Intermountain West Climate Summary

by The Western Water Assessment

Issued March 19, 2007

March 2007 Climate Summary

Hydrological Conditions – Drought persists in Wyoming, and there is potential for drought expansion into Nevada, Utah, western Colorado, and western New Mexico. Streamflow forecasts for the runoff season are highest in the main stem of the Colorado River, and parts of the Colorado Front Range, including the Arkansas.

Temperature – Temperatures were above average for much of the region in February, except northeastern Wyoming and eastern Colorado, which had below average temperatures.

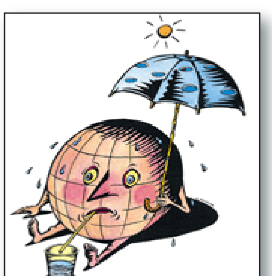
Precipitation/Snowpack – Snowpack is below average around much of the region as of March 1st, except for central and southeastern Colorado and southeastern Wyoming, which is above average.

ENSO – The El Niño event of the past winter has come to a quick end. ENSO-neutral conditions are expected for the April-June 2007 season, and a transition from ENSO-neutral to La Niña conditions is possible during the next 2-3 months.

Climate Forecasts – El Niño or La Niña is not a factor in climate forecasts for the region during the April-June 2007 season; long term trends strongly influence forecasts for the next few months for above average temperatures and below average.

IPCC releases Summary for Policy Makers; WWA releases Water Demand Literature Review

The Intergovernmental Panel on Climate Change (IPCC) recently released the executive summary of its report, "Climate Change 2007: The Physical Science Basis, Summary for Policymakers." IPCC reports, released about every five years, provide a comprehensive assessment of global climate change science, trends, and impacts. Findings include: global average annual temperature increased 1.3°F (0.74°C) from 1906 to 2005; eleven of the last 12 years (1995-2005) rank among the 12 warmest years for average global temperature since 1850; and that it is very likely (greater than 90% chance) that most of the warming since the mid-20th century is due to human-caused increases in greenhouse gas concentrations. The executive summary is available via the WWA "Resources" page on IPCC.



Also available on the WWA page is a literature review on "Factors Influencing Residential Water Demand," recently completed by WWA researchers. The extensive literature on urban water demand discusses variables that are controlled by water utilities and and others like weather and climate, socioeconomic factors, and characteristics of homes that influence demand but are not directly utility-controlled. Utility-controlled variables include the price of water, rate structures, and non-price voluntary and mandatory conservation programs; see http://wwa.colorado.edu/resources/water_demand_and_conservation/wwa_reports_and_publications.html

A clear understanding of the drivers of residential water demand is essential if water managers wish to craft effective demand management policies.

In This Issue

Recent Conditions

Forecasts

On the Web: http://wwa.colorado.edu

Contact Us - To receive an email when a new Summary is available, please email us att: **wwasummary@wwa.colorado.edu.**

Brad Udall – WWA Director
Andrea Ray – Editor/Writer
Jessica Lowrey -- Editor/Writer
Eileen McKim - Assistant Editor/Writer
Christina Alvord - Writer
Barb DeLuisi - Graphic Designer

 This publication was prepared by CIRES/WWA with support in part from the U.S. Department of Commerce/NOAA, under cooperative agreement NA17RJ1229 and other grants.

The Intermountain West Climate Summary is published monthly by Western Water Assessment (WWA), a joint project of the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES) and the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory, researching water, climate and societal interactions.

Drought, Climate Variability & Change, and Potential Impacts on Wyoming's Water Resources

By Dr. Stephen Gray, Wyoming State Climatologist and Director of the University of Wyoming's Water Resources Data Center, with Christina Alvord of Western Water Assessment

"Even the most conservative estimates for regional temperature change would have major consequences for Wyoming's water resources," says Dr. Steven Gray, Wyoming State Climatologist. This article summarizes a series of talks by Dr. Gray, beginning with one presented at an October 2006 workshop co-sponsored by WWA and dedicated to understanding how climate variability and change impact Wyoming's water resources.

Introduction

How vulnerable is Wyoming and the surrounding Intermountain West to climate variability and change? How does climate change contribute to drought? Scientists are interested in the factors that have contributed to water scarcity and caused drought conditions to persist in Wyoming over the past decade. This article addresses what is known about climate change, why Wyoming's water resources are especially vulnerable to climate variability and change, and the relationship between warmer temperatures and water availability. The scientific unknowns about climate change are just as important as areas of scientific consensus, so this article also includes several suggestions for further research.

What do we know about climate change?

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, the earth has warmed approximately 1°F over the past 100 years (IPCC, 2007). An overwhelming majority of climate scientists believe that human activities are a primary driver of this warming, though some disagree on the interactive role of natural factors. Based on regionalized output from leading climate models, the climate of the Upper Colorado River Basin will likely warm anywhere from 2°C to 4°C (3.6°F to 7.2°F) within the next fifty years (IPCC, 2007, Figure 1a). In relation to impacts on Wyoming's water resources, even conservative warming projections will likely have major impacts on regional water supplies. But why would such seemingly small increases in temperature impact Wyoming's water resources? A closer look at regional vulnerabilities to climate variability and change can in part explain the relationship between warmer temperatures and annual water supplies.

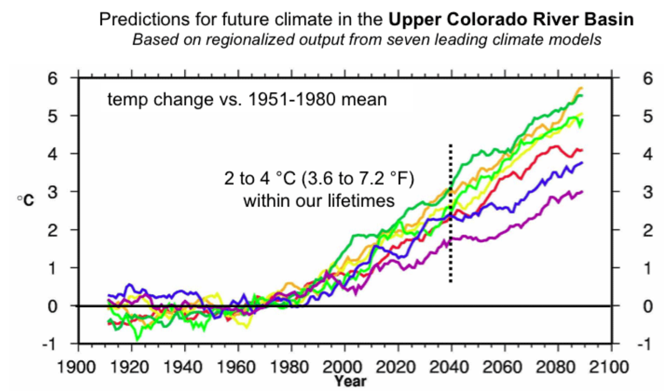


Figure 1a. The IPCC AR4 Report (2007) indicates the Upper Colorado River Basin could warm significantly based on seven different climate models. Even the most conservative warming estimates will have an adverse effect on water supplies for the Upper Colorado River Basin.

Why are Wyoming's water resources vulnerable to climate change?

Wyoming's water resources are sensitive to climate change for several reasons: 1) they are dependent on snowpack; 2) the regional climate is semi-arid; and 3) the geographical features of regional watersheds makes it difficult to capture all available water supplies. Therefore, reduction in average annual snowpack or rapid snowmelt impacts water supplies across the state.

Wyoming relies on runoff from snowpack for annual water supplies; this fact is a primary vulnerability because of the nature of the physical and hydrological processes and the legal framework of western water resources. Snow falls in the mountains in the winter where it is stored as snowpack until it runs off in the spring into streams and reservoirs for use during the rest of the year. So the majority of precipitation falls as snow in the winter, in comparison to watersheds in the east, where precipitation is distributed more evenly throughout the year, regularly replenishing water supplies.

Wyoming's total annual precipitation is also sensitive to climate variability. With an annual average precipitation of 16.84 inches, it is the 5th driest state in the U.S. Wyoming has features of a high altitude desert, and is similar to other warm and dry like New Mexico, Utah, Arizona, and Nevada that have annual average precipitations that do not exceed 15 inches (PRISM Group, Oregon State University, http://www.prismclimate.org). Relatively small changes in precipitation represent a large fraction of the total precipitation.

The third vulnerability is the relatively small geographical size of Wyoming watersheds which are the headwaters of the Upper Colorado River, Green River, and the Platte River. The smaller watershed area for these headwater basins limits the total snowpack that may accumulate, and limits the area over which water resources might be captured. The majority of snowpack in Wyoming is concentrated in a relatively small area above 10,000 feet elevation. In the spring, a few hot days can rapidly melt the majority of this winter snowpack. Because of the small watersheds, the runoff may be transported rapidly downstream and out of Wyoming. Thus Wyoming water users may have limited time and opportunity to store water. Another geographic context is that droughts tend to encompass much or all of these watersheds. In larger basins, on the other hand, dry conditions in one sub-region are often offset by average to wet conditions in other locations.

Impact of Warmer Temperatures on Water Supplies

Warmer temperatures exacerbate water supply vulnerabilities by affecting the frequency and behavior of snowfall and snowmelt, and reducing total snowpack amounts. Slight increases in temperature cause precipitation to fall as rain instead of snow and initiates earlier spring snowmelt. In Wyoming, a large fraction of total annual snow falls as "warm snow" (i.e. near the freezing point) in the late spring (April through May). A shift towards more rain-dominated precipitation alters total snowpack amounts and subsequent water resource availability. This is because rain falling on top of snow causes melting, but more importantly, because rain enters ground and surface water supplies almost immediately instead of being preserved as mountain snowpack that gradually melts throughout the spring and summer.

Warmer temperatures causing premature spring snowmelt is characterized by an earlier and steeper shift in streamflow regimes (Dettinger, 2005, Figure 1b.) Spring runoff beginning as early as mid-March leads to increased rates of evaporation and further diminishes late-season flows (NRC, 2007). Earlier timing of spring snowmelt was first observed in the Sierra Nevada mountains in California, and is now being observed elsewhere in the West (Stewart et al., 2004, Figure 1c). While warmer temperatures threaten present and future water supplies, it is also important to incorporate the Paleo record of drought as another component in identifying Wyoming water supply vulnerabilities.

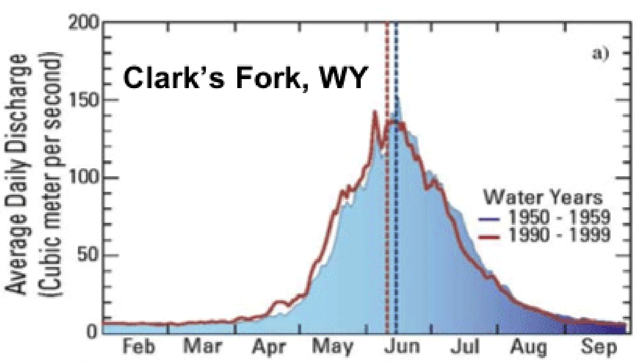


Figure 1b. Increase in temperatures has contributed to earlier peak flows over a long-term average for Clark's Fork, Wyoming (Dettinger, 2005).

What do we know about the Paleo-Climate Record?

A new 500-year reconstruction of annual streamflows on the Upper Colorado River finds that the amount of water in the Colorado River at Lees Ferry varies dramatically from year to year, often greatly exceeding or falling below the 20th century annual mean of roughly 15.2 million acre feet (Figure 1d, Woodhouse, et al., 2006)[1]. These analyses also show that the long-term annual

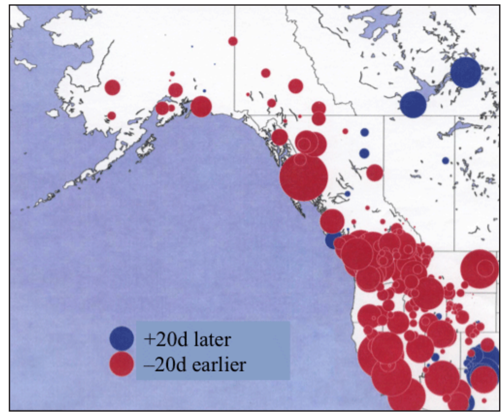


Figure 1c. It is clear that the West, especially in area surrounding the Sierra Nevadas have experienced spring snowmelt upwards of 20 days earlier than averages of spring snowmelt from 1948-2000. Earlier spring snowmelt as a result of warmer temperatures potentially leads to an overall decline in streamflows (Stewart et al., 2004).

means over the past 500 years was actually closer to 14.5 million acre feet, and preliminary work suggests that the annual mean over the past 1000 years may have been even lower. Analysis of 25-year annual means for Upper Colorado River stream flows indicate that the past 500 years have been marked by several extended periods of significantly below average streamflows and that, on the whole, the 20th century was a remarkably wet time in the basin's history (Figure 1e).

Areas of Uncertainty and Areas for Further Research

Many aspects of the relationship between warmer temperatures and decreased water supplies are well documented in Wyoming, however changes in regional precipitation, and potential changes in consumptive water uses are still highly speculative. For example, there is little if any conclusive evidence concerning how and to what degree climate change will impact the amount of precipitation falling on sub-regions within the Intermountain West. A recently released report from the National Research Council on the Colorado River reports that temperatures in the region will rise significantly over coming decades based on leading climate model agreement, but do not show any uniformity in regional amount of future precipitation change (NRC, 2007). Model predictions for precipitation change in the Upper Colorado River Basin over the next fifty years range from an increase of 60% to a decrease of more than 20% (Figure 1a).

There is also a pressing need to better understand how climatic variability and change will impact water supplies and demand. More accurate information concerning current and future consumptive uses of water resources for Wyoming and surrounding states could provide both climate scientists and policy makers with a better indication of available water resources and a clearer picture of where water supply vulnerabilities lie. Better estimates of consumptive uses could help answer questions such as, how does water use throughout the year contribute to water scarcity and in what way? Or specifically, how would a predicted 2-3° C

1 Featured in the June 2006 Intermountain West Climate Summary.

rise in summer temperatures, combined with a significant shift from agricultural to municipal use, affect demand? Answering such questions will be a primary challenge in coming years.

Many critical aspects of snowpack variability and snow climatology in Wyoming are still poorly understood. Although the majority of Wyoming's water supplies come from high elevation snowpack, precise runoff contribution by glaciers, permanent snowfields, and low to mid elevation snowpack is not well documented. Low to mid elevation snowpack is potentially the most vulnerable to future warming, but requires research efforts to better understand warming sensitivity. How increased or decreased rates of snowmelt and rainfall affect Wyoming basins is not well understood as well. Further monitoring and assessment efforts are needed to pinpoint regional-specific impacts and vulnerabilities.

In short, Wyoming's water resources are vulnerable to climate change because water supplies are dependent on snowpack, the regional climate is semi-arid, warmer temperatures negatively affect regional water supplies, and the paleo record clearly demonstrates how drought is a natural, defining feature of the regional climate. However, reducing uncertainties associated with regional precipitation forecasts, identifying new relationships between regional water supplies and climate variability and change, and planning for future water use and demand in coming decades are the next steps in assessing regional water supply vulnerabilities.

Sources

Dettinger, M., 2005: Changes in Streamflow Timing in the Western United States in Recent Decades. National Streamflow Information Program (NSIP), USGS Fact Sheet 2005-3018.

IPCC, Working Group I, 2007. Climate Change 2007: The Physical Science Basis: Summary for Policy Makers, available at, http://ipcc-wg1.ucar.edu/wg1/docs/WG1AR4_SPM_Approved_05Feb.pdf.

National Research Council (NRC). 2007. Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability. Committee on the Scientific Bases of Colorado River Bain Water Management Water Science and Technology Board, Washington D.C.: The National Academies Press.

PRISM Group, Oregon State University, courtesy Chris Daly, http://www.prismclimate.org.

Stewart, I., Cayan, D., and M.D. Dettinger, 2004: Changes in Snowmelt Runoff Timing in Western North America under a 'Business as Usual' Climate Change Scenario. Climatic Change, 62, 217-232.

Woodhouse, C., Gray, S., and D.M. Meko, 2006: Updated streamflow reconstructions for the Upper Colorado River Basin. Water Resources Research, 42. W05415.

On the Web

- For more information on Wyoming water supply vulnerabilities and Paleo streamflow reconstructions on the Colorado River, please contact Steve Gray at sgray8@wyo.edu, or visit the Wyoming State Climatologist homepage at http://www.wrds.uwyo.edu/wrds/wsc/wsc.html.

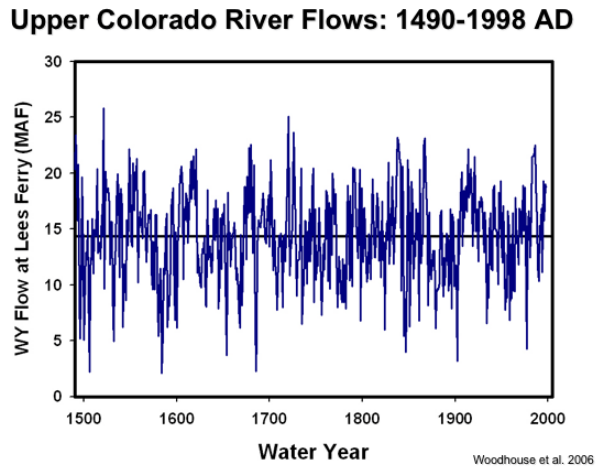


Figure 1d. Graph depicting deviance from 15.2 million acre feet average annual flows for the Colorado River dating back to 1490 A.D. based on historical streamflow reconstructions. Natural variability of Colorado River flows is apparent in this graph (Woodhouse, et al., 2006).

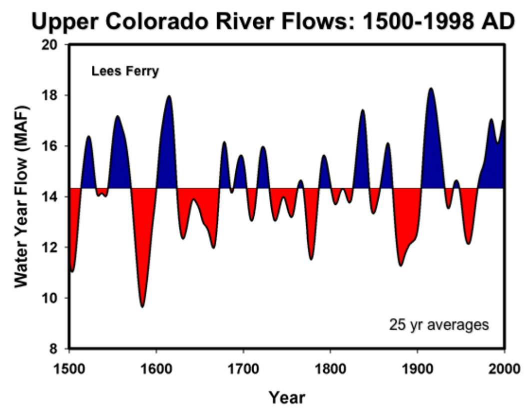


Figure 1e. By examining 25-year averages of flows dating back to 1500 A.D., it is evident that drought is a defining feature of the Colorado River (Woodhouse et al., 2006).

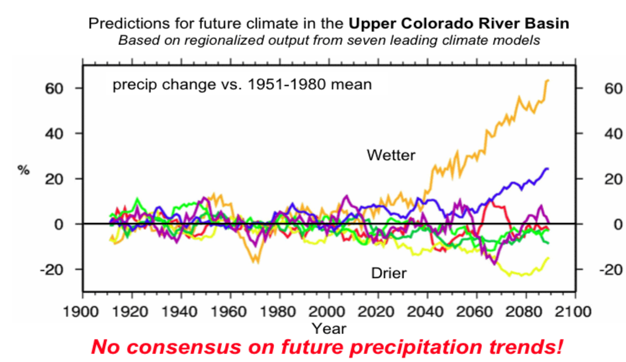


Figure 1f. Climate models used in the IPCC AR4 Report (2007) are not in agreement concerning change in precipitation for the Upper Colorado Region. Wyoming and the Intermountain West are dependent on snow precipitation for water supplies, so further research on regional precipitation projections is necessary for long-term water management and planning.

Temperature 2/1/07 - 2/28/07

Monthly average temperatures for February 2007 for the Intermountain West region ranged from lows in the mid-teens in western and northeastern **Wyoming** and north central **Colorado** mountains to highs in the mid-40s in southeast and northwest **Utah** (Figure 2a). Eastern Colorado, and especially south-eastern **Colorado** had the lowest departure from average with temperatures ranging from 6 - 15° F below average. Parts of northern and eastern **Wyoming** were also below average by 3 - 6° F. On the other hand, most of **Utah**, the western half of **Colorado**, and western **Wyoming** were above average, with the highest departure from average in northwest **Utah** with temperatures of 3 -12° F above average (Figure 2b). The NWS Salt Lake City reports that a few record temperature highs were set in **Utah** in February, while the NWS Denver/Boulder reports that February average temperature was 4°F below average, with one record low of -18°F set on February 2nd.

In comparison to February 2006 (Figure 2c) temperatures in 2007 were higher in **Wyoming**, **Utah** and in western **Colorado**. **Wyoming** had the largest difference between years, with temperatures below average by 2 – 8° F in February 2006, whereas in February 2007, much of western and southern **Wyoming** were average to above average by 2 - 9° F. **Utah** had lower average temperatures in February 2006 than in 2007 by 0 – 6° F.

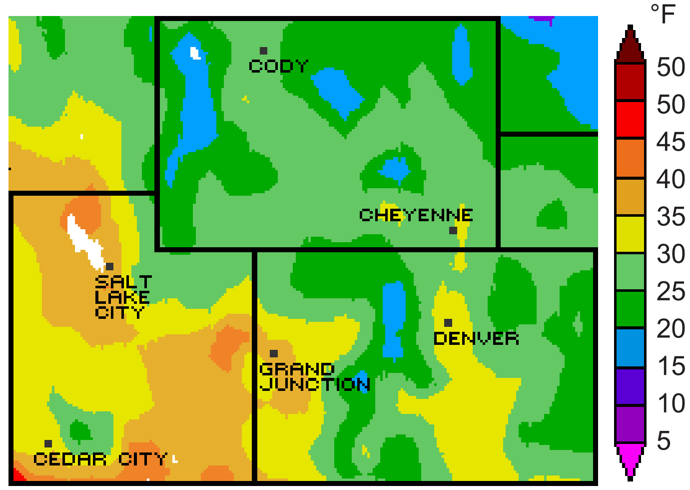


Figure 2a. Average temperature for the month of February 2007 in ° F. Figures 2 (a-c) courtesy of High Plains Regional Climate Center.

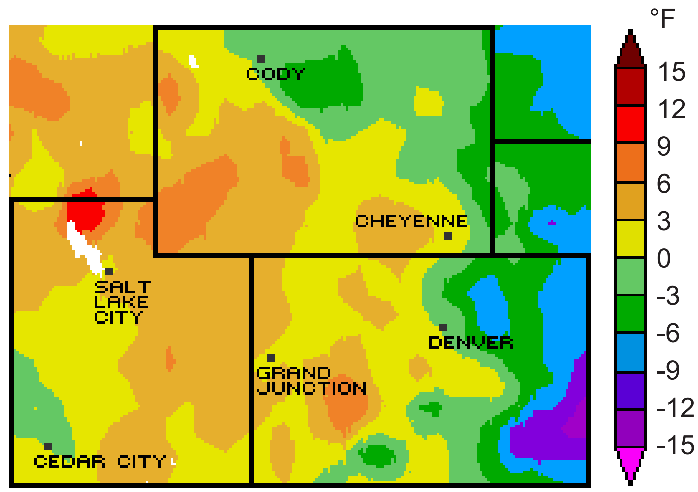


Figure 2b. Departure from average temperature for the month of February 2007 in F°.

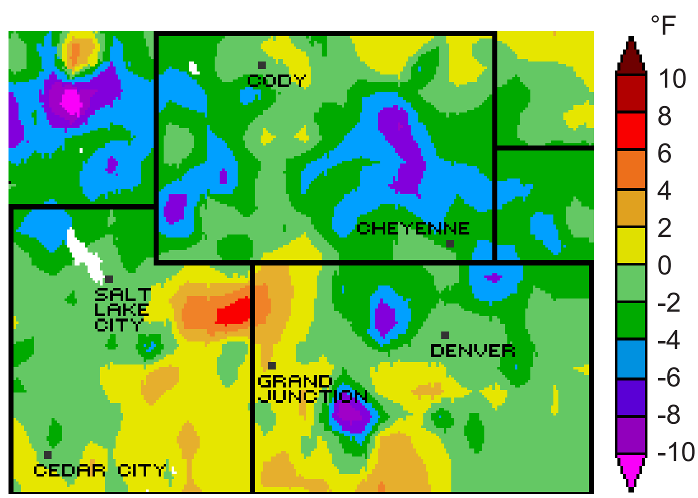


Figure 2c. Departure from average temperature in F° for last year, February 2006.

Notes

Figures 2a-c are experimental products from the High Plains Regional Climate Center. These data are considered experimental because they utilize the newest data available, which are not quality controlled. These maps are derived by taking measurements at individual meteorological stations and interpolating (estimating) values between known points to produce continuous categories. Interpolation procedures can cause aberrant values in data- sparse regions. For maps with individual station data, please see web sites listed below. Average refers to the arithmetic mean of annual data from 1971- 2000. Departure from average temperature is calculated by subtracting current data from the average. The result can be positive or negative.

On the Web

- For the most recent versions of these and maps of other climate variables including individual station data, visit: http://www.hprcc.unl.edu/products/current.html.
- For information on temperature and precipitation trends, visit: http://www.cpc.ncep.noaa.gov/trndtext.htm.
- For a list of weather stations in Colorado, Utah, and Wyoming, visit: http://www.wrcc.dri.edu/summary

Precipitation 2/1/07 - 2/28/07

Total precipitation for February 2007 in the Intermountain West regions ranged from 0 to 3+ inches (Figure 3a). North central **Colorado**, northwest and south central **Wyoming**, and north central **Utah** received the highest totals. Most of the rest of the Intermountain West region received from 0.5 to 2 inches. However, eastern **Colorado**, northeast **Utah**, and southwest **Wyoming** only received from 0 to 0.5 inches of precipitation in February, with a large section of southeast **Colorado** receiving < 0.25 inches of precipitation.

Precipitation in eastern **Colorado** was greater than 200% of average in December, but due to low precipitation in February, it is now average to below average (Figure 3b). According to the NWS Denver/Boulder, after December and January had above average snowfall, February was slightly below average. However, Denver has accumulated 65.0 inches of snowfall since the start of water year 2007, or 3.3 inches above the entire seasonal average. Much of **Wyoming** had near average precipitation in February, but areas in southwest and central **Wyoming** had below average. Parts of the west, and north-east and southwest corners had above average. **Utah** had 120 – 150% of average precipitation in February in the northwest section, while much of the northeast and southwest only had 40 – 80 % of average.

Percent of average precipitation since the start of the water year (Figure 3c) is near average or above for all of **Colorado** and Utah, with southeast **Utah** and the eastern half of **Colorado** at 150 - 200% of average. Most of western and southern **Wyoming** is near average, while the north central and northeast sections of **Wyoming** are at 40 – 80 % of average.

Notes

The data in Figs. 3 a-c come from NOAA's Climate Prediction Center. The maps are created by NOAA's Earth System Research Laboratory and are updated daily (see website below). These maps are derived by taking measurements at individual meteorological stations and interpolating (estimating) values between known data points to produce continuous categories. The water year runs from October 1 to September 30 of the following year. As of October 1, 2006, we are in the 2007 water year (Figure 3c). The water year is more representative of climate and hydrological activity than the standard calendar year. It reflects the natural cycle of accumulation of snow in the winter and run-off and use of water in the spring and summer. Average refers to the arithmetic mean of annual data from 1996-2005. This period of record is only ten years long because it includes SNOTEL data, which have a continuous record beginning in 1996. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100.

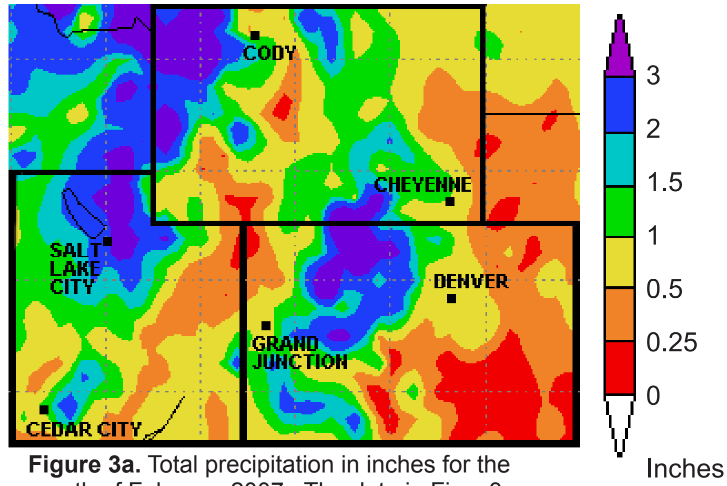


Figure 3a. Total precipitation in inches for the month of February 2007. The data in Figs. 3 a-c come from NOAA's Climate Prediction Center. The maps are created by NOAA's Earth System Research Laboratory.

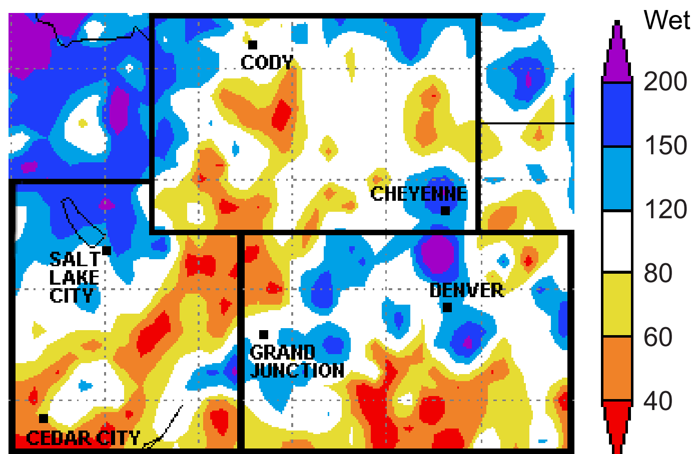


Figure 3b. Percent of average precipitation for the month of February 2007.

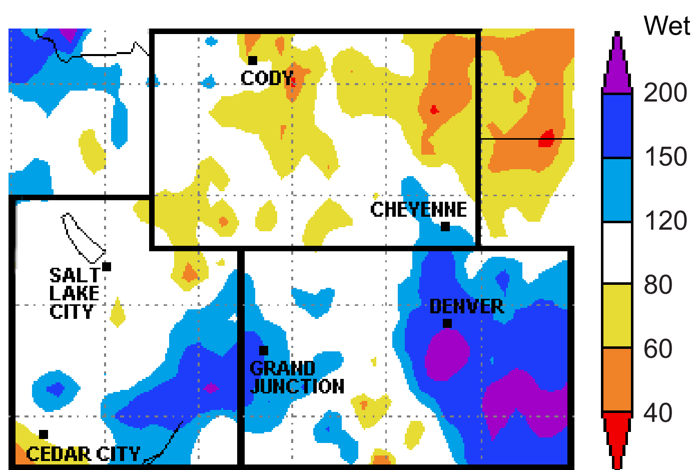


Figure 3c. Percent of average precipitation accumulation since the start of the water year 2007. (Oct. 1, 2006 – Feb. 28, 2007).

On the Web

- For the most recent versions of these and maps of other climate variables including individual station data, visit: http://www.hprcc.unl.edu/products/current.html.
- For precipitation maps like these and those in the previous summaries, which are updated daily visit: http://www.cdc.noaa.gov/Drought/.
- For National Climatic Data Center monthly and weekly precipitation and drought reports for Colorado, Utah, Wyoming, and the whole U. S., visit: http://lwf.ncdc.noaa.gov/oa/climate/research/monitoring.html.
- For a list of weather stations in Colorado, Utah, and Wyoming, visit: http://www.wrcc.dri.edu/index.html.

U.S. Drought Monitor conditions as of 3/13/07

According to the National Drought Monitor on March 15, 2007, drought intensity status has decreased slightly for northern and eastern **Wyoming** from D3 (extreme) to D2 (severe) (Figure 4). The rest of the state remains in moderate to extreme drought status. **Utah** remains unchanged from last month, with the entire state in DO (abnormally dry) status. **Colorado** is currently not in drought status, except for abnormally dry conditions in the northeast and southwest corners.

According to the U. S. Drought Monitor Impacts Reporter, **Colorado's** Governor Owens has sent a formal request to the U.S. Farm Service Agency that farmers in eight Front Range counties be eligible to apply for agricultural disaster assistance loans. The requested aid would be intended to help mitigate losses sustained from drought, fire, high winds, and heat occurring throughout 2006. The USGS Drought Watch reports that nine counties in north central **Wyoming** are in moderate hydrologic drought and streamflow averages are below average.

Notes

The U. S. Drought Monitor (Figure 4) is released weekly (every Thursday) and represents data collected through the previous Tuesday. The inset (lower left) shows the western United States from the previous month's map.

The U. S. Drought Monitor maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of the several agencies; the author rotates among the agencies.

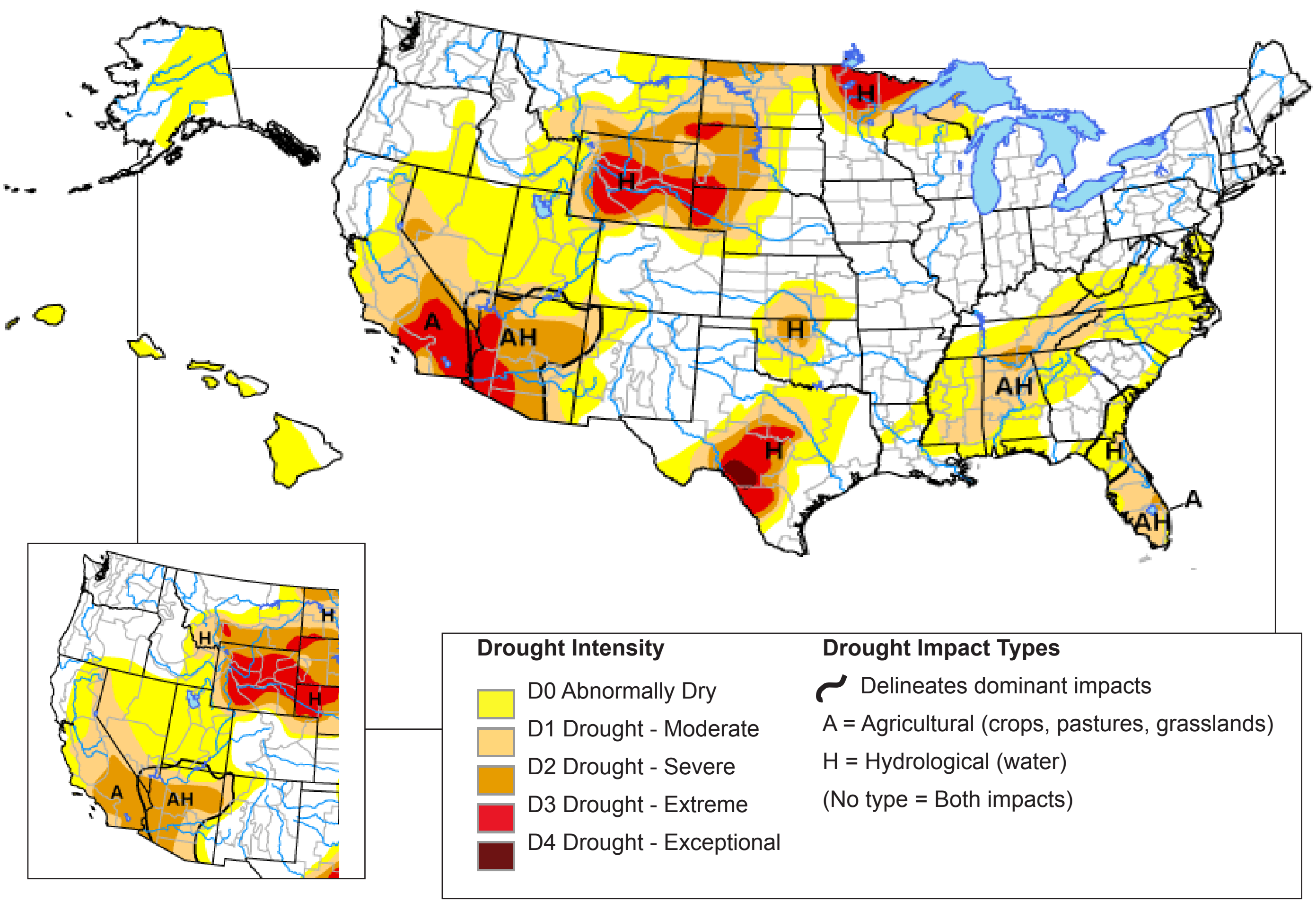


Figure 4. Drought Monitor released March 15, 2007 (full size) and last month, February 20, 2007 (inset, lower left) for comparison.

On the Web

- For the most recent Drought Monitor, visit: http://www.drought.unl.edu/dm/monitor/html
  This site also includes archives of past drought monitors
- Drought Impact Reporter (National Drought Mitigation Center): http://droughtreporter.unl.edu/

Intermountain West Snowpack data through 3/1/07

Snowpack conditions across the Intermountain West are below average or near average, except for east of the Continental Divide in **Colorado** where conditions are above average. The South Platte River Basin in northern **Colorado** ranges from 110-129% of average snowpack and in the southern part of the state, Arkansas River sub-basins of Purgatorie and Cucharas are reporting 146% and 126% of average snowpack. Elsewhere in the state, the Upper Rio Grande Basin snowpack fell to 93% of average, down from 102% of average last month, the Animas River Basin located in Southwest **Colorado** near Durango is reporting 73% of average, and the San Miguel Basin snowpack is 90% of average. For more information of snowpack conditions for **Colorado**, refer to page 10.

Wyoming and **Utah** snowpack conditions are still below average for much of the region. **Utah** statewide snowpack is 71% of average, ranging from 59% in Southwest **Utah** to 78% of average in the Uintahs. Statewide snowpack for **Utah** increased 5-8% this month due to recent storm activity; however snow accumulations for the remainder of March need to be 234% of average statewide in order to boost snowpack conditions to average by April 1, according to NRCS. Across **Wyoming**, snowpack conditions have largely maintained or improved over the last month, especially in northeast **Wyoming** where snowpack conditions are currently 70-89% of average, a significant increase from 50% of average or less reported on February 1. The majority of the Wind River and Big Horn basin snowpack is in the 50-69% of average range, while the Green River Basin snowpack near the **Colorado**, **Utah**, and **Wyoming** border is 70-89% of average, falling from February 1 estimates of 90-109% of average.

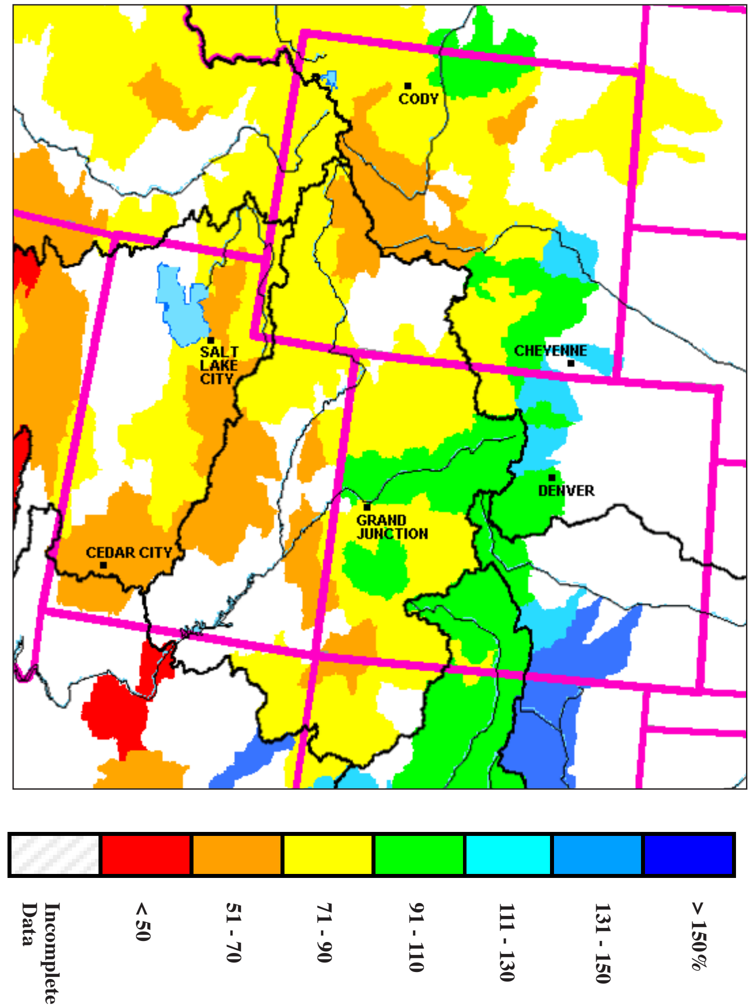


Figure 5. Snow water equivalent (SWE) as a percent of average for available monitoring sites in the Intermountain West as of March 1, 2007 courtesy of the Natural Resources Conservation Service.

Notes

Snow water equivalent (SWE) or snow water content (SWC) refers to the depth of water that would result by melting the snowpack at the measurement site. SWE is determined by measuring the weight of snow on a "pillow" (like a very large bathroom scale) at the SNOTEL site. Knowing the size of the pillow and the density of water, SWE is then calculated from the weight measurement. Given two snow samples of the same depth, heavy, wet snow will yield a greater SWE than light, powdery snow. SWE is important in predicting runoff and streamflow. Snowpack telemetry (SNOTEL) sites are automated stations operated by NRCS that measure snowpack. In addition, SWE is measured manually at other locations called snow courses. (See page 18 for streamflow forecasts.)

Figure 5 shows the SWE based on SNOTEL and snow course sites in the Intermountain West states, compared to the 1971-2000 average values. The number of SNOTEL or snow course sites varies by basin. Individual sites do not always report data due to lack of snow or instrument error, these basins with incomplete data are designated in white on the map. To see the locations of individual SNOTEL sites, see each state's water availability page.

On the Web

- For graphs like this and snowpack graphs of other parts of the western U.S., visit: http://www.wcc.nrcs.usda.gov/snowcourse/snow_map.html.
- For snow course and SNOTEL data updated daily, please visit one of the following sites:
  - River basin data of SWE and precipitation: http://www.wrcc.dri.edu/snotelanom/snotelbasin.
  - Individual station data of SWE and precipitation for SNOTEL and snow course sites: http://www.wcc.nrcs.usda.gov/snowcourse/snow_rpt.html or http://www.wcc.nrcs.usda.gov/snotel/.
  - Graphic representations of SWE and precipitation at individual SNOTEL sites: http://www.wcc.nrcs.usda.gov/snow/snotel-data.html.

Regional Standardized Precipitation Index data through 2/28/07

The Standardized Precipitation Index (SPI) can be used to monitor conditions on a variety of time scales. 3- and 6-month SPIs are useful in short-term agricultural applications and longer-term SPIs (12 months and longer) are useful in hydrological applications. The 12- month SPI for the Intermountain West region (Figure 6) reflects precipitation patterns over the past 12 months (through the end of February 2007) compared to the average precipitation of the same 12 consecutive months during all the previous years of available data.

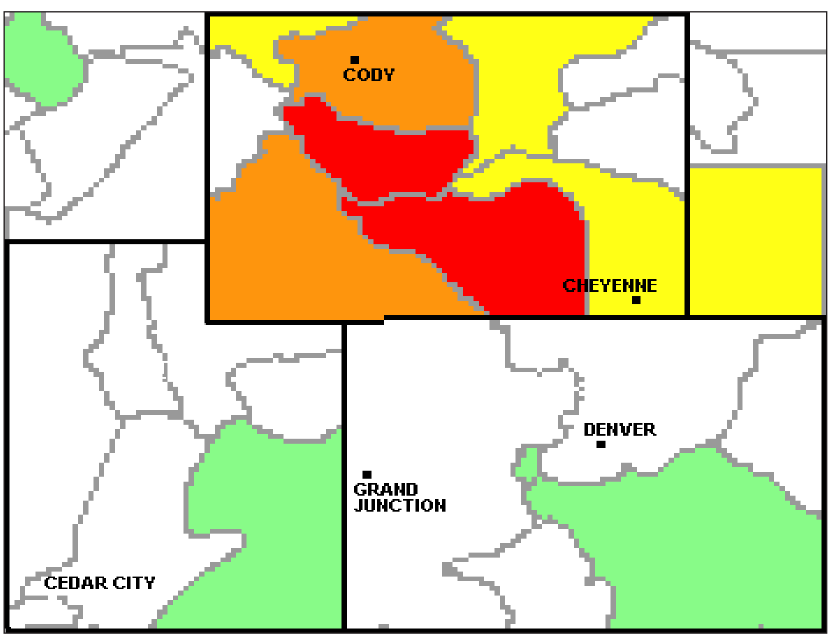
The SPI has not changed very much from the January IMW Climate Summary. **Wyoming** is still dry and **Utah** and **Colorado** are average to moderately wet. Northeastern and northwestern **Wyoming** got a little less dry due to above average precipitation in February. But, the driest parts of the region are still in central and south-central **Wyoming**, in the Wind River and Upper Platte climate divisions, which are in the extremely dry category. The rest of **Wyoming** is in the normal to very dry categories.

In **Utah**, February's below average precipitation in the Upper Colorado River watershed helped bring the Southcentral climate division from moderately wet to the near normal category. The rest of the state is in the near normal category as well, except the Southeast division that is still in the moderately wet category. Most of **Colorado** is still in the near normal category. The Arkansas River Basin in the southeast moved into the moderately wet category. Although this climate division received below average precipitation in February, it received above average precipitation in the headwaters area back in January, enough to move it into a wetter SPI category.

Notes

The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI is computed by NCDC for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought. (courtesy of the National Climatic Data Center) The SPI is valuable in monitoring both wet and dry periods, and it can be applied to other types of data (e.g. streamflow, reservoir levels, etc.) Near normal SPI means that the total precipitation for the past 12 months is near the long-term average for one year. An index value of -1 indicates moderate drought severity and means that only 15% would be expected to be drier. An index value of -2 means severe drought with only 2.5% of years expected to be drier. (courtesy of the Colorado Climate Center)

A 12-month SPI is used for the Intermountain West region (Figure 6) and compares precipitation patterns for 12 consecutive months with the same 12 consecutive months during all the previous years of available data. The SPI at these time scales reflect long-term precipitation patterns. The graphic in Figure 6 comes from the Western Regional Climate Center, which uses data from the NOAA National Climatic Data Center (NCDC) and the NOAA Climate Prediction Center.



(blue)	+3.00 and above	Exceptionally Wet
(dark green)	+2.00 to +2.99	Extremely Wet
(green)	+1.25 to +1.99	Very Wet
(light green)	+0.75 to +1.24	Moderately Wet
(white)	-0.74 to +0.74	Near Normal
(yellow)	-1.24 to -0.75	Moderately Dry
(orange)	-1.99 to -1.25	Very Dry
(red)	-2.99 to -2.00	Extremely Dry
(magenta)	-3.00 and below	Exceptionally Dry

Figure 6. 12-month Intermountain West regional Standardized Precipitation Index. (data through 2/28/07)

On the Web

- For information on the SPI, how it is calculated, and other similar products for the entire country, visit http://www.wrcc.dri.edu/spi/spi.html.
- For information on past precipitation trends, visit: http://www.hprcc.unl.edu/products/current.html.
- For SPI products directly form the NCDC, visit: http://lwf.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html. These maps use the same data as Figure 6, but the categories are defined slightly differently.

Colorado Water Availability

Colorado statewide snowpack conditions for March 1 are 92% of average, increasing slightly from February 1 conditions. According to the NRCS, SWE percentages are highest along the Northern Continental Divide, ranging from 100-160% of average (Figure 7). The South Plate and Arkansas basins continue to have above average snowpack conditions, reporting 111% and 102% of average snowpack respectively. Northern sub-basins in the South Platte including Boulder Creek and Clear Creek have 132% and 116% of average snowpack and the Cache la Poudre basin average snowpack is 112%. The Yampa and White River Basin snowpack is 84% of average on March 1, a significant increase from February 1 conditions of 68%. The lowest snowpack conditions in the state are 85% of average in the Gunnison River basin due to four consecutive months of below average monthly precipitation.

Statewide precipitation totals are 98% of average as of March 1. Located near Winter Park, Colorado, Berthoud Summit precipitation is currently 106% of average, Wolf Creek Summit, located at the headwaters of the San Juan River is 99% of average precipitation, and due to consistent winter storm activity throughout the South Platte basin in February, Niwot Ridge precipitation is 133% of average.

April-July 2007 runoff forecasts for Colorado, courtesy of Colorado Basin River Forecast Center (CBRFC) and NRCS, vary across the state. Near average to above average streamflow volumes are projected for eastern Colorado, while near average to below average runoff conditions are projected for much of western Colorado. Runoff forecasts range from 80% of average for the San Juan basin to 99% of average for Colorado River inflow into Dillon reservoir. Water Supply Forecasts from the CBRFC project that unregulated inflow into Blue Mesa reservoir will be 86% of average during April-July. However, with 4-6 weeks remaining in the typical snow accumulation season left, snowfall during March will largely decide the final state of water availability conditions for the 2007 water year. See page 18 for a map of Intermountain West spring and summer streamflow forecasts.

The NRCS now produces graphs of non-exceedance projections of SWE for Colorado river basins available at: http://www.co.nrcs.usda.gov/snow/snow/watershed/current/daily/maps_graphs/swe_projections.html. We featured these new products in the March 2006 IMW Climate Summary.

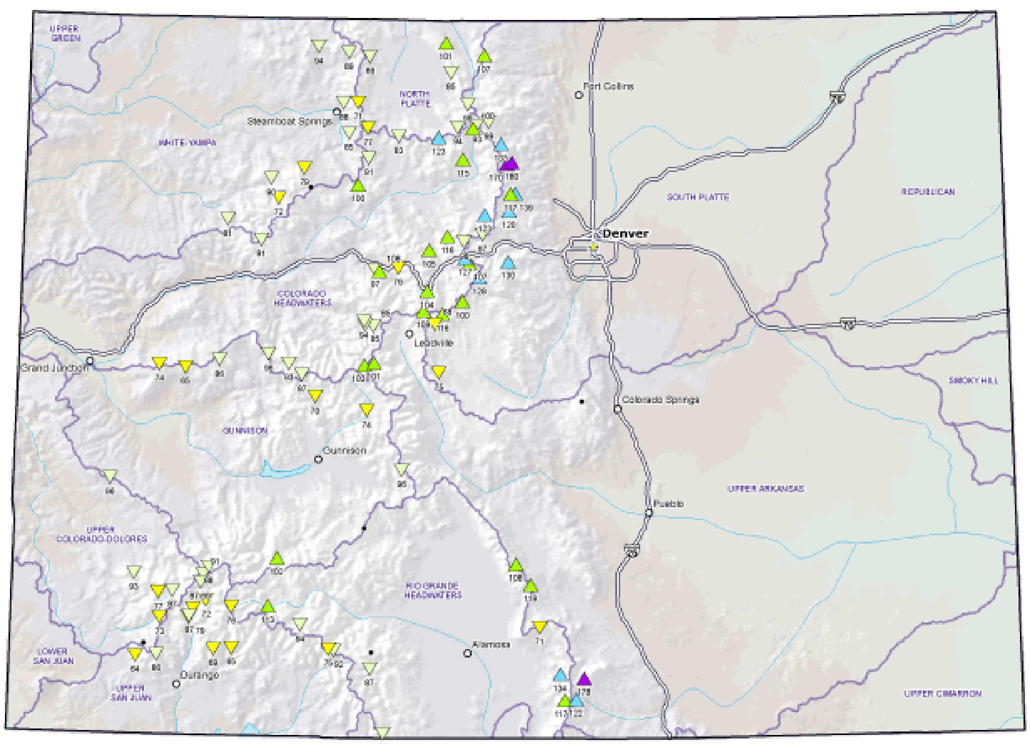


Figure 7. Current snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Colorado as of March 1, 2007, courtesy NRCS. Note: this is provisional information.

On the Web

- For current maps of SWE as a percent of normal as shown in Figure 7, visit: http://www.wcc.nrcs.usda.gov/gis/snow.html.
- For current SNOTEL data and plots of specific sites, visit: http://www.wcc.nrcs.usda.gov/snotel/.
- The Colorado SWSI, along with more data about current water supply conditions for the state can be found at: http://www.co.nrcs.usda.gov/snow/index.html.
- For monthly State Basin Outlook Reports on water supply conditions and forecasts for CO river basins, visit: http://www.wcc.nrcs.usda.gov/cgibin/bor.pl.
- Water Supply Outlook information for the Upper Colorado River Basin, produced by the Colorado Basin River Forecast Center, is available at: http://www.cbrfc.noaa.gov/wsup/wsup.cgi.
- The Colorado Water Availability Task Force information, including agenda & minutes of upcoming & previous meetings are available at: http://www.cwcb.state.co.us/Conservation/Drought/taskForceAgendaMinPres.htm.

Wyoming Water Availability

Wyoming's SNOTEL data shows that as of March 1, 2007, the current SWE as a percent of average varies throughout the state, but is generally below average (Figure 8). The north central and south central basins have the highest SWE of 100 – 141% of average, while all the western basins are 30 – 88 % of average. The Bighorn and Cody basins in northern Wyoming have the lowest SWE of from 30 – 54% of average.

According to the NRCS Wyoming State Basin Outlook Report as of March 1, February precipitation was below average across most of Wyoming. The Lower Green River Basin had the lowest precipitation for the month at 76% of average. The Belle Fourche & Cheyenne River Basin has the highest precipitation amount at 181% of average. Basin reservoir levels for Wyoming vary from 34 – 209% of average, with an overall average of 91%. Reservoirs on the North Platte River are well below average at 55% of average. Most of the reservoirs in the northeast and reservoirs in the Wind River Basin and Big Horn are below average. However, the Buffalo Bill Reservoir and reservoirs on the Green River are slightly above average. Spring streamflow yield is expected to be below average across Wyoming with a statewide average forecast yield of 79% (varying from 58-104% of average). See page 18 for a map of Intermountain West spring and summer streamflow forecasts.

According to the latest Drought Status Update (not shown) released March 7, 2007 a drought watch or warning remains in effect for all of Wyoming. Washakie, Hot Springs, Fremont and Sweetwater counties are in extreme drought status. You can find more information about the Wyoming Drought Status at: http://www.wrds.uwyo.edu/wrds/wsc/dtf/drought.html.

This month's Feature Article (Page 2) and Focus Page (Page 19) discuss also current water availability in Wyoming.

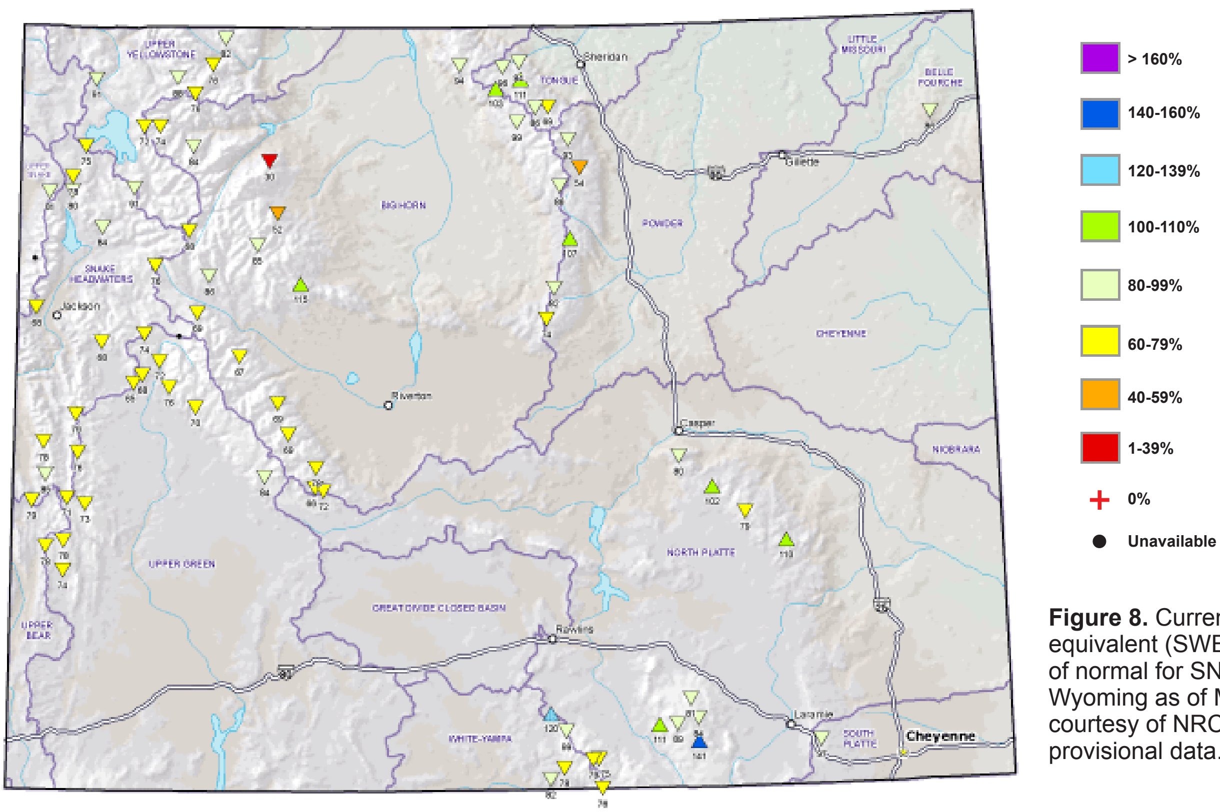


Figure 8. Current snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Wyoming as of March 1, 2007, courtesy of NRCS. Note: this is provisional data.

On the Web

- For current maps of SWE as a percent of normal as shown in Figure 8, visit: http://www.wcc.nrcs.usda.gov/gis/snow.html.
- For current SNOTEL data and plots of specific sites, visit: http://www.wcc.nrcs.usda.gov/snotel/.
- The Wyoming SWSI, along with more data about current water supply conditions for the state can be found at: http://www.wrds.uwyo.edu/wrds/nrcs/nrcs.html.
- For monthly State Basin Outlook Reports on water supply conditions and forecasts for WY river basins, visit: http://www.wcc.nrcs.usda.gov/cgibin/bor.pl.
- Wyoming Water Resource Data system's drought page is located at: http://www.wrds.uwyo.edu/wrds/wsc/dtf/drought.html.

Utah Water Availability

According to the NWS Salt Lake City, while Utah's climate conditions for January 2007 were very cold and dry, February was warm and wet. Utah's SNOTEL data shows that as of March 1, 2007, the current SWE as a percent of average varies throughout the state of Utah, but is generally below average (Figure 9). The statewide average is 71% of average. The northwestern basins have the highest SWE of 90 – 110% of average, while the northern, central, and southern basins are generally 40 – 90 % of average. The Virgin and lower Sevier basins in southwest Utah have the lowest SWE of only 12 – 21% of average. According to the NRCS Utah State Basin Outlook Report, recent storms have brought statewide snowpack up 5 – 8 %, however Utah needs between 200 – 400 % of aver
age snowpack accumulation in March to reach average conditions. The probability of getting this accumulation ranges from 0 – 14 % with most areas at 0%.

The NRCS reports that mountain precipitation during February was from near average in northern Utah to much below average across southern Utah. The seasonal accumulation (Oct – Feb) is 88% of average statewide. Reservoirs across the state have been making steady gains in storage, and storage in Utah's key irrigation reservoirs is at 71% of capacity, increase of 3% from last year. Bear Lake in northern Utah remains extremely low due to the prolonged drought. Spring and summer streamflows are expected to have a wide range from much below average to near average. Most flows are forecast to be in the 50 – 70% range. See page 18 for a map of Intermountain West spring and summer streamflow forecasts.

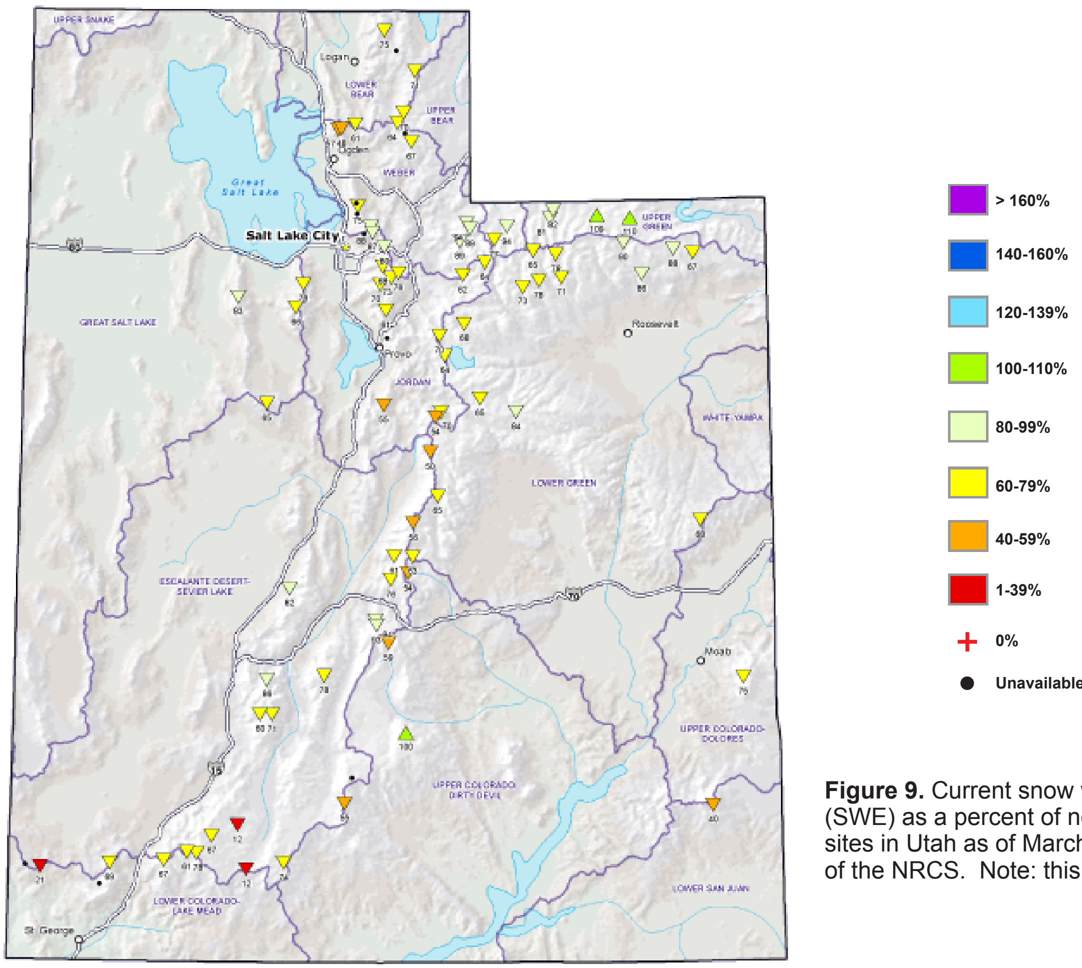


Figure 9. Current snow water equivalent (SWE) as a percent of normal for SNOTEL sites in Utah as of March 1, 2007, courtesy of the NRCS. Note: this is provisional data.

On the Web

- For current maps of SWE as a percent of normal as shown in Figure 9, visit: http://www.wcc.nrcs.usda.gov/gis/snow.html.
- For current SNOTEL data and plots of specific sites, visit: http://www.wcc.nrcs.usda.gov/snotel/.
- The Utah SWSI, along with more data about current water supply conditions for the state can be found at: http://www.ut.nrcs.usda.gov/snow/watersupply/.
- For monthly State Basin Outlook Reports on water supply conditions and forecasts for UT river basins, visit: http://www.wcc.nrcs.usda.gov/cgibin/bor.pl.
- Water Supply Outlook information for the Upper Colorado River Basin, produced by the Colorado Basin River Forecast Center, is available at: http://www.cbrfc.noaa.gov/wsup/wsup.cgi.

Temperature Outlook April - August 2007

According to the NOAA/CPC, the temperature outlook for April 2007 favors above normal temperatures across much of the western and central U.S., including all of the Intermountain West (Figure 10a). Probabilities for above normal temperatures were reduced – but still reflect in increased chance for above normal temperatures in many areas -- across portions of the north-central Rockies due to significant snowpack and the expectation of a prolonged melting period of snow and ice.

The outlooks for August-October 2007 through spring 2008 (not shown, see CPC website) largely reflect trends, which are positive and substantial for the southwestern U.S. in most of the year and over much of the country in the winter, and are weakest in the fall. CPC does not expect any El Niño or La Niña impacts on the climate of the United States during the April-June 2007 season; although models suggest that a weak La Niña could develop by summer, the certainty in these projections is too weak to put much confidence in this for U.S. climate impacts later in the year (Figure 10b).

An updated April 2007 temperature forecast will be available on March 31st, on the CPC web page. Because of the shorter lead time, the updated monthly forecast maps often have increased skill over the half-month lead forecasts.

Notes

The seasonal temperature outlooks in Figures 10a-d predict the likelihood (chance) of temperature amounts corresponding to the above-average, near-average, and below-average categories. The numbers on the maps do not refer to actual temperatures, but to the probability in percent that temperature will be in one of these three categories.

The NOAA-CPC outlooks are a 3-category forecast based largely on the status of El Niño and recent trends. As a starting point, the 1971-2000 climate record for each particular 1 or 3 month period is divided into 3 categories (terciles), each with a 33.3% chance of occurring. The middle tercile is considered the near-average (or normal) temperature range. The forecast indicates the likelihood of the temperature being in the above-average (A) or below-average (B)--with a corresponding adjustment to the opposite category, The near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high.

Thus, using the NOAA-CPC temperature outlook, areas with dark brown shading indicate a 40.0-50.0% chance of below-average, a 33.3% chance of near-average, and a 16.7-26.6% chance of above-average temperature, Light brown shading display a 33.3-39.9% chance of below-average, a 33.3% chance of near-average, and a 26.7-33.3% chance of above-average temperature and so on. Correspondingly, green shades indicate areas with a greater chance of above average temperature.

Equal Chances (EC) indicates areas for which the models cannot predict the temperature with any confidence. EC is used as a "default option" representing equal chances or a 33.3% probability for each tercile, indicating areas where the reliability (i.e., 'skill') of the forecast is poor.

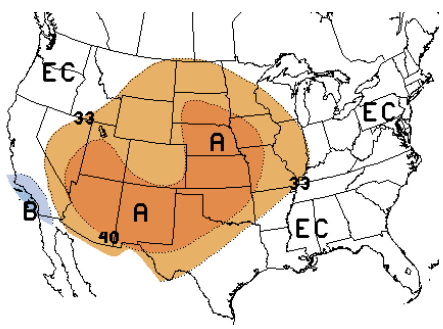


Figure 10a. Long-lead national temperature forecast for April 2007. (released March 15, 2007)

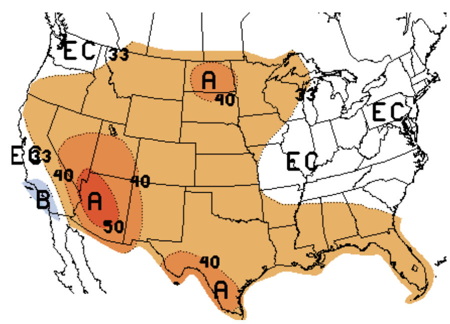


Figure 10b. Long-lead national temperature forecast for April – June 2007. (released March 15, 2007)

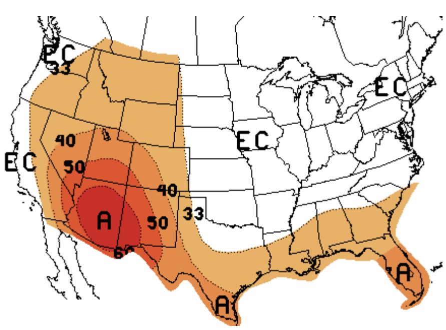


Figure 10c. Long-lead national temperature forecast for May – July 2007. (released March 15, 2007)

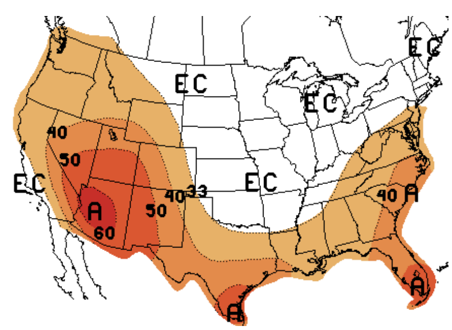


Figure 10d. Long-lead national temperature forecast for June – August 2007. (released March 15, 2007)

A = Above
- 60.0–69.9%
- 50.0–59.9%
- 40.0–49.9%
- 33.3–39.9%

B = Below
- 40.0–49.9%
- 33.3–39.9%

EC = Equal Chances

On the Web

- For more information and the most recent forecast images, visit: http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html. Please note that this website has many graphics and may load slowly on your computer.
- The CPC "discussion for non-technical users" is at: http://www.cpc.noaa.gov/products/predictions/90day/fxus05.html
- For IRI forecasts, visit: http://iri.columbia.edu/climate/forecast/net_asmt/.
- More information about temperature distributions at specific stations in Colorado, Utah, Wyoming, and across the West can be found at the Western Regional Climate Center, http://www.wrcc.dri.edu/CLIMATEDATA.html.

Precipitation Outlook April - August 2007

According to the NOAA/CPC forecasts issued March 15th, there is an increased risk of below average precipitation in the southwest, including parts of southern **Utah** for April 2007 (Figure 11a). In the forecast periods for the next three overlapping seasons (April-June, May-July, and June-August 2007), the area of increased risk of below average precipitation includes western **Colorado**, all of **Utah**, and parts of **Wyoming** (Figures 11b-d). The IRI multi-model world precipitation forecast also indicates an increased risk for below average precipitation in **Utah**, western **Colorado** and southern **Wyoming** for the April- June forecast period (not shown, see http://iri.ldeo.columbia.edu/)

The outlooks for April - June 2007 through July-Sept 2007 are based on the NOAA consolidation tool, which is a skill-weighted objective blend of forecast models. The constructed analog soil moisture prediction technique (CAS) was considered strongly because this model has its greatest seasonal skill for forecasts initiated in the early spring. Unfortunately the initial soil moisture anomalies in early March 2007 are neither strong nor large scale. The forecasts for April-June 2007 and beyond also reflect trends in precipitation; however, these trends appear only in scattered areas and are weak. These include a trend for relatively wet conditions in parts of the Pacific Northwest during April-June and May-July, and relative dryness over parts of the Great Basin, including **Utah**, for April-June and June-August. This trend towards dryness expands further to the north, including parts of **Wyoming**, and west during July-September and August-October.

CPC does not expect any El Niño or La Niña impacts on the climate of the United States during the April-June 2007 season; although models suggest that a weak La Nina could develop by summer, the certainty in these projections is too weak to put much confidence in this for U.S. climate impacts later in the year. An updated April 2007 precipitation forecast will be available on March 31st, on the CPC web page. Because of the shorter lead time, the updated monthly forecast maps often have increased skill over the half-month lead forecasts.

Notes

The seasonal precipitation outlooks in Figures 11a-d predict the likelihood (chance) of precipitation occurring in the above-average, near-average, and below-average categories. The numbers on the maps do not refer to amounts of precipitation, but to the probability in percent that precipitation will be in one of these three categories.

The NOAA-CPC outlooks are a 3-category forecast based largely on the status of El Niño and recent trends. As a starting point, the 1971-2000 climate record for each particular 1 or 3 month period is divided into 3 categories (terciles), each with a 33.3 % chance of occurring. The middle tercile represents near-average (or normal) precipitation range. The forecast indicates the likelihood of the precipitation being in the above-average (A) or below-average (B) tercile--with a corresponding adjustment to the opposite category. The near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high. For a detailed description of how this works, see notes on the previous page.

(continued on the following page...)

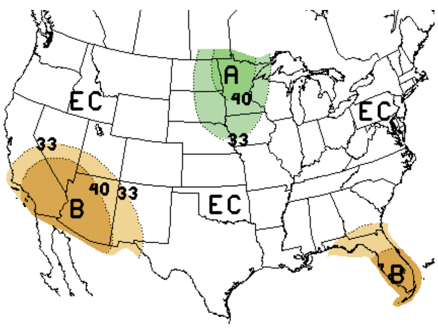


Figure 11a. Long-lead national precipitation forecast for April 2007. (released March 15, 2007)

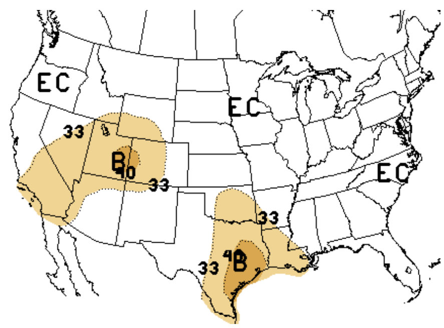


Figure 11b. Long-lead national precipitation forecast for April – June 2007. (released March 15, 2007)

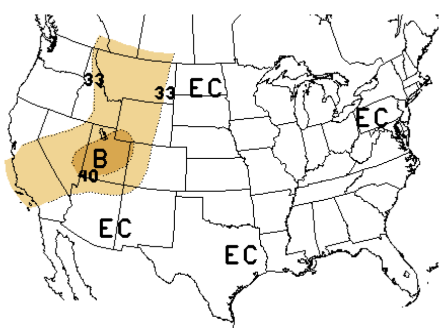


Figure 11c. Long-lead national precipitation forecast for May – July 2007. (released March 15, 2007)

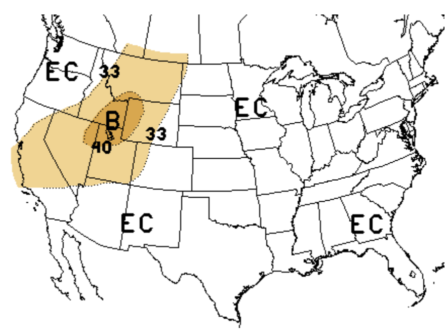


Figure 11d. Long-lead national precipitation forecast for June – August 2007. (released March 15, 2007)

A = Above
- 40.0–49.9%
- 33.3–39.9%

B = Below
- 40.0–49.9%
- 33.3–39.9%

EC = Equal Chances

On the Web

- For more information and the most recent CPC forecast images, visit: http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html. Please note that this website has many graphics and may load slowly on your computer.
- The CPC "discussion for non-technical users" is at: http://www.cpc.noaa.gov/products/predictions/90day/fxus05.html
- For IRI forecasts, visit: http://iri.columbia.edu/climate/forecast/net_asmt/.
- More information about temperature distributions at specific stations in Colorado, Utah, Wyoming, and across the West can be found at the Western Regional Climate Center, http://www.wrcc.dri.edu/CLIMATEDATA.html

Precipitation Outlook cont.

(continued from page 14)

Equal Chances (EC) indicates areas for which the models cannot predict the precipitation with any confidence. EC is used as a "default option" representing equal chances or a 33.3% probability for each tercile, indicating areas where the reliability (i.e., 'skill') of the forecast is poor.

The WWA Experimental Forecast Guidance for the Interior Southwest (SWcast), updated on March 15th, indicates that a rapidly declining El Niño and the possibility of a La Niña bring an increased probability of a dry spring (April – June) to western **Colorado**, eastern **Utah**, southern New Mexico and the southeast corner of Arizona (Figure 11e). There is a a positive tilt in the odds towards wetter than average conditions for the northeastern corner of **Colorado**, western **Utah** and the northwestern corner of Arizona. This forecast has the highest skill in the areas that have a forecast for above average precipitation for the spring season.

According to the SWcast Executive Summary, lingering snow cover has kept temperatures below normal over much of eastern **Colorado** into early March, but this snow is now mostly gone. A wet spell during late February (in particular over northwestern **Colorado**) was followed by near-record warmth and dry conditions in March. While mid-winter dry spells are typical for El Niño winters in **Colorado** and **Utah**, dryness in Arizona has been atypical and prolonged. While El Niño events favor wet springs in much of the southwestern U.S., rapidly declining events are not as favorable for wetter than average conditions in this region. If La Niña were to become established this spring, the probability of renewed drought conditions would increase even more.

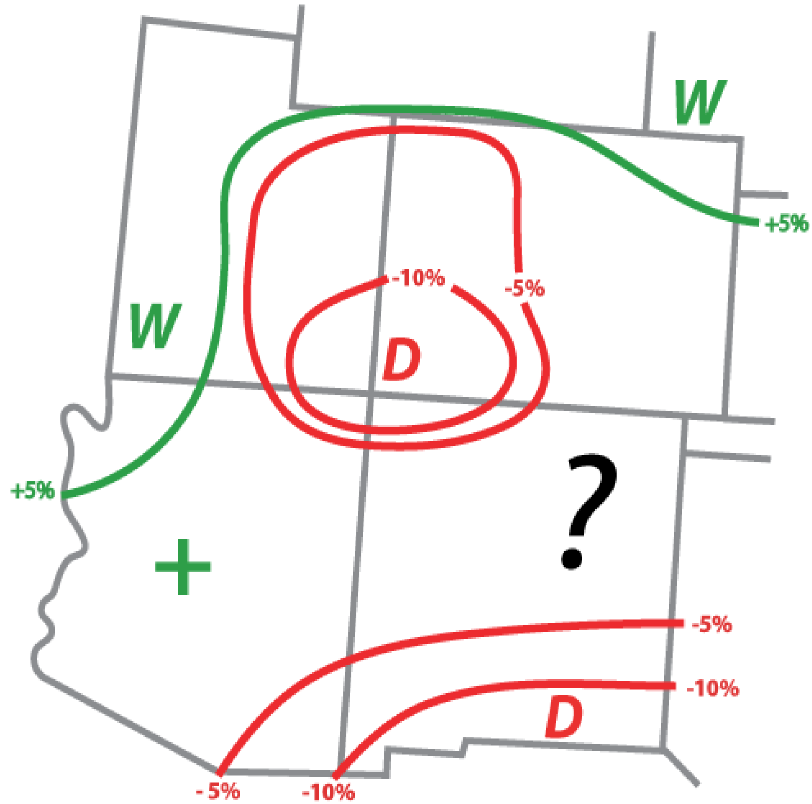


Figure 11e. Experimental guidance for seasonal precipitation in the southwest for April - June. (issued March 14, 2007)

Notes

The experimental guidance for seasonal future precipitation in Figure 11e shows most recent forecast of shifts in tercile probabilities for April - June 2007. In order to be shown on this map, a forecast tilt in the odds has to reach at least 3% either towards wet (above-average), dry (below-average), or near-normal (average). Shifts towards the wettest (driest) tercile are indicated in green (red), and are contoured in 5% increments, while near-normal tilts of at least 3% are indicated by the letter "N". Shifts over 10% considered significant. Positive (negative) shifts between three and five percent are indicated by a green (red) plus (minus) sign, while minor shifts of one or two percent are left blank in this display.

On the Web

- The WWA experimental guidance product, including a discussion and executive summary, is available on the web at: http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/index.html.

Seasonal Drought Outlook through June 2007 Source: NOAA Climate Prediction Center

The Seasonal Drought Outlook issued March 15th depicts general, large-scale trends from March 15th through the end of June 2007 (3.5 months), and is developed by experts based on their subjective judgement of various forecasts (Figure 12). The Outlook indicates that drought is likely to persist in **Wyoming**, but western **Nebraska** and many other areas in the northern Plains should see some improvement. There is potential for drought expansion into Nevada, **Utah**, western **Colorado**, and western New Mexico.

NOAA/CPC is soliciting comments on a proposed change in the scheduled release time for this product. Currently the U.S. Drought Outlook is issued on the third Thursday of each month at 8:30 a.m. eastern time with a valid period of 3 1/2 months after issuance. This proposal would change the scheduled release date to the first day of the month at 8:30 a.m. eastern time with a valid time covering the three calendar months starting the day of issuance. This new schedule issuance time would allow better use of the updated monthly precipitation and temperature outlooks issued on the last day of the previous month.

For additional information please contact Douglas LeComte at: Douglas.Lecomte@noaa.gov. You may provide comments via a form on the Drought Outlook page, or by email to LeCompte.

Notes

The delineated areas in the Seasonal Drought Outlook (Figure 12) are defined subjectively and are based on expert assessment of numerous indicators, including outputs of short- and long-term forecasting models. Areas of continuing drought are schematically approximated from the Drought Monitor (D1 to D4). For weekly drought updates, see the latest Drought Monitor text on the website: http://www.drought.unl.edu/dm/monitor.html. NOTE: The green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.

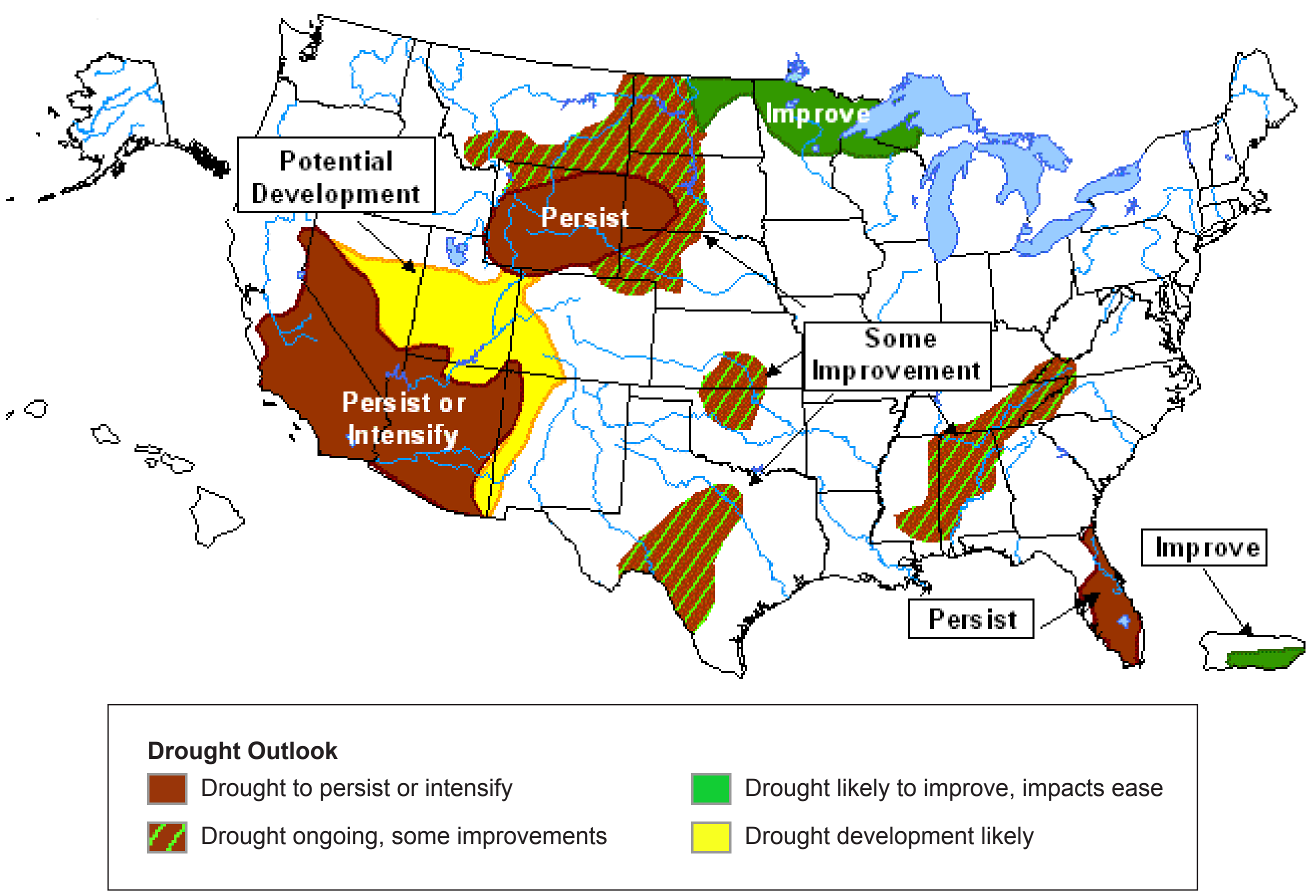


Figure 12. Seasonal Drought Outlook through June 2007 (release date March 15, 2007).

On the Web

- For more information, visit: http://www.drought.noaa.gov/.
- Drought termination probabilities: http://www.ncdc.noaa.gov/oa/climate/research/drought/current.html

El Niño Status and Forecast through April 2007

In January, discussions from both the NOAA Climate Prediction Center and the International Center for Climate and Society (IRI) indicated that the El Niño event of the past winter had peaked and was weakening. According to information recently issued by both centers, the El Niño event of the past winter has come to a very quick end, as indicated by Pacific equatorial sea surface temperatures (SSTs) their long-term average in the past month (Figure 13a). The atmospheric indicators during the past two months were also consistent with vanishing El Niño conditions. Perhaps most significantly, the equatorial upper-ocean total heat content of the Pacific, which peaked in late November 2006, has decreased rapidly since then to a moderately negative anomaly value in the most recent week. Although ENSO-neutral conditions are expected to be in place in the April-June 2007 season, these observations indicate that a transition from ENSO-neutral to La Niña conditions is possible during the next 2-3 months. CPC does not expect any El Niño or La Niña impacts on the climate of the United States during the April-June 2007 season.

Most of the statistical and coupled models, including the NCEP Climate Forecast System (CFS), indicate additional anomalous cooling during the next 2-3 months (Figure 13b). Some of the forecast models, especially the CFS, indicate a rapid transition to La Niña conditions during March-May 2007. This scenario is supported by the latest surface and subsurface oceanic conditions, and the persistence of stronger than-average low-level easterly winds over the central equatorial Pacific. IRI ENSO forecasts indicates about a 50% chance of a La Nina developing by mid- 2007 (July-Sep) but only about a 10% chance of El Nino conditions.

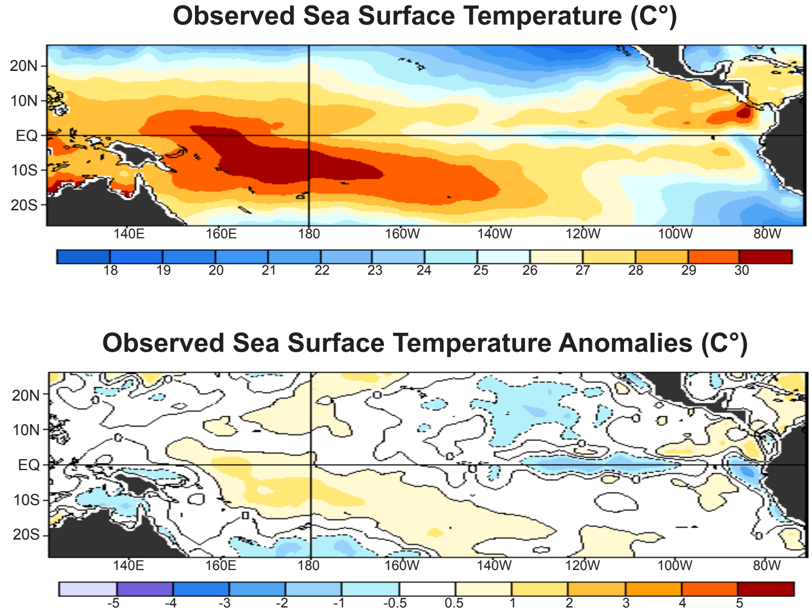


Figure 13a. Observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. The Niño 3.4 region encompasses the area between 120ºW-170ºW and 5ºN-5ºS. The graphics represent the 7-day average centered on March 7, 2007.

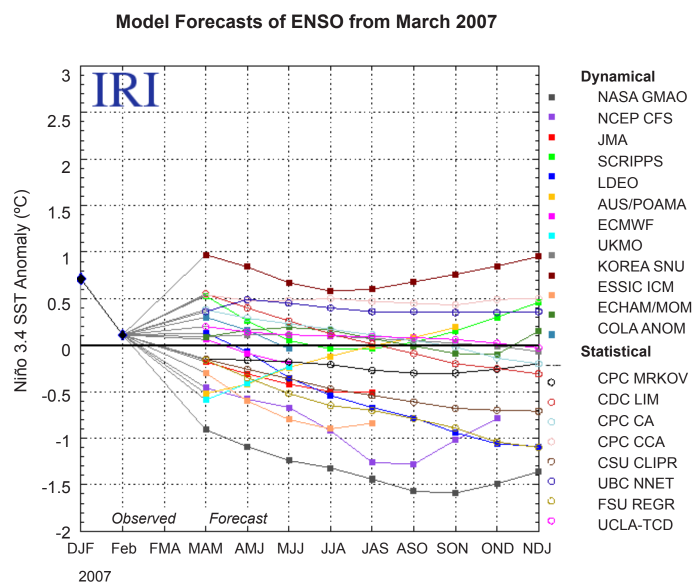


Figure 13b. Forecasts made by dynamical and statistical models for sea surface temperatures (SST) in the Niño 3.4 region for nine overlapping 3-month periods from March 2007 through January 2008 (released March 15, 2007). Forecast graphic is from the International Research Institute (IRI) for Climate and Society.

Notes

Two graphics in Figure 13a produced by NOAA show the observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. These data are from the TOGA/TAO Array of 70 moored buoys spread out over the Pacific Ocean, centered on the equator. They measure temperature, currents and winds in the Pacific equatorial band and transmit data in real-time. NOAA uses these observations to predict short-term (a few months to one year) climate variations.

Figure 13b shows multiple forecasts for SST in the Niño 3.4 region for nine overlapping 3-month periods from September 2005 to July 2006. "Niño 3.4" refers to the region of the equatorial Pacific from 120oW to 170oW and 5oN to 5oS, which is used as an index for defining ENSO sea surface temperature anomalies. Initials at the bottom of the graph represent groups of three months (e.g. SON = Sept-Nov). The expected skills of the models, based on historical performance, are not equal to one another. The skills also generally decrease as the lead-time increases. Forecasts made at some times of the year generally have higher skill than forecasts made at other times of the year, and forecasts made between June and December are generally better than between February and May because of seasonal differences in predictability of the system. Differences among the forecasts of the models reflect both differences in model design and actual uncertainty in the forecast of the possible future SST scenario.

On the Web

- For a technical discussion of current El Nino conditions, visit: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/.
- For updated graphics of SST and SST anomalies, visit this site and click on "Weekly SST Anomalies": http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml#current.
- For more information about El Nino, including the most recent forecasts, visit: http://iri.columbia.edu/climate/ENSO/.

Spring and Summer Streamflow Forecasts for the 2007 runoff Season

Across the Intermountain West region, streamflow forecasts for the upcoming spring and summer months vary with near average to above average streamflow volumes (90-150% of average) expected in **Colorado** basins east of the Continental Divide, Figure 14. The highest streamflow forecasts (110-150% of average) are in northern and **Colorado** in the Upper South Platte River where projected streamflow volumes on Boulder Creek are 128%, and in southern **Colorado** in the Arkansas River basin, where 131% of average streamflows are expected for the Cucharas River near La Veta. The lowest streamflow forecasts (<50% of average) in the Intermountain West are in southern **Utah** in the Virgin, Escalante, and San Juan basins due to prolonged below average snowpack amounts. Streamflow forecasts for the majority of basins in **Wyoming** range from 50-89% of average, with near average streamflow volumes (90-109%) expected in the Laramie River basin in the southeast and the Yellowstone region located at the northwest tip of the state. For more information on streamflow forecasts, snowpack, and precipitation by state, refer to the **Colorado**, **Wyoming**, and **Utah** state water availability pages, 10-12.

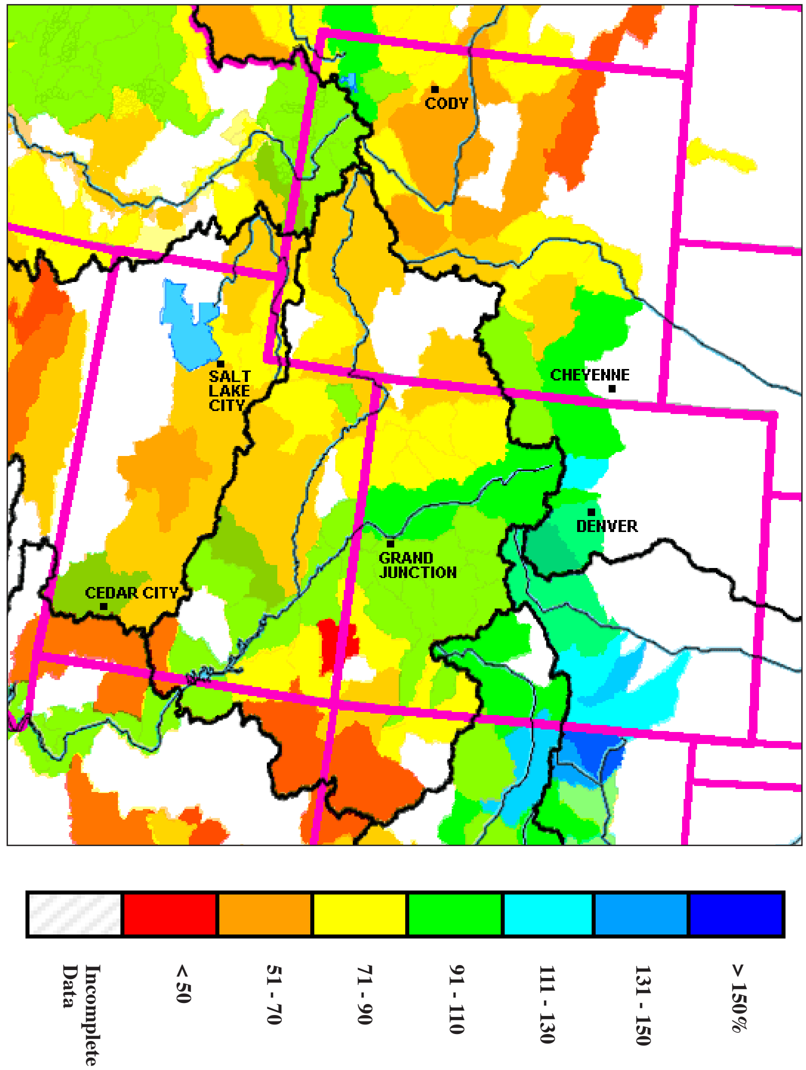


Figure 14. NRCS outlook for natural streamflows for spring and summer in the Intermountain West region as a percent of average streamflows. (data through March 1, 2007 courtesy of Natural Resources Conservation Service)

Notes

This page provides the NRCS spring and summer streamflow forecasts for the entire Intermountain West region. The official NOAA streamflow forecasts are developed by individual river basin forecast centers. (See 'On the Web' box below for links to the official NOAA forecasts.)

Forecasts of natural runoff are based principally on measurements of precipitation, snow water equivalent, and antecedent runoff, influenced by precipitation in the fall before winter snowfall (Figure 14). Forecasts become more accurate as more of the data affecting runoff are measured (i.e. accuracy increases from January to May). In addition, these forecasts assume that climatic factors during the remainder of the snow accumulation and melt season will have an average affect on runoff. Early season forecasts are, therefore, subject to a greater change than those made on later dates.

On the Web

- For more information about NRCS water supply forecasts based on snow accumulation and access to the graph on this page, visit: http://www.wcc.nrcs.usda.gov/wsf/.
- The official NOAA streamflow forecasts are available through the following websites of individual River Forecast Centers:
  - Colorado Basin (includes Great Basin): http://www.cbrfc.noaa.gov/
  - Missouri Basin (includes South Platte and North Plate: http://www.crh.noaa.gov/mbrfc/
  - West Gulf (includes Rio Grande): http://www.srh.noaa.gov/wgrfc/
  - Arkansas Basin: http://www.srh.noaa.gov/abrfc/

Assessing Water Supply Conditions for Southeast Wyoming in 2007

By Melissa Goering, Science Operations Officer, NOAA National Weather Service Weather Forecast Office, Cheyenne, Wyoming

For the 7th year in a row, Wyoming is facing a state-wide drought, and the National Weather Service Weather Forecast Office in Cheyenne (NWS Cheyenne) is predicting another year of below average spring streamflows for the southeastern part of the state. There are a variety of hydrologic factors that contribute to the below average to much below average conditions in streamflow and the extreme to severe drought conditions that are expected across Southeast Wyoming in early 2007. These factors include (but are not limited to) precipitation, snowpack, and soil moisture. This article will discuss the hydrologic factors that have contributed to the much below to below normal volume forecast for spring runoff and the extreme to severe drought conditions for 2007 across southeast Wyoming.

Spring runoff from the high mountains in the western part of Wyoming provides needed water to lower elevations. Agriculture, recreation, water supply, and hydro-electric power are a few of the things dependent on this renewable resource. Precipitation and snowpack are always critical to water supply in the Intermountain West, but especially so this spring because of the pre-existing drought conditions reported by NOAA's Climate Prediction Center (CPC).

In the fall of 2005, CPC reported moderate-to-severe drought conditions across southeast Wyoming. Snowpack and snow liquid water equivalents (SWE's) started the 2006 water year much above normal, but these conditions didn't persist through the winter. While snowpack telemetry (SNOTEL) sites in the Medicine Bow and Sierra Madre mountain ranges, located in southern Wyoming, initially recorded SWE's nearly 130% of average in February 2006, much of the SNOTEL sites in Wyoming east of the Continental Divide recorded below or much below average SWE's by May 2006.

Powder River near Arvada, WY, July 2002 (Photo courtesy of D. Peterson , USGS)

Precipitation affects both snowpack, and soil moisture conditions. Therefore, NWS Cheyenne examines recent precipitation trends and how that has impacted the snowpack and soil moisture. At the beginning of the 2007 water year in October 2006, the Upper North Platte and Little Snake river basins (located in southeast Wyoming) recorded much above normal precipitation compared to the Lower North Platte, Laramie, Crow and Lodgepole Creek river basins (Figure 15a). But by November (not shown), all river basins across southeast Wyoming recorded much below normal precipitation values. In fact, many locations along the Lower North Platte River basin did not have any precipitation for the entire month. There was a brief reprieve for far

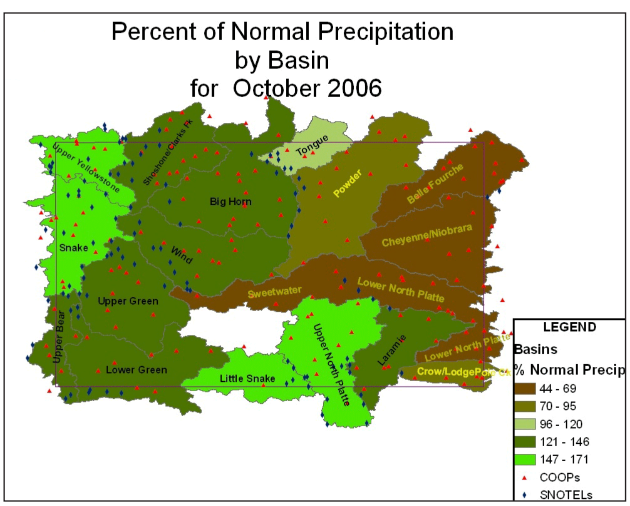


Figure 15a: Percent of normal precipitation by basin for Wyoming for October 2006 (courtesy of Jim Fahey, service hydrologist at the Riverton Weather Forecast Office).

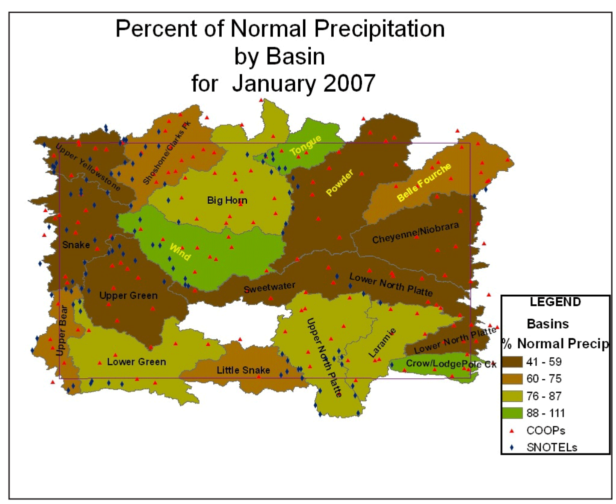


Figure 15b: As in Figure 15a, but for January 2007 (courtesy of Jim Fahey, service hydrologist at the Riverton Weather Forecast Office).

southeast river basins in December, as two storm systems at the end of month brought nearly 18 inches of snow across far southeast Wyoming. This precipitation brought the percent of normal precipitation (not shown) to much above normal in the Lower Platte River basin and near normal precipitation for the Laramie and Niobrara river basins. However, all other major river basins remained below normal for December. Finally, conditions worsened once again in January 2007 with all major river basins receiving below to much below normal precipitation (Figure 15b). The below average conditions in snowpack are observed at all the SNOTEL sites within the Sierra Madre and Medicine Bow mountain ranges, located in southern Wyoming. The North French Creek SNOTEL site illustrates that as of March 2007, the 2007 water year precipitation and SWE are below both the average and the 2006 precipitation and SWE values (Figure 15c). Due to low precipitation and snowpack levels, soil moisture is also below average in parts of Wyoming. Both the calculated ranking percentile of soil moisture for November (not shown) and March indicated significant soil moisture deficits over southern Wyoming. (Figure 15d).

Given the hydrologic conditions examined, NWS Cheyenne, in conjunction with the Missouri and Colorado Basin Forecast Center, expect a below average to much below average volume forecast for spring runoff and extreme to severe drought conditions for 2007 across southeast Wyoming. The preliminary average volume spring runoff forecasts for spring 2007 are expected to be much below average for river basins in southeast Wyoming (Table 1). However, in addition to the current snowpack, the peak flow magnitudes depend on the late spring temperatures and any additional snowpack in the next couple months. Spring conditions may add to or further diminish the late spring and early summer peak streamflows. The CPC three-month outlooks for temperature and precipitation during March, April, and May indicated slightly above normal temperatures and near normal precipitation. (See pages 13-15 for current Temperature and Precipitation outlooks from CPC.)

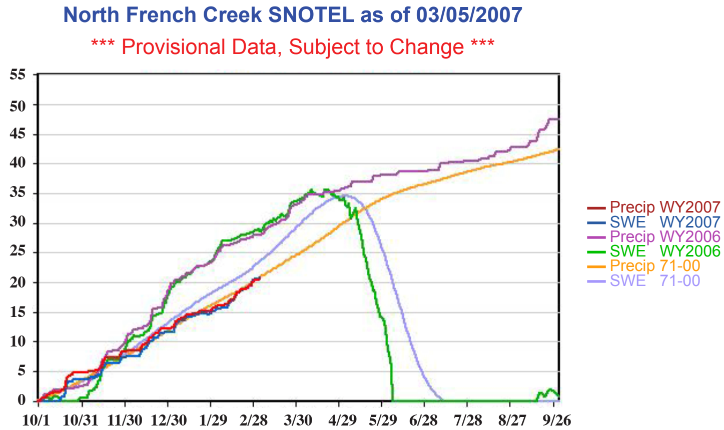


Figure 15c: The average precipitation (orange) and SWE (light blue), 2006 precipitation (purple) and SWE (green), and 2007 precipitation (red) and SWE (dark blue) shown for North French Creek SNOTEL site in the Upper North Platte River basin at 10,103 feet (courtesy of Natural Resources Conservation Services), March 5, 2007.

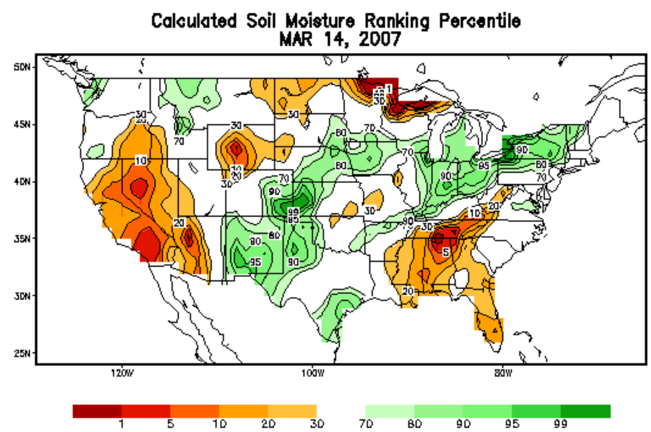


Figure 15d: Calculated soil moisture ranking percentile for March 14, 2007 (courtesy of CPC).

		Volume	Forecast				Volume	Forecast
Stream & Station	Period	1000 AF	% of Avg		Stream & Station	Period	1000 AF	% of Avg
North Platte River					**Encampment River**			
Northgate	Apr-Sep	230	85		Encampment	Apr-Sep	137	83
Seminoe Reservoir	Apr-Sep	650	81		**Laramie River**			
Glendo	Apr-Sep	750	76		Woods Landing	Apr-Sep	138	102
Guernsey Reservoir	Apr-Sep	180	77		**Little Laramie River**			
Alcova to Orin	Apr-Sep	135	84		Filamore	Apr-Sep	53	83
Rock Creek					**Little Snake River**			
Arlington	Apr-Sep	46	81		Slater	Apr-Jul	115	72
La Prele Creek					Dixon	Apr-Jul	205	62
La Prele Reservoir	Apr-Sep	14.2	59					

Table 1: Preliminary streamflow volume forecasts for April-September 2007 across southeast Wyoming, released in Febraury 2007.

On the Web

- National Weather Service Weather Forecast Office, Cheyenne: http://www.crh.noaa.gov/cys/.
- Hydrologic Outlook, issued weekly by the NWS Cheyenne WFO: http://www.crh.noaa.gov/product.php?site=CYS&product=ESF&issuedby=CYS&glossary=1.
- Wyoming Drought Outlook, a collaborative effort issued monthly by NOAA's National Weather Service and the National Climatic Center, the NRCS, Wyoming State Climatologist's Office, regional center climatologists, and the National Drought Mitigation Center: http://www.crh.noaa.gov/images/riw/hydro/drought_info.pdf.
- Wyoming Water Resources Data System and State Climate Office: http://www.wrds.uwyo.edu/.
- Wyoming Natural Resources Conservation Service Snow Survey: http://www.wrds.uwyo.edu/wrds/nrcs/.