Preliminary Assessment

Water Year 2004 Upper Klamath Lake Inflow Forecasts

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Water Year 2004 Overview

Once again, the Klamath Basin experienced significant climate variability that affected water supply forecasts during water year 2004. A very promising snowpack of 135% of average on March 1, 2004 rapidly diminished during March and April when warm temperatures and dry conditions dominated the basin. Water supply forecasts, which were 97% of average on March 1, 2004, were revised to 56% of average by June 15, 2004 in response to these extraordinary hydroclimatic conditions.

Similar to the fall of 2002, precipitation and snowpack were below average through the end of December 2003, when a series of winter storms traversed the Pacific Northwest. On January 1, 2004, Upper Klamath Basin SNOTEL sites recorded a basin average snowpack of 130% of normal, significantly higher than the 98% of normal recorded the previous year (Figure 1). The NRCS issued a January 1, 2004 Upper Klamath Lake water supply forecast of 78% of average, which reflected the continued dry hydroclimatic conditions experienced during water year 2003.

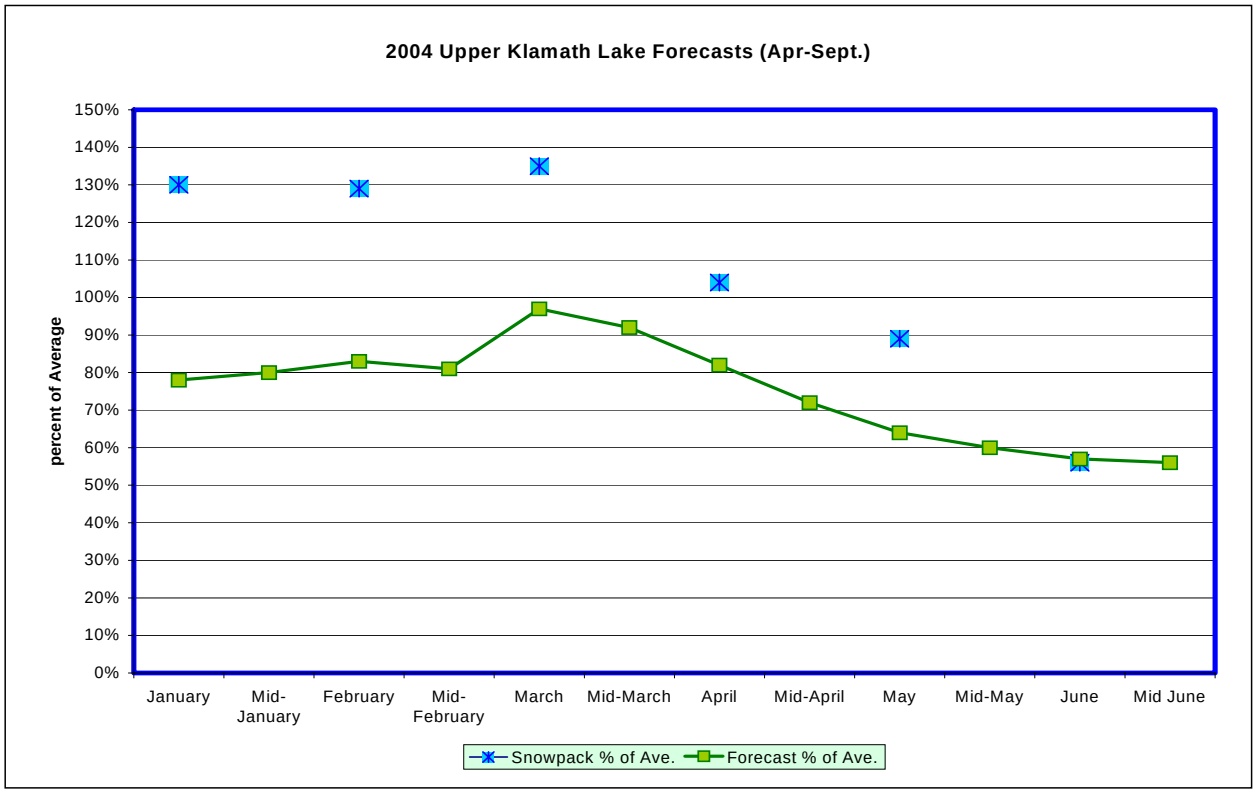

Figure 1. Upper Klamath Basin Water Year 2004 Snowpack and Water Supply Forecasts

In contrast to the winter of 2003, the months of January and February 2004 were more productive, resulting in an average basin snowpack of 135% of normal by March 1, 2004 and the Upper Klamath Lake inflow forecast was increased to 97% of average. However, beginning in March 2004, the basin experienced one of the driest and warmest months on record, with many SNOTEL sites losing snowpack directly into the dry soils and groundwater aquifers.

On April 1, 2004, the Upper Klamath Lake snowpack fell to 104% of average, a decrease of 31% from March 1, 2004. The April 1, 2004 water supply forecast reflected these unusual conditions and was lowered to 80% of average. As the warm and dry spring progressed, many lower elevation SNOTEL sites melted-out several weeks earlier than normal. Klamath Basin United States Geological Survey (USGS) streamgages also reported an earlier than average snowmelt peak and below average runoff beginning in early April.

April was also drier than normal and this resulted in a May 1, 2004 snowpack of 89% of average and an updated Upper Klamath Lake water supply forecast of 70% of average.

Continued dry spring conditions in the basin resulted in a June 15, 2004, NRCS Upper Klamath Lake May-September water supply forecast of 56% of average reflecting continued dry and warm spring, groundwater recharge and above average evaporation.

In summary, based on winter snowpacks of 135% of average on March 1, 2004, the Klamath basin was poised to provide near average spring and summer streamflows. However, the rapid loss of an abundant snowpack in the Klamath Basin during March was unprecedented. Short and long-term climate forecasts did not indicate an event of this magnitude. The SNOTEL network provided the critical information needed to update water supply forecasts as needed to reflect these extraordinary hydroclimatic events.

Geography

The Klamath River originates at Upper Klamath Lake in Oregon and flows in a southwesterly direction, through the Cascade Range and the Klamath Mountains, and discharges to the Pacific Ocean (Figure 1). The Upper Klamath Basin encompasses approximately 8,000 square miles and is located in south-central Oregon and northeastern California. The Oregon part of the basin, approximately 5,600 square miles, lies primarily in Klamath County, with smaller parts in Jackson and Lake Counties. The California part of the basin lies in Modoc and Siskiyou Counties.

The data collection network in the Klamath basin is spread throughout the mountainous areas in the basin. The network consists of stations needed to provide weather data for forecasting in the basin (Figure 2). The primary data source for water supply forecasting is the SNOTEL network. The SNOTEL network consists of 19 remote sites that collect hourly precipitation, snowpack water content, snow depth and temperature data. Six SNOTEL sites have been augmented to provide soil moisture and soil temperature measurements at five different soil depths.

The four aerial markers are poles that indicate snow depth. They are read from a small airplane every month January-June. Six snow courses are manually measured and provide an average measurement of snow water equivalent and snow depth once a month, January-June.

The single SCAN (Soil Climate Analysis Network) site very similar to the SNOTEL enhanced site without the snow measurements due to its location in the valley floor. Five National Weather Service Cooperative Observer sites, located in the valley, are used in to create water supply forecasts. The five water supply forecast points within the basin located at long term stream gages that provide historic and current streamflow data collected by the Bureau of Reclamation and US Geological Survey.

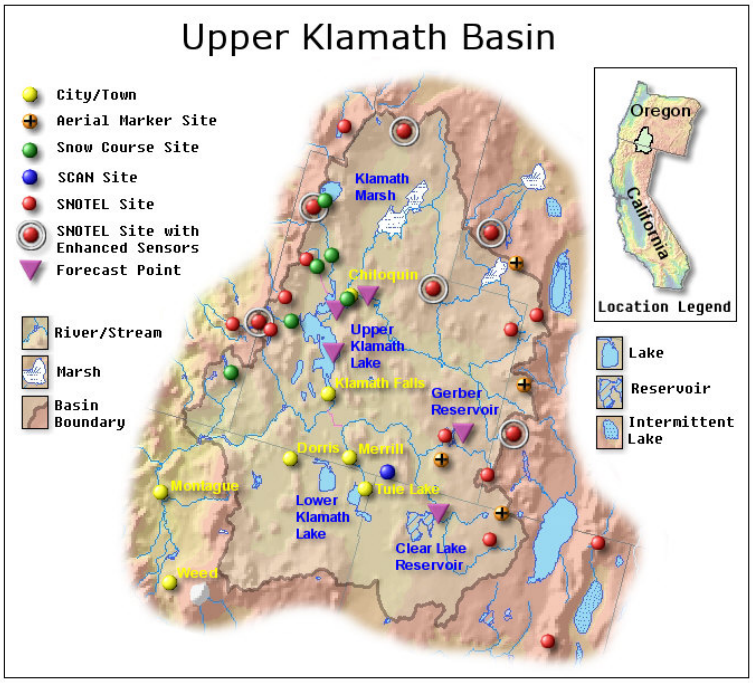

Figure 2. Upper Klamath Basin Hydromet Network Water Supply Forecast Points

Observed Snowpack

After a dry fall, a series of winter storms traversed the Pacific Northwest and the Klamath Basin bringing snow to the Klamath Basin. On January 1, 2004, the Klamath Basin observed snowpack was 130% of normal. The snowpack remained above average through February (129%) and in March (135%) as shown in Figure 3. March was very warm and dry throughout the state and the snowmelt began six to eight weeks earlier than average. By early April these conditions reduced to the basin snowpack to 104% of average, with continued dry conditions reducing the snowpack to 89% of average by May 1st.

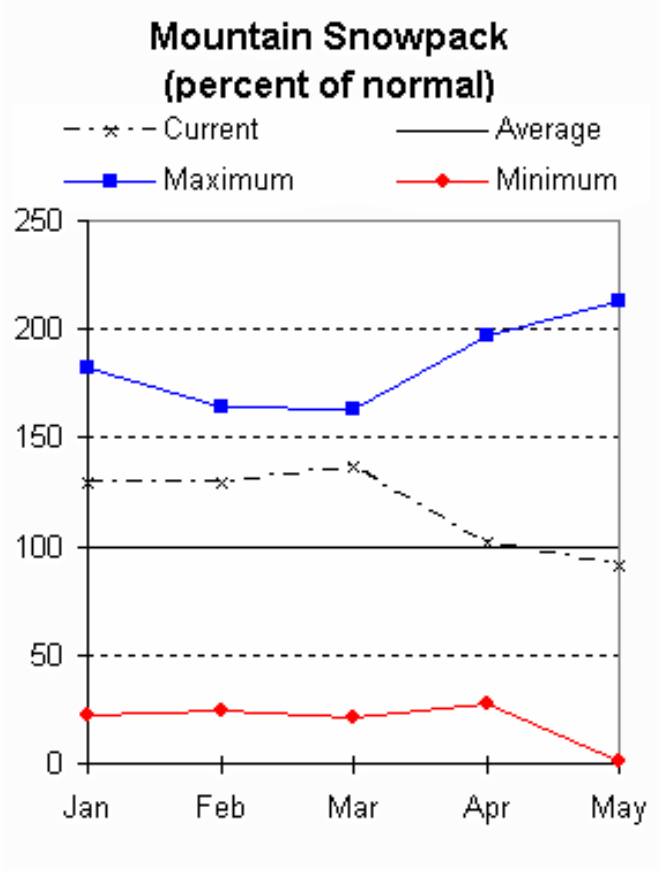

Figure 3. WY-2004 Klamath Basin snowpack (percent of average)

Figures 4 and 5 show time series plots of snow water equivalent and accumulated precipitation for two SNOTEL stations in the Klamath Basin. Both water years are shown to illustrate the higher snowpack conditions recorded this year compared to last year. The SNOTEL stations plots indicate a decline in snow water equivalent beginning in early March 2004. Coldsprings Camp site is a good indicator of high elevation snowpack conditions for Cascade mountain sites (Figure 4). Strawberry is a good site for the lower elevation mountains snowpack conditions in the eastern part of the basin (Figure 5).

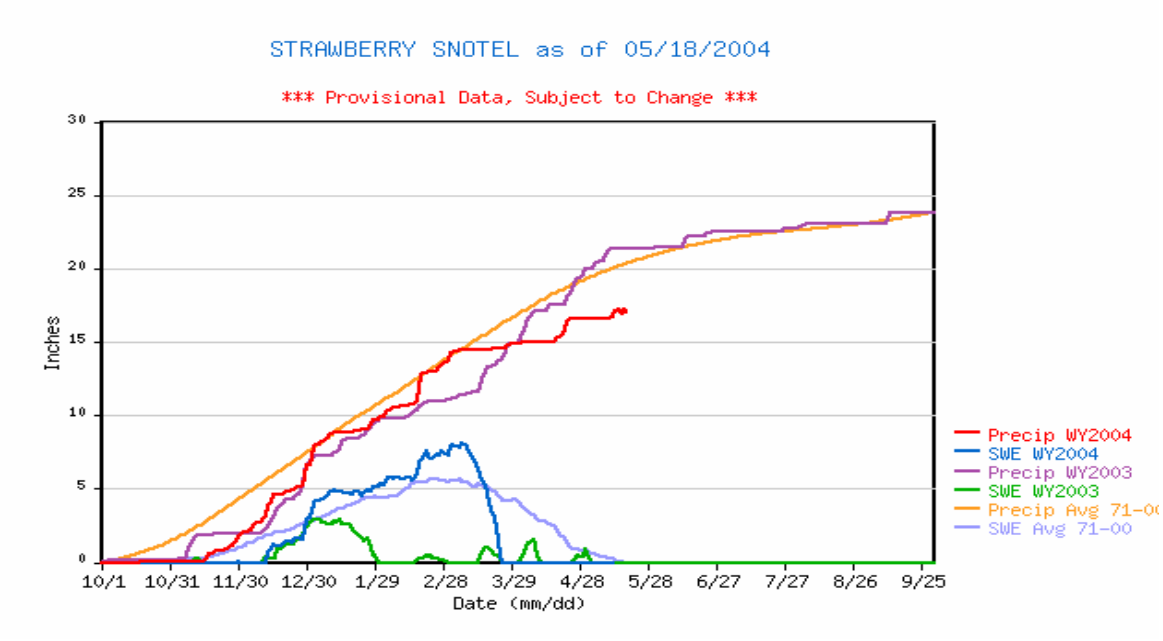

Figure 4. Strawberry SNOTEL (5,760') Precipitation and Snow Water Equivalent

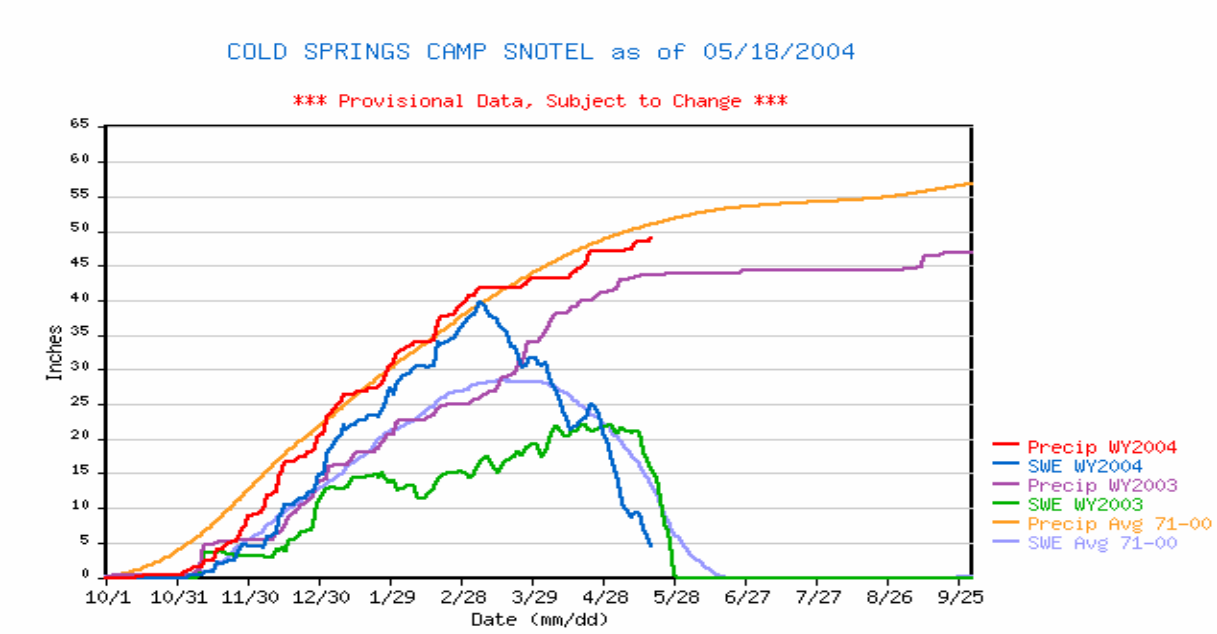

Figure 5. Cold Springs Camp SNOTEL (6,100') Precipitation and Snow Water Equivalent.

Observed Precipitation

Water year 2004 precipitation in the Klamath Basin began dry. October precipitation was 12% of average continuing a trend of below average totals recorded during the spring and summer of 2003 (Figure 6). November recorded 72% of average while December totals were 119% of average. January reported 102% of average and February continued the above average trend with 123% of average for the basin. As mentioned earlier, March was extremely warm and dry, reporting 42% of average during a month that normally accumulates precipitation. April was also below average at 65% of normal. As of May 1, 2004, the cumulative water year precipitation for the basin was 83% of average, never exceeding the seasonal average.

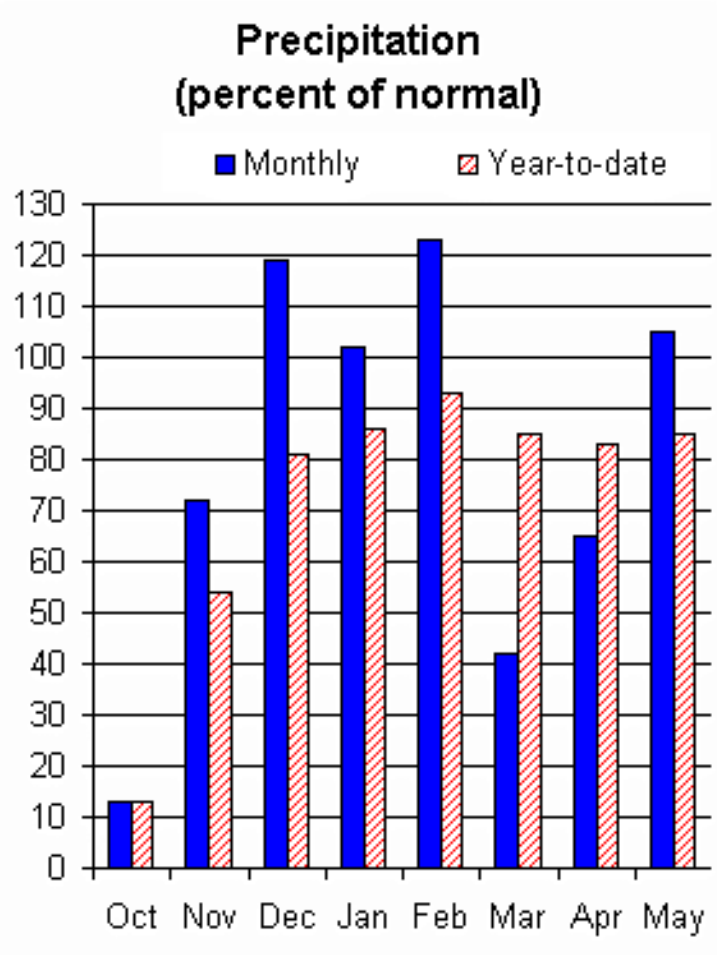

Figure 6. Klamath Basin SNOTEL Precipitation for WY-2004.

Observed Streamflow

Observed Upper Klamath Lake inflow has remained below average during every month of water year 2004. Multiyear snowpack and precipitation deficits are a likely reason for these conditions. The much of the above average basin snowpacks melted earlier six to eight weeks earlier than normal, with the streamflow peaks occurring in mid March instead of late April. Streamflows receded quickly and the snowmelt provided little support for normal late spring runoff. The Williamson River below Sprague River near Chiloquin is a good indication of the below average streamflow observed throughout the basin (Figure 7).

Monthly provisional inflow into Upper Klamath Lake was below average each month and showed below average increases during the snowmelt runoff (Figure 8). The water year 2004 cumulative streamflow illustrates the continuing trend of below average runoff from several years of below average snowpack (Figure 9). During March and April, the cumulative inflow continued to recede, reflecting dry conditions.

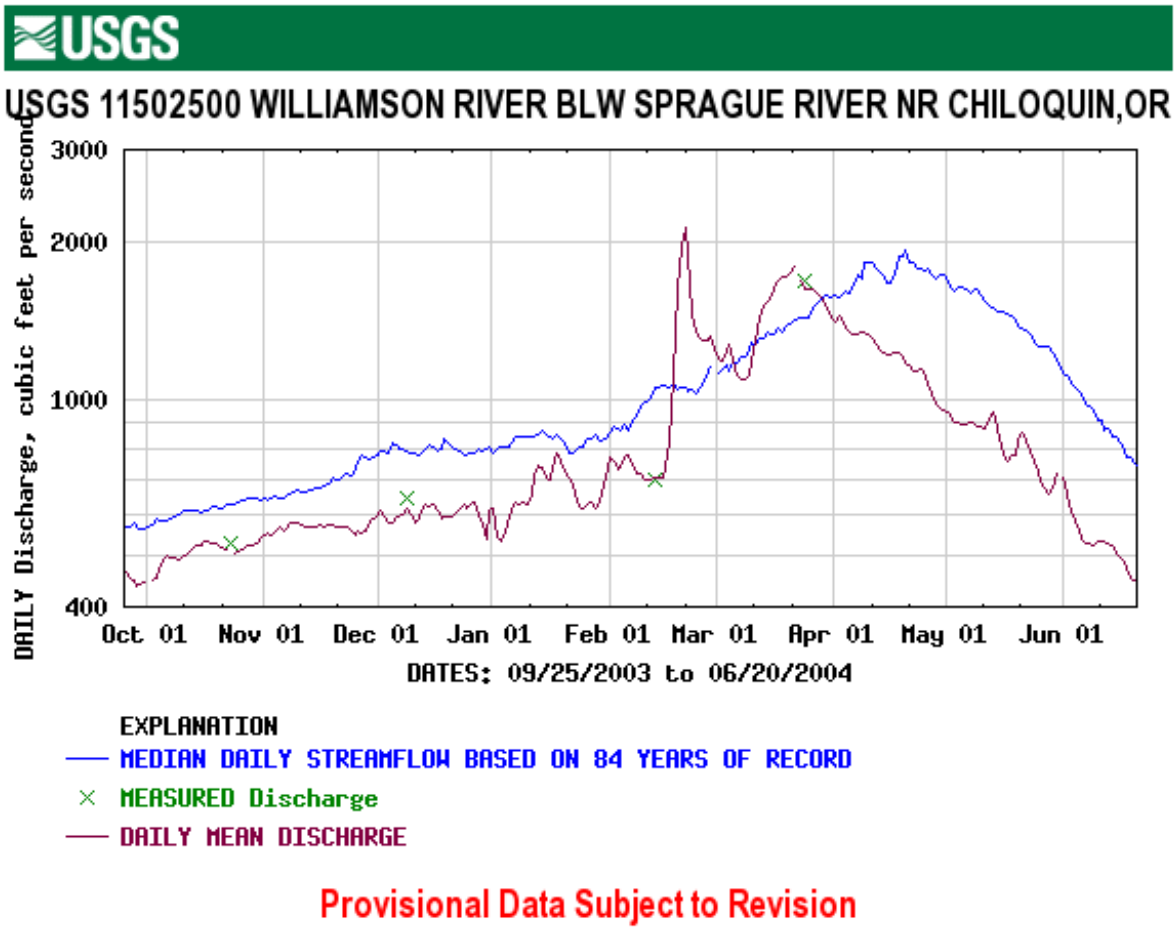

Figure 7. USGS Williamson River WY-2004 streamflow, a UKL Tributary

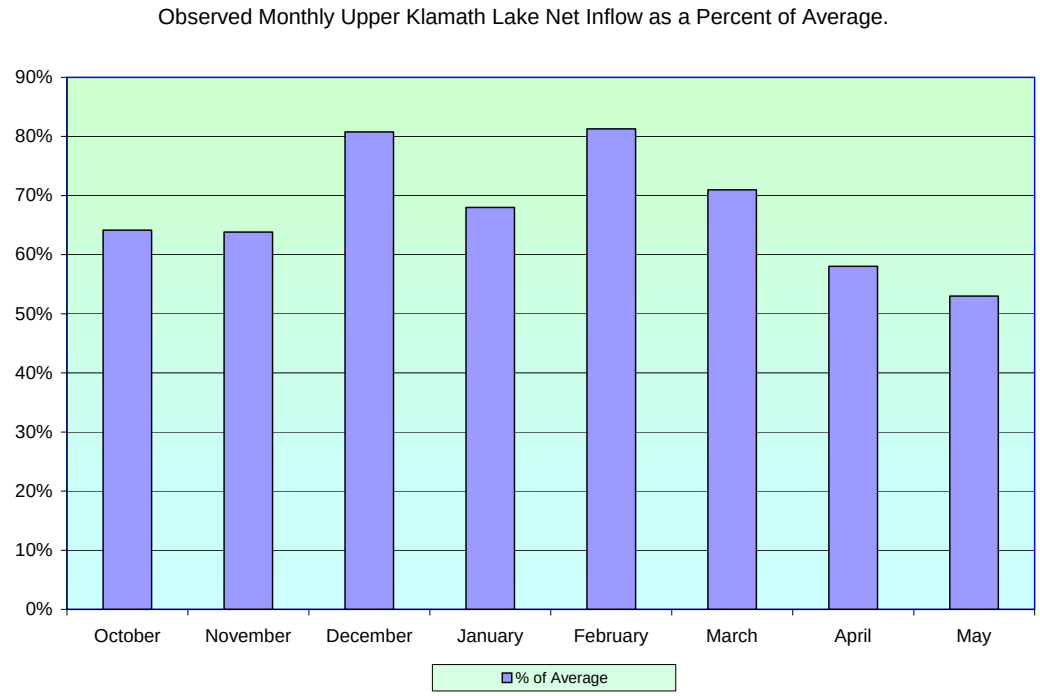

Figure 8. Upper Klamath Lake Monthly Inflows

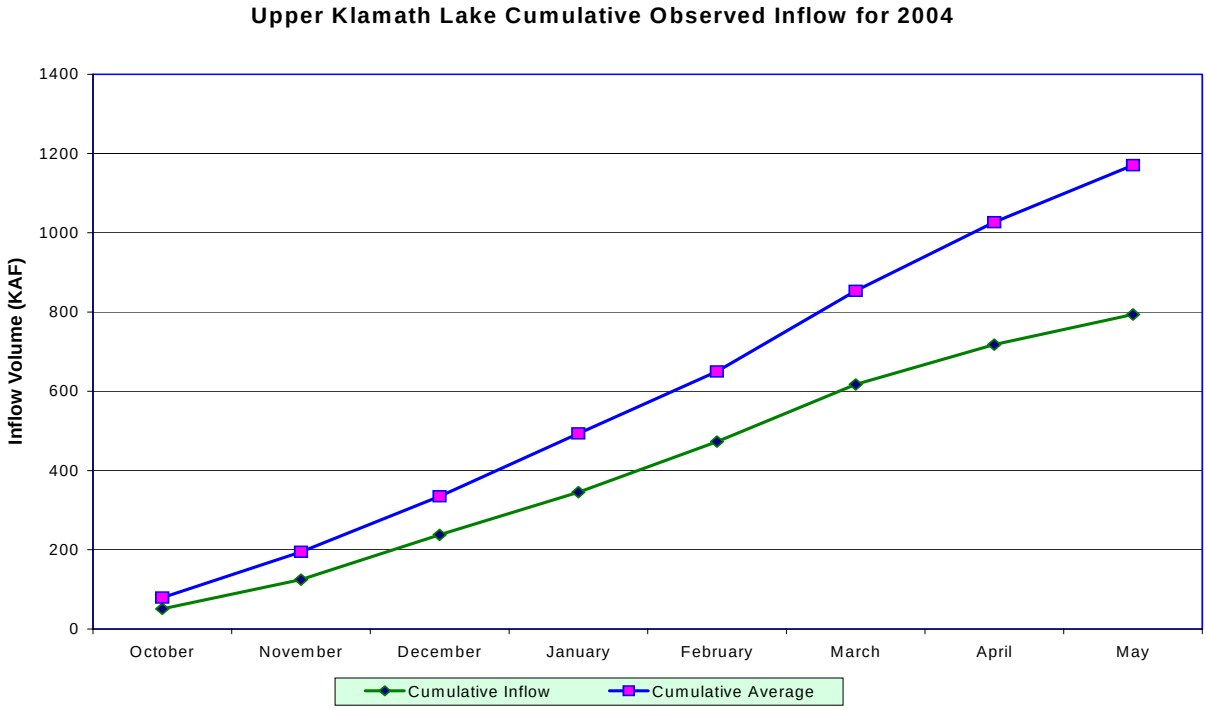

Figure 9. Upper Klamath Lake Water Year 2004 Cumulative Observed Inflow

Temperatures

Klamath Basin temperatures were extremely warm for the most of March, averaging 5 to 7 degrees above normal (Figure 10). These temperatures melted and sublimated the snowpack, drying out soils in the lower elevations. April continued above average until midmonth when temperatures cooled. Well above average temperatures returned for the first week of May.

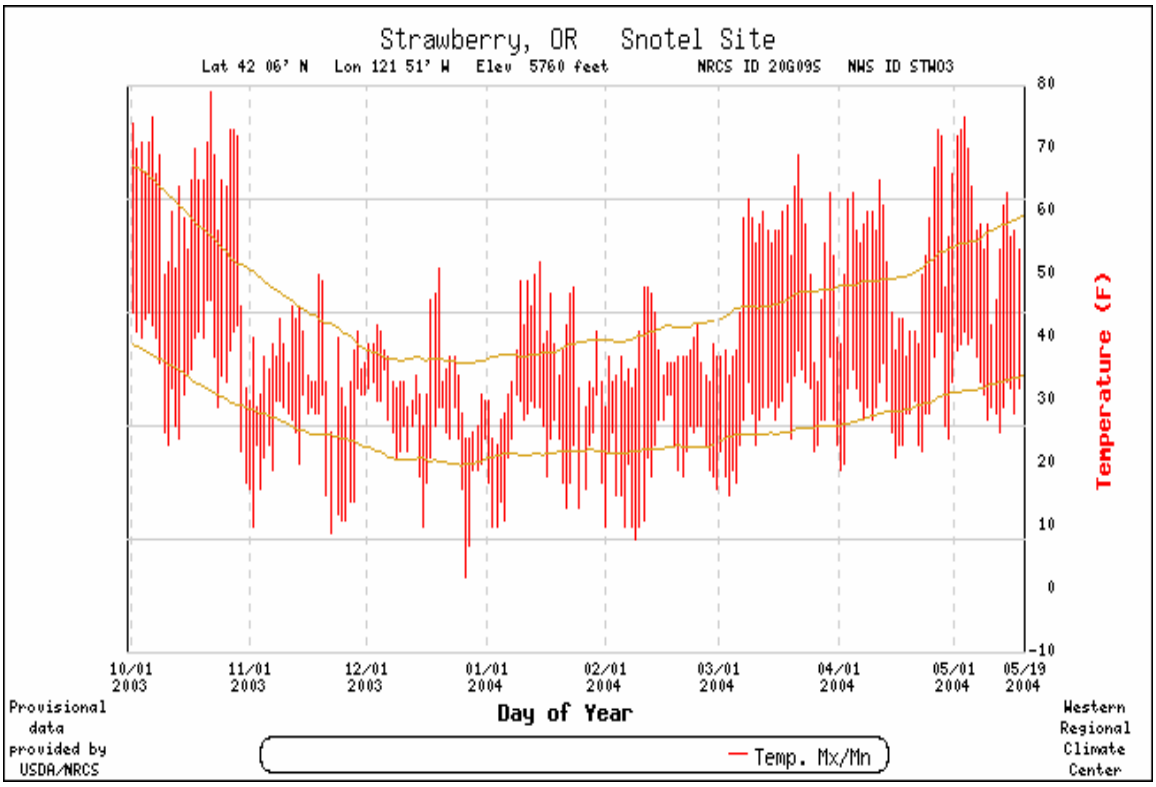

Figure 10. The 2004 Strawberry SNOTEL maximum and minimum temperatures.

Water Supply Forecasts

Monthly Upper Klamath Lake net inflow forecasts issued from January through mid-May were below average for the entire period (Table 1). Figure 11 summarizes forecasts issued for water year 2004. Water supply forecasts, in thousands of acre-feet (vertical axis), are issued bi-monthly beginning January and ending in June for 5%, 30%, 50%, 70% and 95% exceedance thresholds.

Exceedance thresholds provide confidence limits for water resource mangers to determine risk. For example, the forecast volume associated with a 70% exceedance probability has a 70% chance of receiving more than the forecast volume (and a 30% chance of receiving less than the forecast volume). The April-September forecast volumes issued on January 1, 2004 corresponding to these exceedance thresholds are 135,000 acre-feet (95% exceedance),

Forecast Date	Forecast period	50% Exceedance Forecasted volume (Acre-Feet)	Percent of Average	30-Year Average volume (Acre-Feet)	UKL Snowpack (%)	UKL Cumulative Water Year Precipitation (%)
January	Apr-Sept	400,000	78%	515,000	130%	81%
Mid January	Apr-Sept	410,000	83%	515,000		
February	Apr-Sept	425,000	83%	515,000	129%	86%
Mid February	Apr-Sept	415,000	81%	515,000		
March	Apr-Sept	500,000	97%	515,000	135%	93%
Mid March	Apr-Sept	475,000	92%	515,000		
April	Apr-Sept	420,000	82%	515,000	104%	85%
Mid-April	Apr-Sept	370,000	72%	515,000		
May	May-Sept	230,000	68%	340,000	89%	83%
Mid May	May-Sept	210,000	62%	340,000		
June	May-Sept	195,000	57%	340,000	56%	85%
Mid June	May-Sept	190,000	56%	340,000		

Table 1. Upper Klamath Lake Water Year 2004 Inflow Forecasts, Snowpack, Precipitation

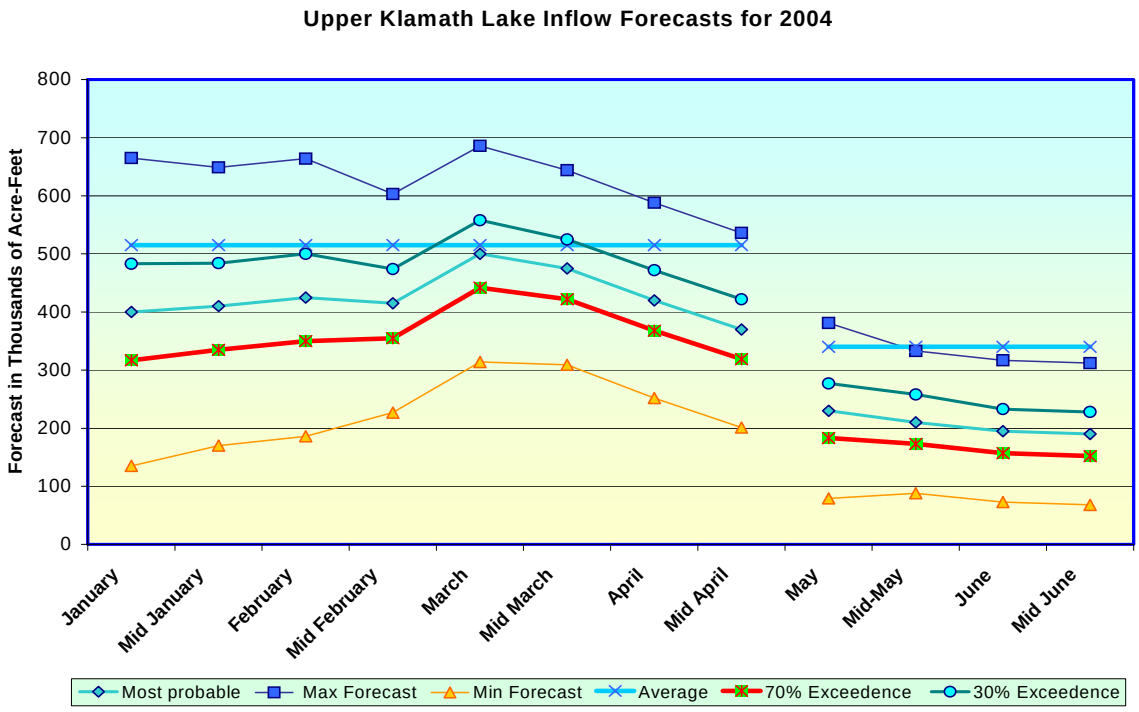

Figure 11. Upper Klamath Lake Inflow Forecasts - Water Year 2004

317,000 acre-feet (70% exceedance), 400,000 acre-feet (50% exceedance), 483,000 acre-feet (30% exceedance), and 665,000 acre-feet (95% exceedance).

As shown in Figure 10, confidence limits are widest early in the forecast period, starting in January when the snowpack accumulation period begins and the seasonal snowpack peak is unknown. Confidence limits narrow as the year progresses and the snowpack peak becomes apparent, spring precipitation is known and snowmelt runoff begins, generally near April 1.

During water year 2004, snowpack increased during January and February, and the Upper Klamath Lake net inflow forecasts increased slightly to reflect the above average snowpacks, but recognized the antecedent dry conditions from the previous water year. The March 1, 2004 forecast was the highest issued during the season, with the 50% exceedance volume at 97% of average, and the 70% exceedance volume was at 86% of average.

The warm and dry March ignited snowmelt and the snowpack decreased rapidly. An Upper Klamath Lake snowmelt peak inflow was recorded in Mid-March. Mid March forecasts were revised down by 5%. By April 1, using data that described the scope and amplitude of the warm and dry weather, the April 1 water supply forecast was revised downward another 10%. The dry and warm weather continued through mid-April, prompting another 10% drop in the forecast to 72% of average. The end of April recorded a slight increase in snowpack and precipitation during a cool stormy few days.

On May 1st the forecast period switches from April-July to May-July volume. The precipitation event at the end of April resulted in only a slight decrease in the inflow forecast on May 1 to 68% of average, as the streamflow showed only a slight response to the precipitation and snowfall at that time. The continued decline in the streamflows in May and the return to warm dry weather, resulted in a mid-May decrease of 6% of average in the May-September forecasted volume.

Summary

In summary, based on winter snowpacks of 135% of average on March 1, 2004, the Klamath basin was poised to provide near average spring and summer streamflows. However, the rapid loss of an abundant snowpack in the Klamath Basin during March was unprecedented, with short and long-term climate forecasts did not indicating an event of this magnitude. The SNOTEL network provided the critical information needed to revise water supply forecasts to reflect this dramatic event. In response to these unusual climatic conditions, the water supply volume forecasts were adjusted downward due to dry conditions and loss of snowpack. As of June 15, 2004, water supply forecast for Upper Klamath Lake is 56% of average reflecting continued dry and warm spring, groundwater recharge and above average evaporation.

Contacts

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