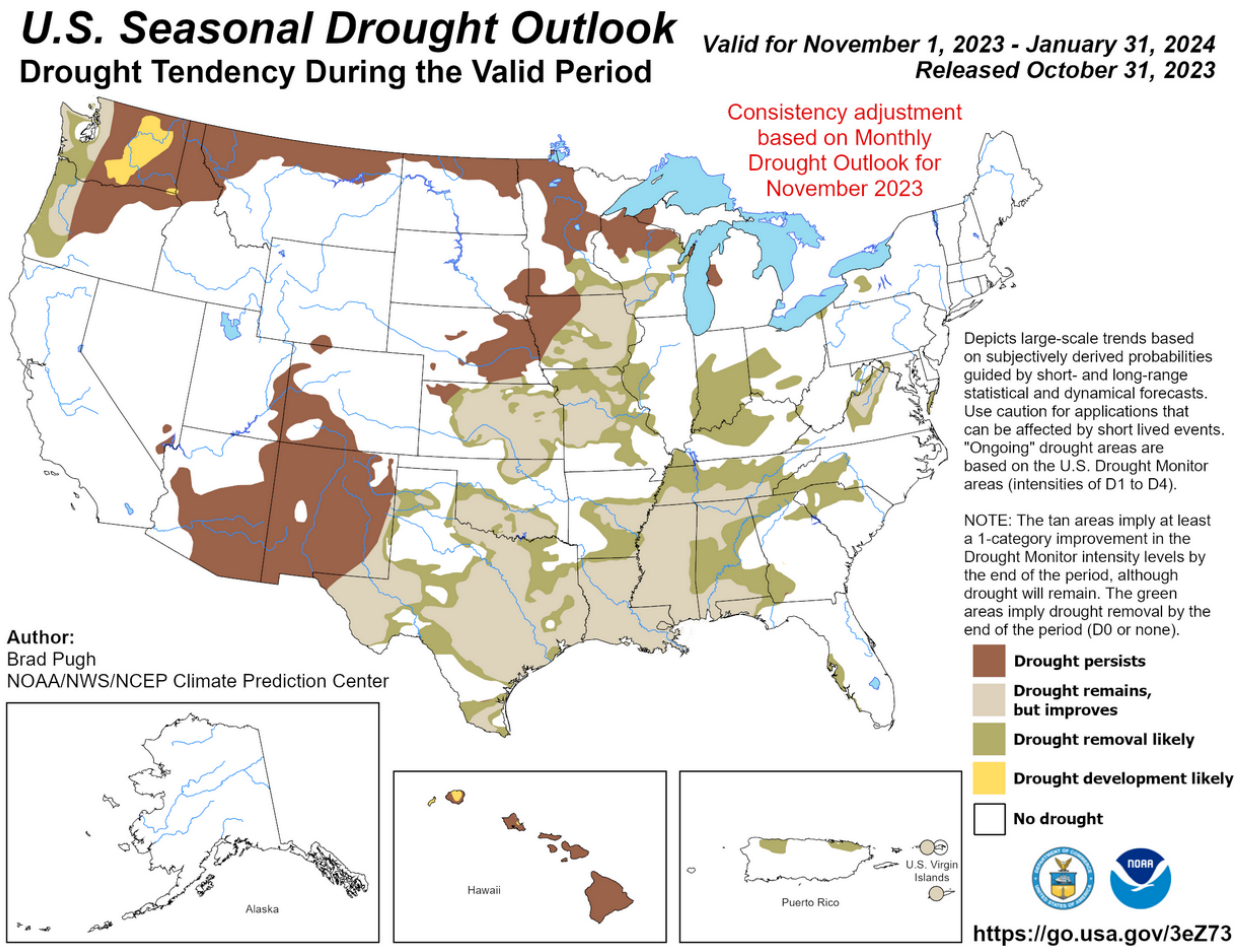


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The October precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was mixed over the Basin last month. Large areas of the upper Basin experienced 150 to 400 percent of normal precipitation, while a stretch along the North and South Dakota border observed 5 to 75 percent of normal precipitation. The lower Basin had 25 to 75 of normal precipitation in most areas during October.

Precipitation as a percent of normal for the August-September-October period (**Figure 4**) was normal to slightly above normal across most of the upper Basin. The lower Basin observed below-normal precipitation in most areas.

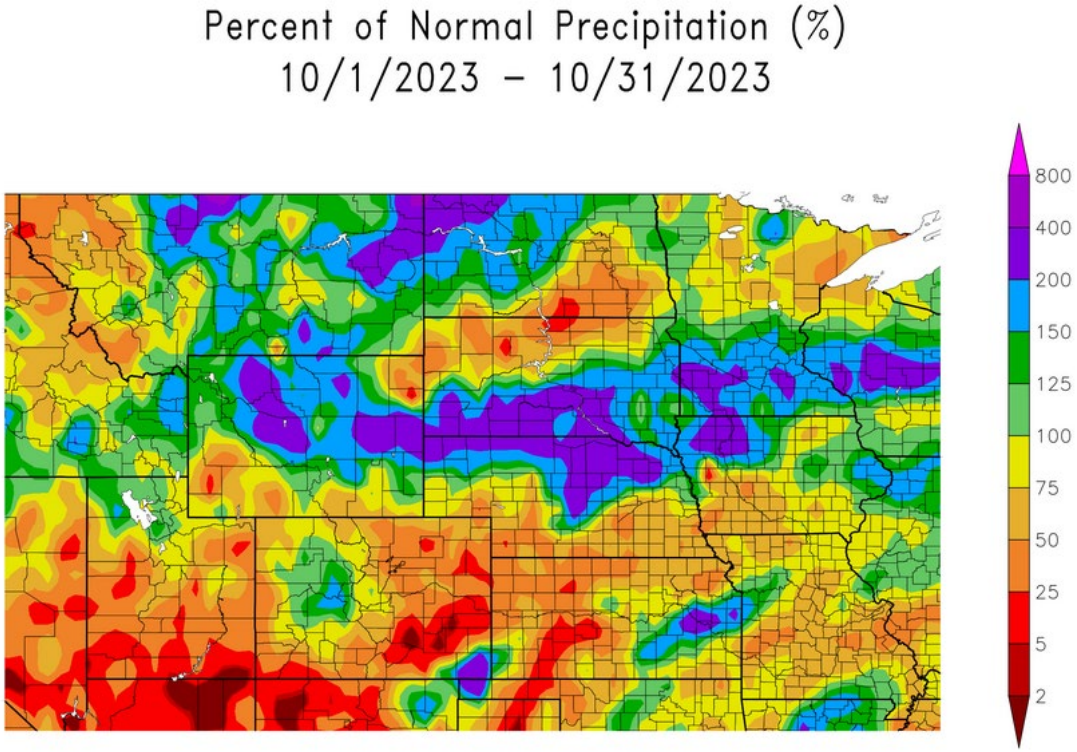


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

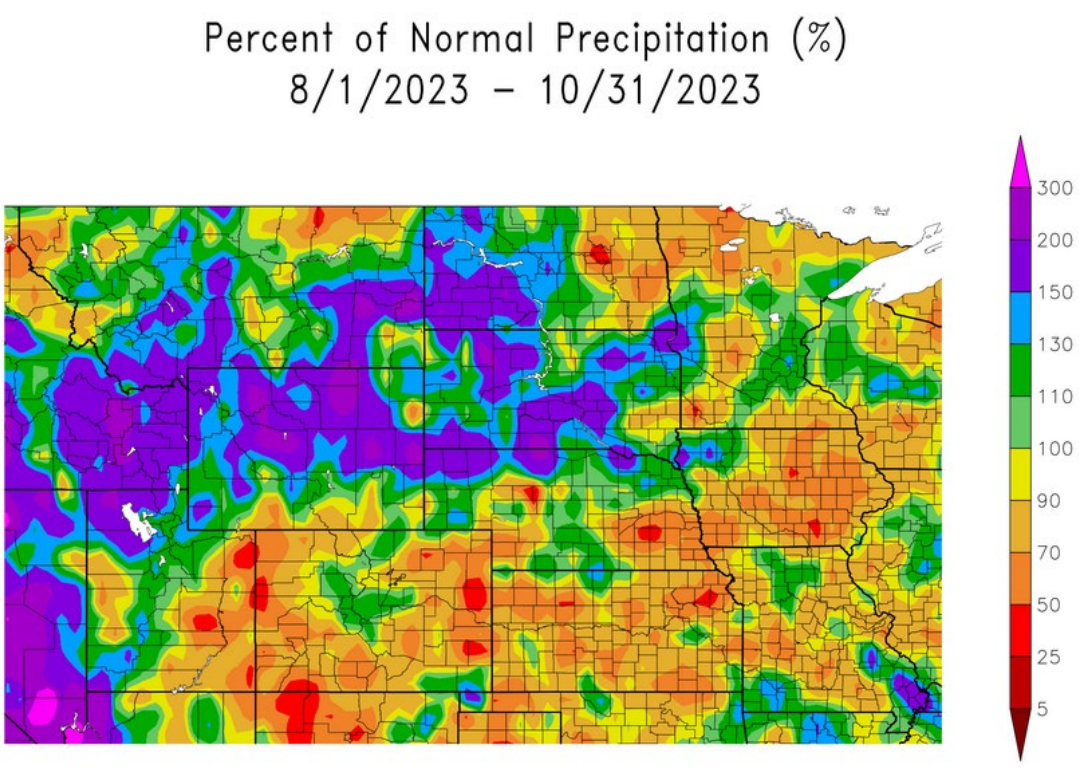


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

October temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate near-normal temperatures across most of the Basin, with temperatures varying from 3 degrees below normal to 3 degrees above normal. August-September-October temperature departures are shown in **Figure 6**. The three-month average temperature departures were above normal across most of the Basin, with an area on the Montana-North Dakota border seeing temperatures as high as 8 degrees above normal.

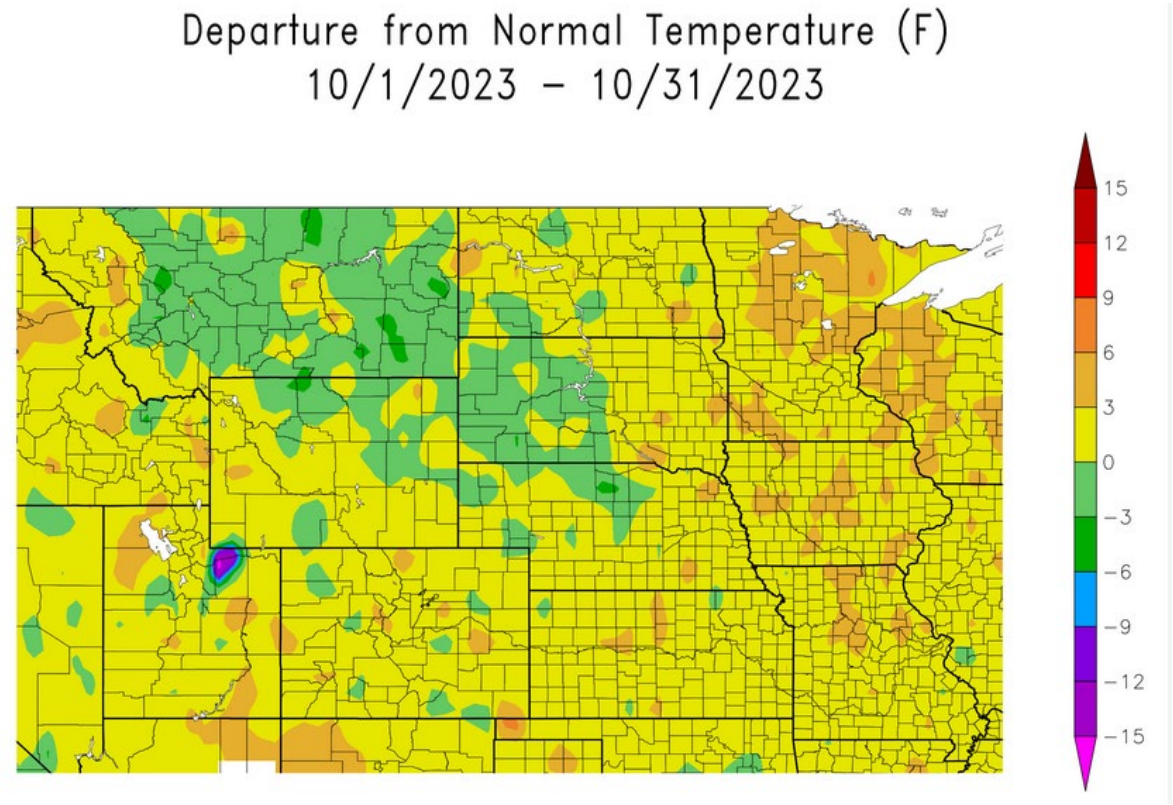


Figure 5. HPRCC Previous Month Departure from Normal Temperature

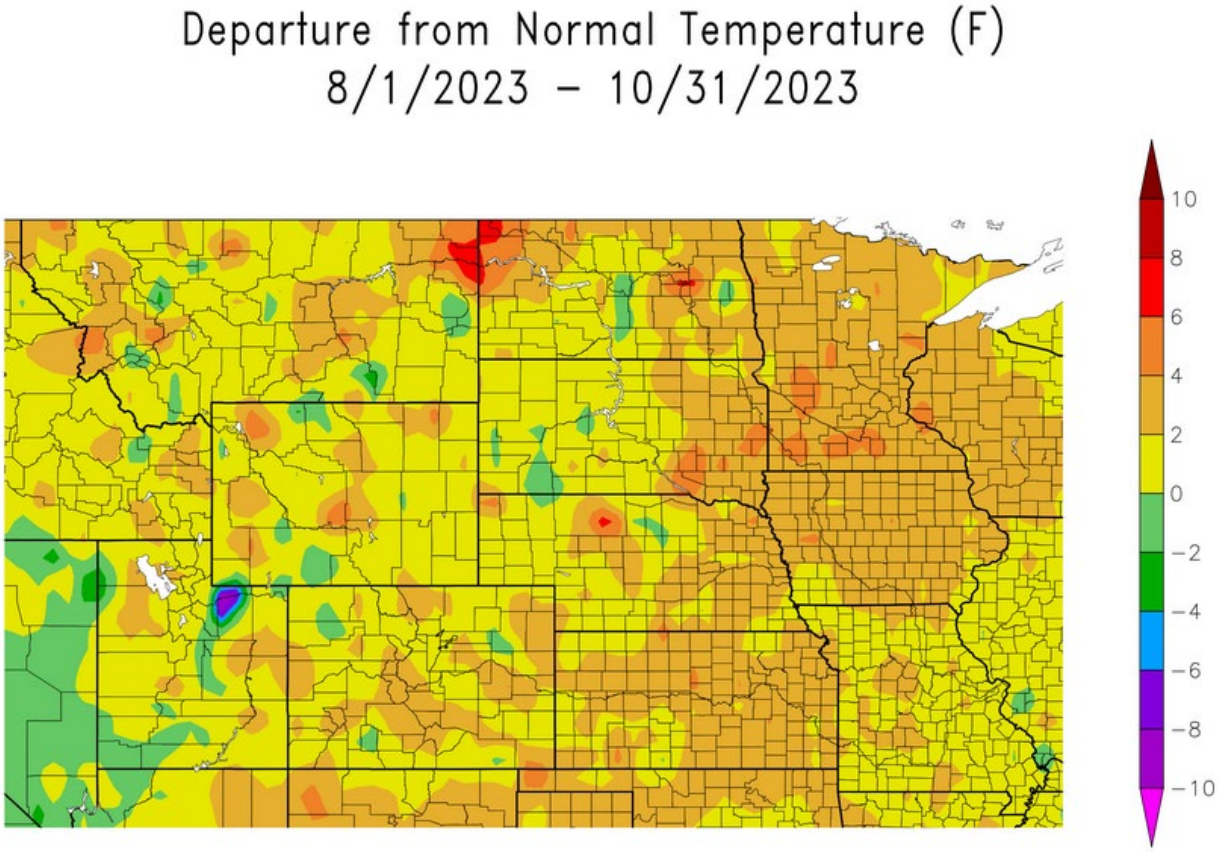


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of October is shown in **Figure 7**. Soil moisture is normal to wetter than normal across most of the upper Basin. Soil moisture in the lower basin is normal to drier than normal.

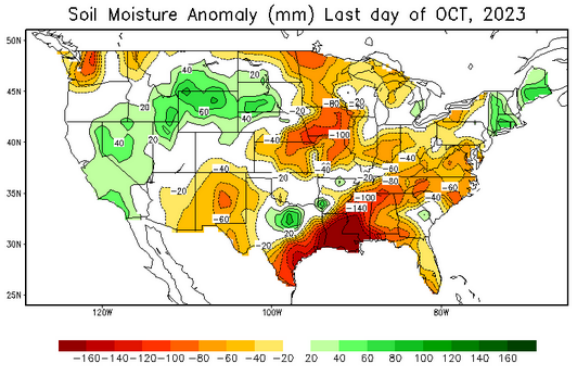
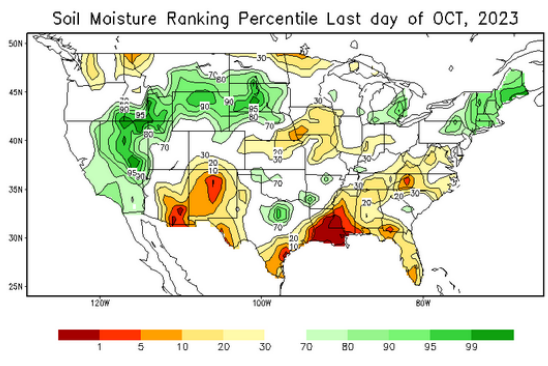
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
October 31, 2023	
	

Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. Plains snowpack is not a factor in the November runoff forecast.

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. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 8** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line). Mountain snowpack peaked in the Fort Peck reach on April 24 at 18.6” SWE and 117% of the normal peak. The Garrison reach peaked on April 6 at 15.9” SWE and 109% of the normal peak. As of June 25, all mountain snowpack had melted in both reaches.

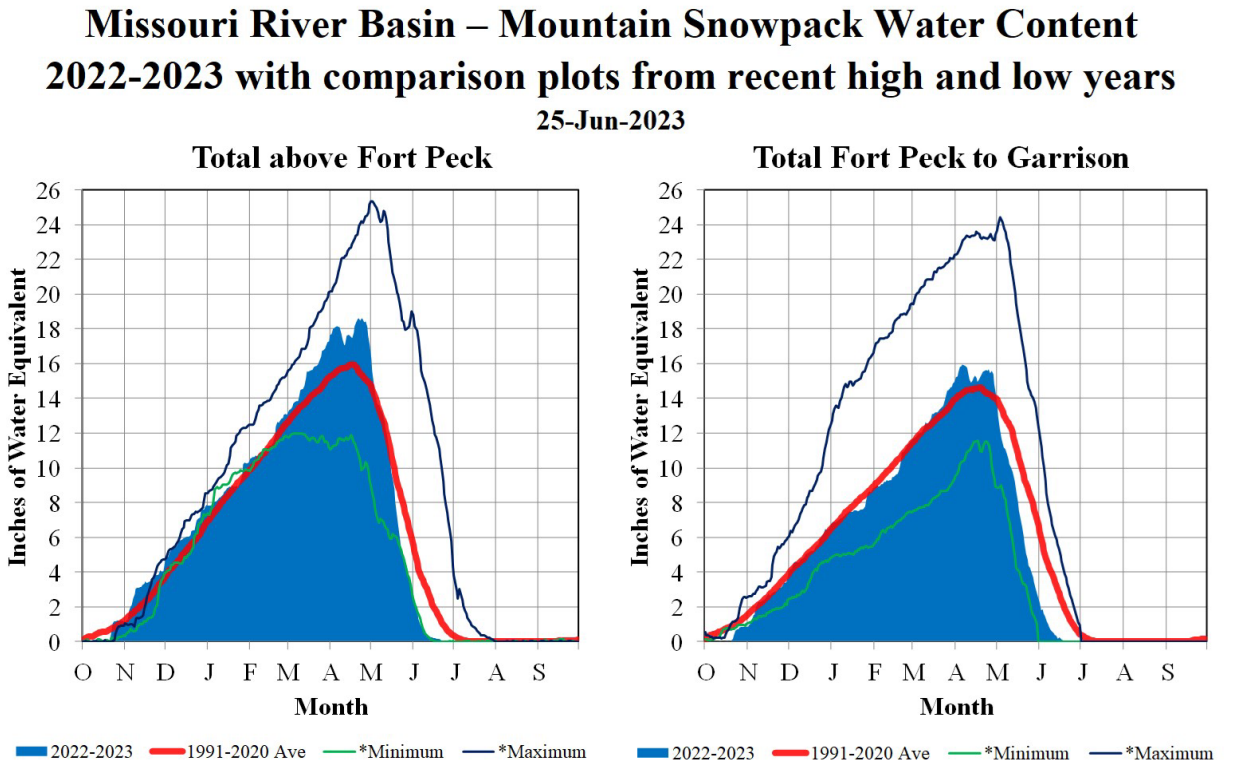


Figure 8. Mountain Snowpack Water Content

Climate Outlook

The Missouri River Basin Water Management office participates in the monthly North Central US Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists. These webinars provide updates on near-term climate outlooks and impacts, including the El Niño Southern Oscillation (ENSO) climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

El Niño Southern Oscillation

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

El Niño conditions are currently present. According to the latest ENSO outlook, these conditions have an 80% chance of continuing through the spring with a 75-85 percent chance of developing into a moderate to strong El Niño event.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The outlooks for November (**Figure 9**) indicate increased chances for above-normal temperatures across the western half of the Basin, and equal chances for below-normal, normal, or above-normal temperatures in the eastern half of the Basin. The precipitation outlook indicates equal chances for below-normal, normal, or above-normal precipitation across the entire Basin.

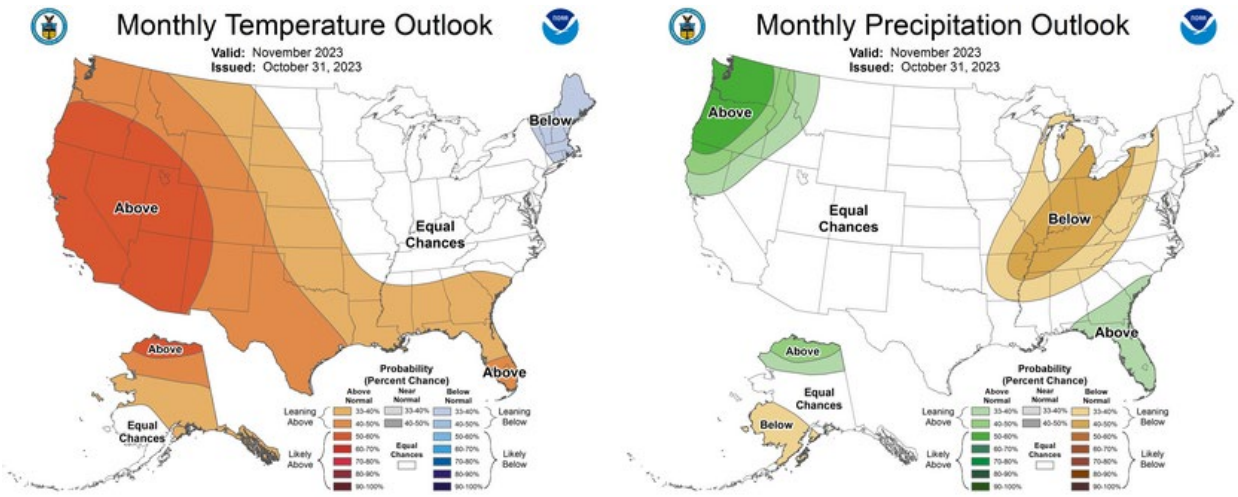


Figure 9. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 10**. The November-December 2023-January 2024 outlooks show increased chances for above-normal temperatures across most of the Basin, with increased chances for below-normal precipitation in Montana and North Dakota and above-normal precipitation in Kansas and Missouri. There are equal chances for below-normal, normal, or above-normal precipitation across the remainder of the Basin.

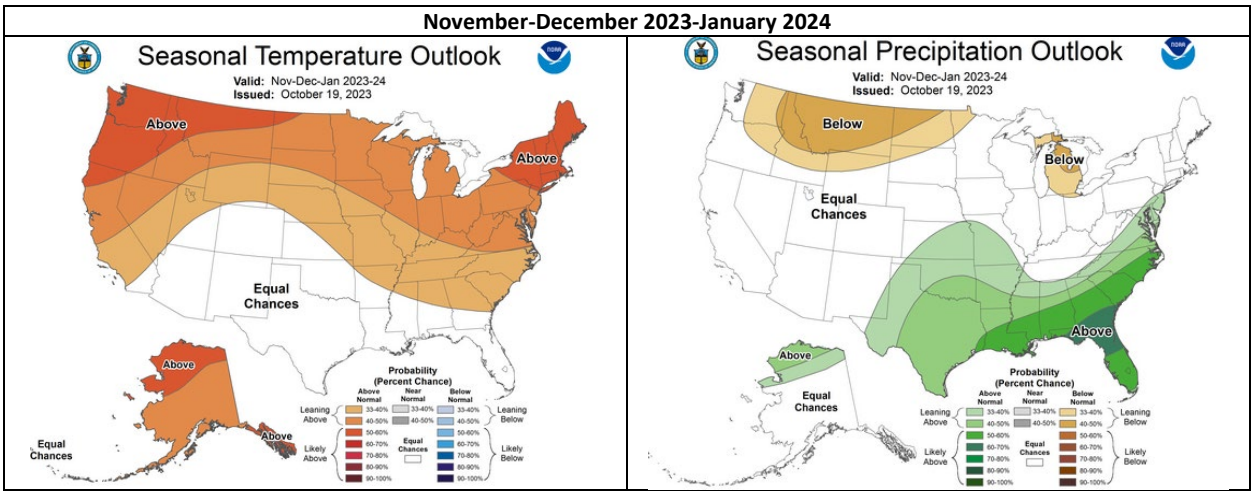


Figure 10. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given the conditions described in the preceding sections, runoff for the remainder of the year is forecasted to be near normal but will depend on precipitation received over the next two months.

In summary, the 2023 calendar year runoff forecast is **29.8 MAF, 116% of average**.

Upper Missouri River Basin
December 2023 Calendar Year Runoff Forecast
December 1, 2023

US 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 for the Missouri River Basin above Sioux City, IA (upper Basin) is available here. 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, IA. 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 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 1.1 MAF, or 107% of average, for the Basin above Sioux City, and 1.1 MAF, or 115% of average, above Gavins Point. Runoff was the same as forecasted for November. Runoff was above average in the Fort Peck and Garrison reaches, near average in the Gavins Point reach, and below average in the Oahe, Fort Randall, and Sioux City reaches.

Calendar Year Runoff Forecast Synopsis

The 2023 calendar year runoff forecast for the Missouri Basin above Sioux City, IA is **29.9 MAF, 116% of average** and 0.1 MAF more last month's forecast. The 2023 calendar year runoff forecast for the Missouri Basin above Gavins Point Dam is **27.2 MAF, 117% of average**.

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 29.7 MAF lower basic forecast to the 30.1 MAF upper basic forecast. The lower and upper basic forecasts are used in long-term regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for November 28 is shown in **Figure 1**. The drought monitor is available here. The US Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry conditions are present over 37% of the Basin, with about 2.5% of that being Extreme or

Exceptional Drought. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of February, indicates drought conditions are likely to persist in the upper Basin, with the potential for improvement in the lower Basin.

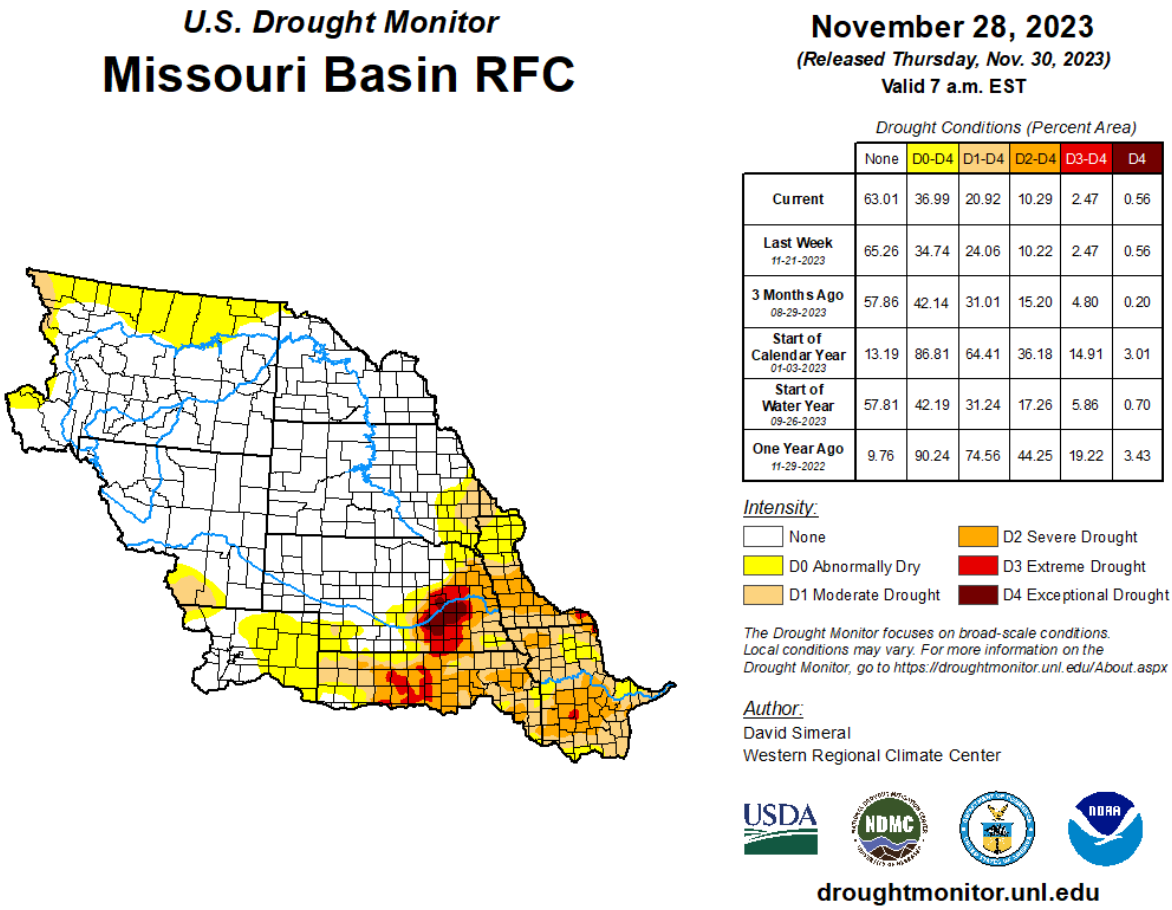


Figure 1. National Mitigation Center US Drought Monitor for the Missouri Basin

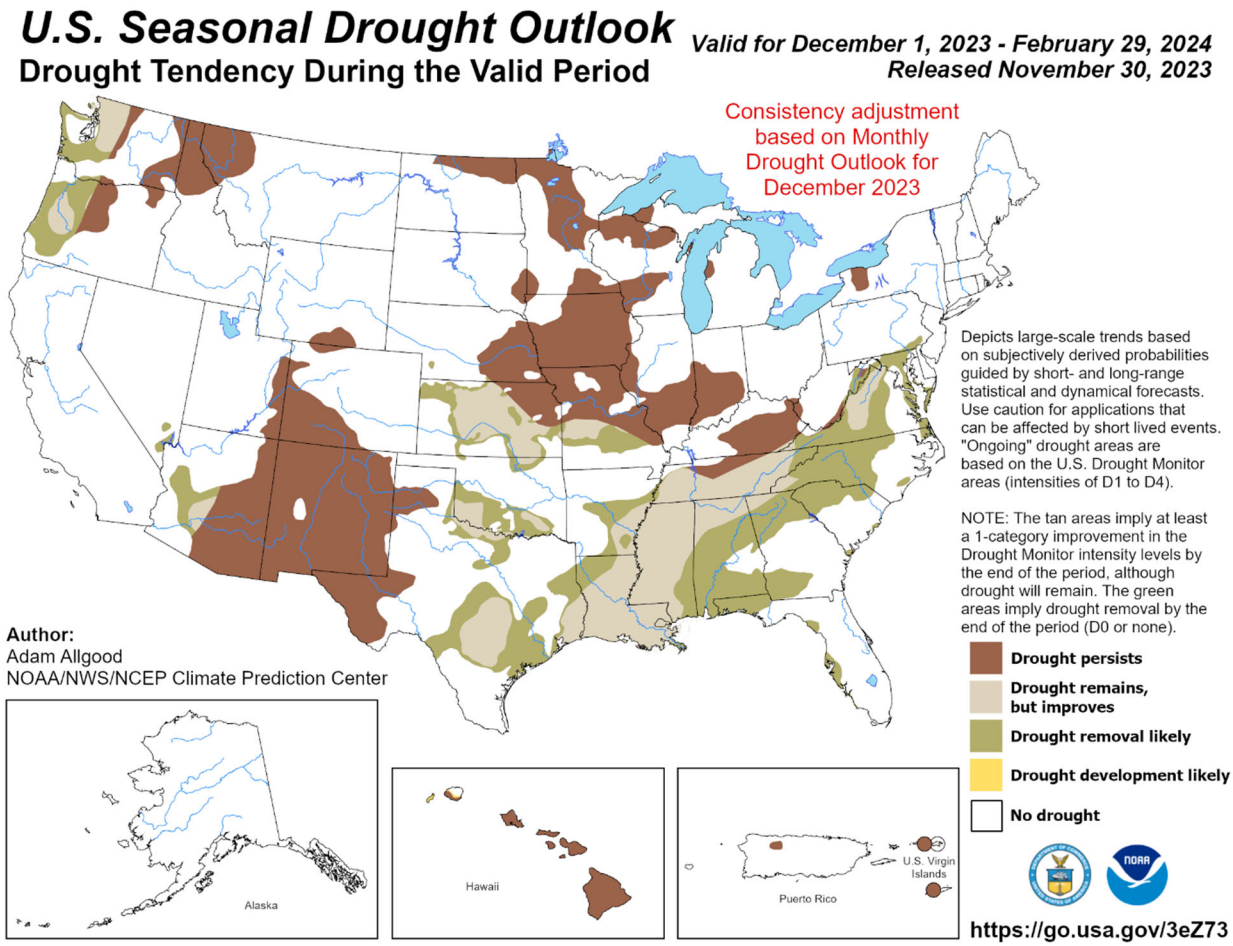


Figure 2. Climate Prediction Center US Seasonal Drought Outlook

Precipitation

Monthly precipitation accumulations are shown using the High Plains Regional Climate Center (HPRCC) images available here. The November precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. Precipitation was below normal across most of the Basin in November except for small pockets in northern Montana, north-central Nebraska, and eastern Kansas, which saw near to above-normal precipitation.

Precipitation as a percent of normal for the September-October-November period (**Figure 4**) was normal to slightly above normal across most of the upper Basin. The lower Basin observed below-normal precipitation in most areas.

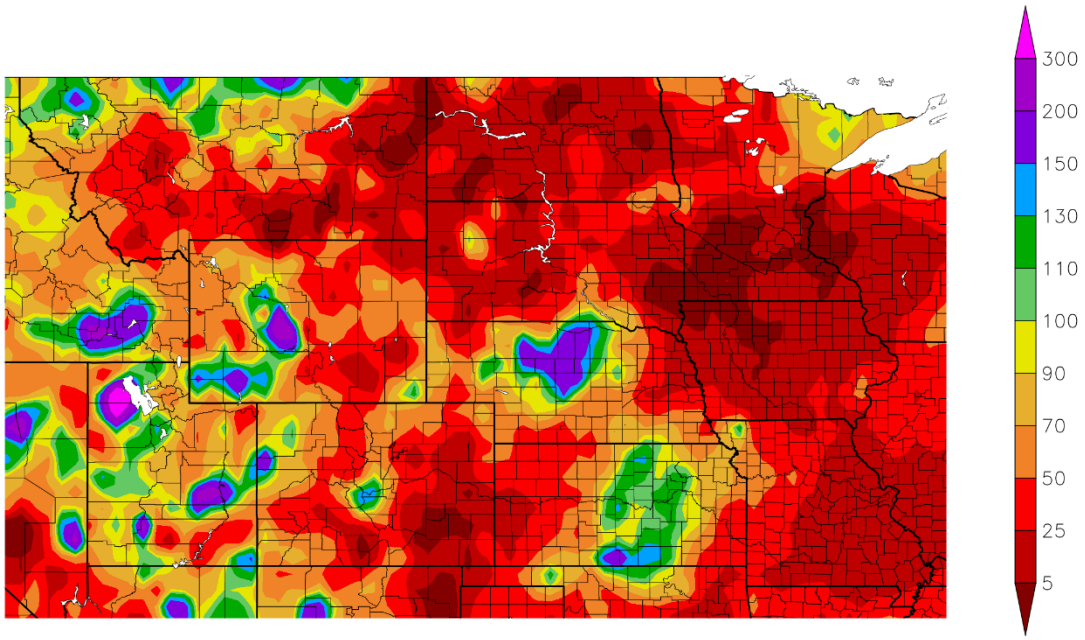


Figure 3. HPRCC Last Full-Month Percent of Normal Precipitation

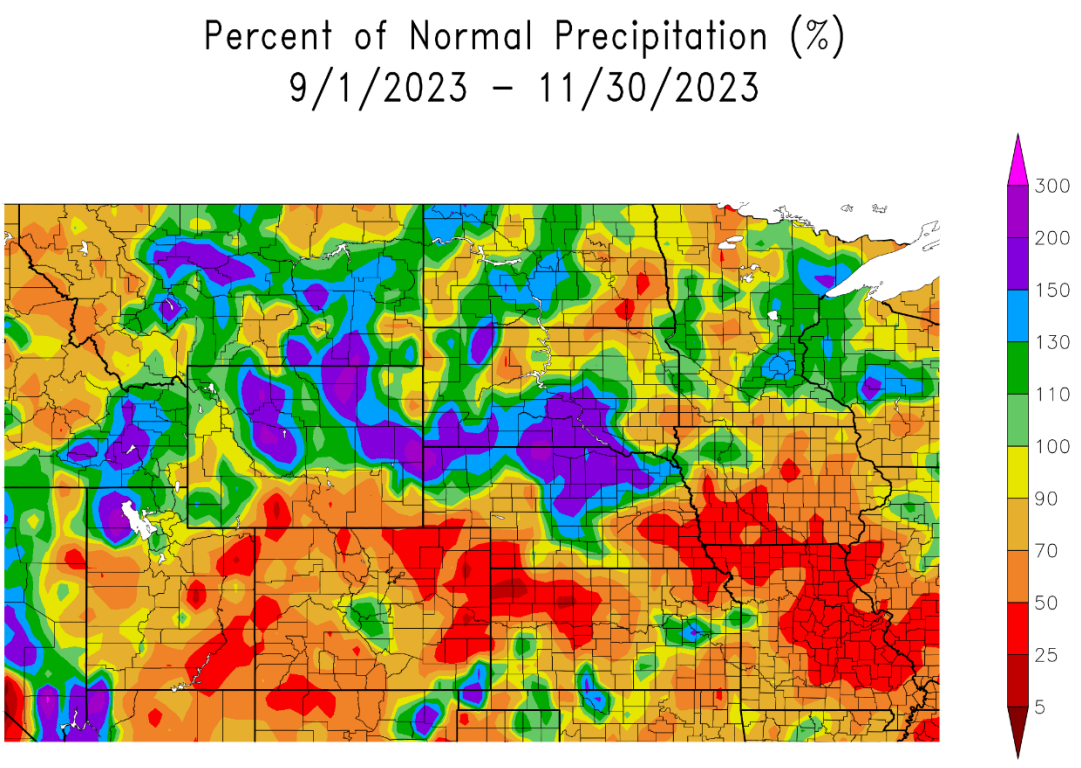


Figure 4. HPRCC Last 3-Month Percent of Normal Precipitation

Temperature

November temperature departures from normal in degrees Fahrenheit (deg F), shown in **Figure 5**, indicate warmer-than-normal temperatures across the Basin. August-September-October temperature departures are shown in **Figure 6**. The three-month average temperature departures were normal to above normal across the Basin.

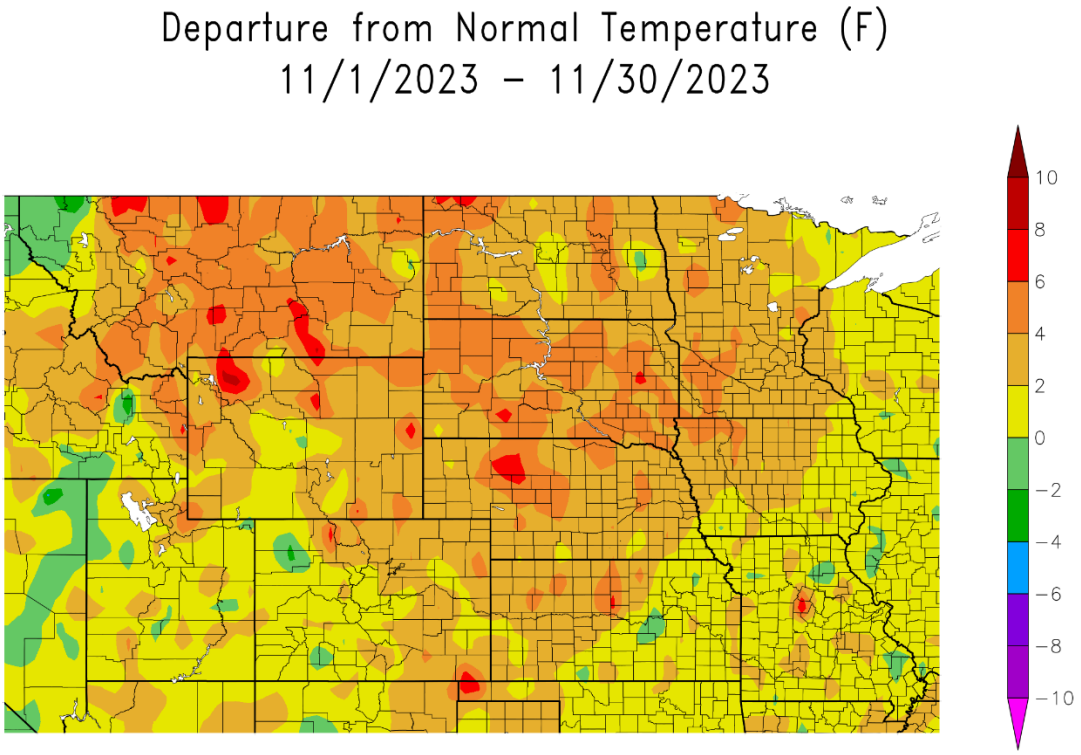


Figure 5. HPRCC Previous Month Departure from Normal Temperature

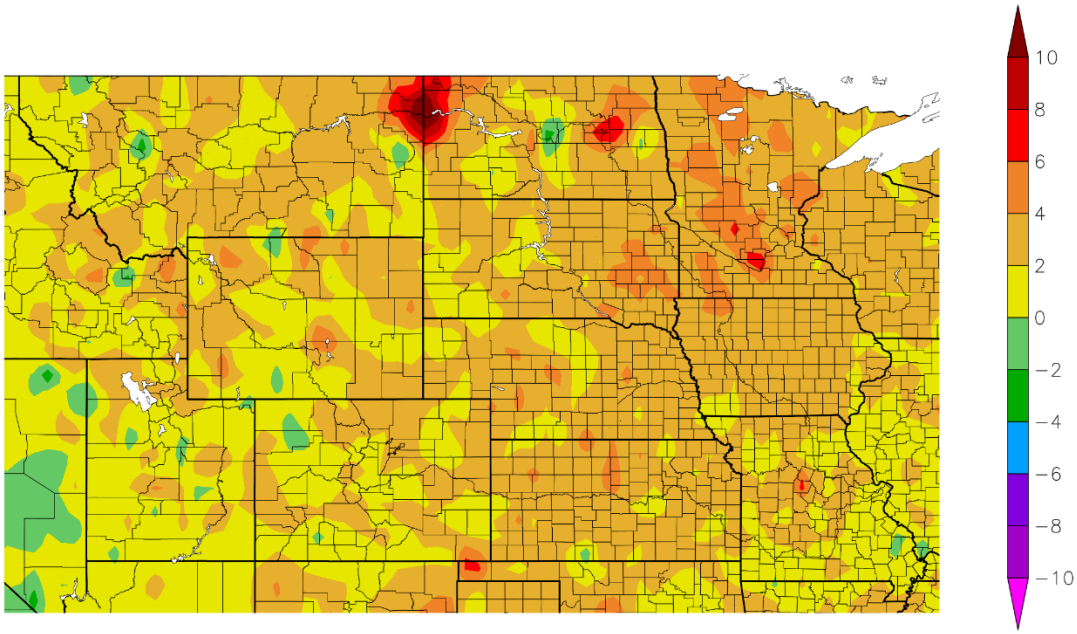


Figure 6. HPRCC Last 3-Month Departure from Normal Temperature

Soil Moisture

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

Soil moisture anomalies and soil moisture percentiles are shown using the Climate Prediction Center (CPC) images available here. Soil moisture at the end of November is shown in **Figure 7**. Soil moisture is dryer than normal across the northern and eastern edges of the Basin, and much below normal across the lower Basin. Wetter conditions are present in western South Dakota into Wyoming and southern Montana.

Soil Moisture Anomaly (mm)	Soil Moisture Percentile
November 30, 2023	

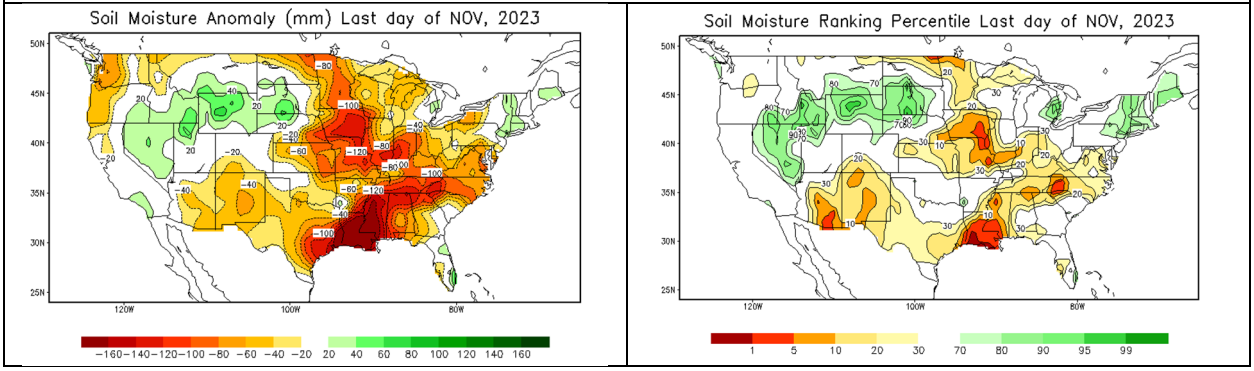


Figure 7. CPC Soil Moisture Anomaly and Soil Moisture Percentile

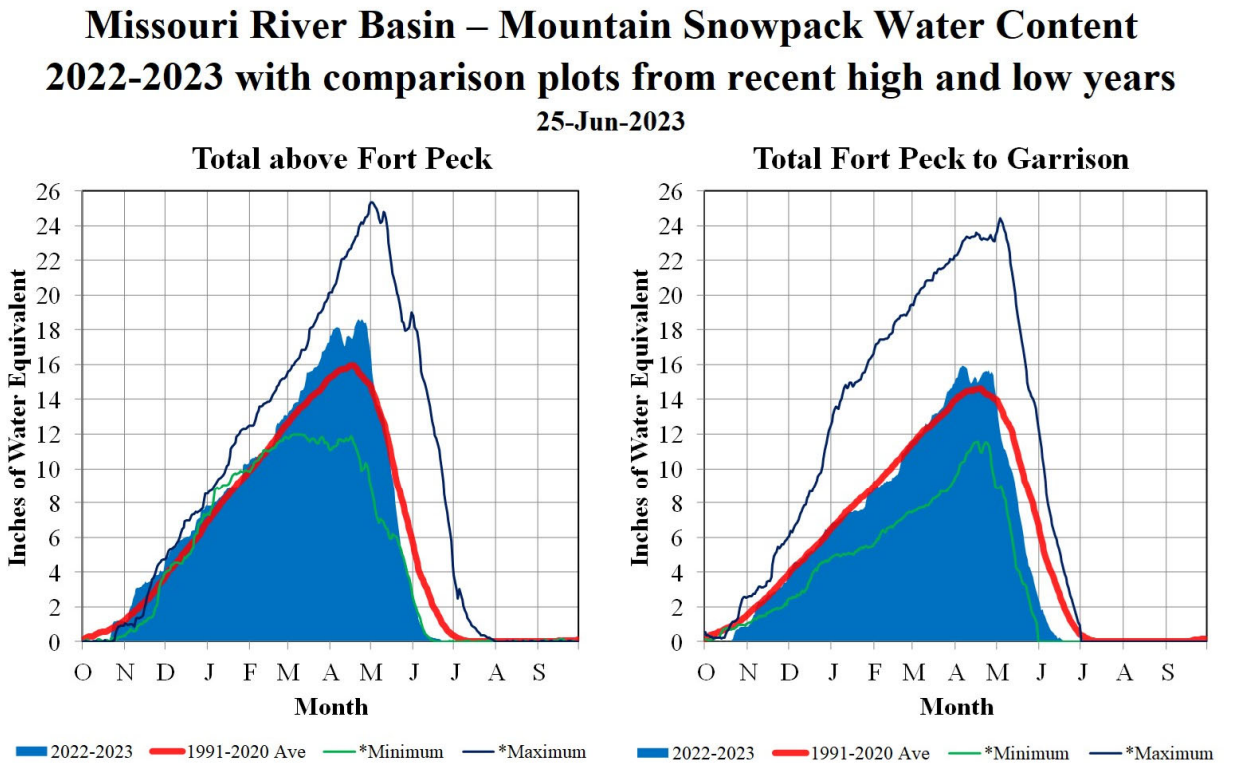
Plains Snowpack

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 only of plains snowmelt. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due both to 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 is 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. Plains snowpack is not a factor in the December runoff forecast.

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. Mountain snowpack typically peaks in mid-April; therefore, later measurements of mountain snowpack are better runoff indicators.

Mountain snowpack for the Fort Peck and Fort Peck to Garrison reaches can be found here. **Figure 8** includes time series plots of the average mountain SWE beginning on October 1 based on the Natural Resources and Conservation District SNOw TELemetry (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 1991-2020 basin average SWE (bold red line), the historic low SWE year between 1991-2020 (green line) and the historic high SWE year between 1991-2020 (dark blue line).



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Mountain snowpack peaked in the Fort Peck reach on April 24 at 18.6” SWE and 117% of the normal peak. The Garrison reach peaked on April 6 at 15.9” SWE and 109% of the normal peak. As of June 25, all mountain snowpack had melted in both reaches.

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winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above-normal snowfall across the northern Rockies.

El Niño conditions are currently present. According to the latest ENSO outlook, these conditions are expected to continue through the spring with a 62% chance of continuing from April to June 2024.

Temperature and Precipitation Outlooks

The CPC outlooks provide the forecasted probability of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available here.

The temperature outlook for December (**Figure 9**) indicates increased chances for above-normal temperatures across the Basin. The December precipitation outlook (**Figure 9**) shows increased chances for below-normal precipitation in eastern North Dakota and increased chances for above-normal precipitation in eastern Kansas and Missouri. Equal chances for below-normal, normal, or above-normal precipitation are present in the rest of the Basin.

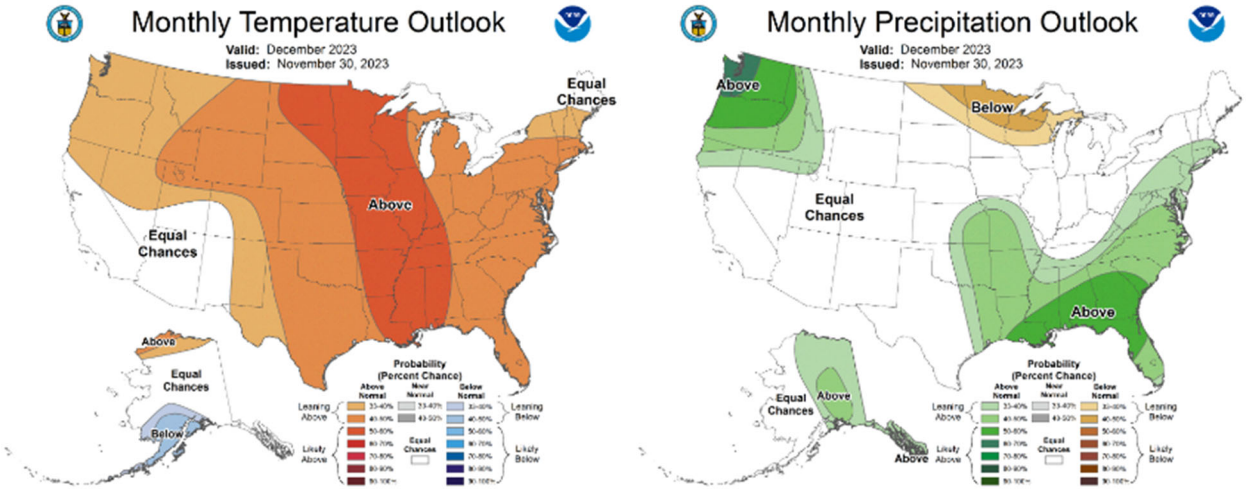

Figure 9. CPC Monthly Temperature and Precipitation Outlooks

Three-month temperature and precipitation outlooks for the remainder of the year are shown in **Figure 10**. The December 2023 – January-February 2024 temperature outlooks show increased chances for above-normal temperatures across most of the Basin except parts of Nebraska and Kansas, which show equal chances for below-normal, normal, or above-normal temperatures. The precipitation outlooks show increased chances for below-normal precipitation across Montana and North Dakota, equal chances for below-normal, normal, or above normal precipitation in South Dakota and Missouri, and increased chances for above-normal precipitation in Nebraska and Kansas.

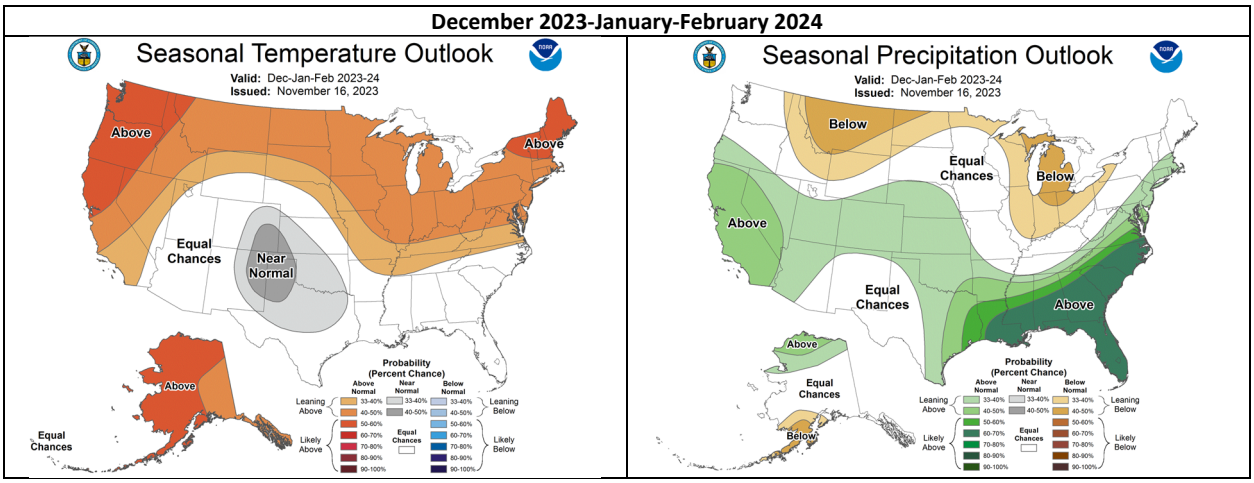

Figure 10. CPC Three-Month Temperature and Precipitation Outlooks

Summary

Given the conditions described in the preceding sections, runoff for the remainder of the year is forecasted to be near normal.

In summary, the 2023 calendar year runoff forecast is **29.9 MAF, 116% of average**.