**Climate trends at the headwaters of the White River**
**Summary of snotel and flow data**

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This report summarizes temperature and precipitation records from the Flat Tops region at the headwaters of the White River for water year 2024. It also includes flow records from the White River near Meeker, CO, along with analysis and brief commentary. The purpose of the report is to update regional climate and hydrologic data for reference by water managers and the public. Data from the USGS gauging station and snotels are preliminary; USGS and NWCC have not completed data verification as of 01/01/2025.

Temperature and precipitation measurements come from the Trappers Lake Snotel (9700 ft. elevation, Trappers Snotel); Ripple Creek Snotel (10,340 ft. elevation, Ripple Creek Snotel); and the Burro Mountain Snotel (9400 ft. elevation, Burro Mountain Snotel). I compare daily mean temperatures for water years 1987-1991 with daily mean temperatures for water years 2020-2024. I also plot trends in yearly accumulated precipitation from 1987 through 2024. Those dates include all available data from the snotels.

I analyze historical trends in White River discharge using data from the USGS continuous real time gauging station near Meeker (station 09304500) from water years 1910 through 2024. A "water year" in the USGS flow records runs from October 1 to September 30 with year date in January as the designated water year identifier. Data analysis includes trends in total runoff, peak flow volume, timing of peak flow, April vs. June flow, and September flow.

I evaluate trends using Mann-Kendall statistics. Graphs show trend lines calculated by least squares.

## Summary of Results

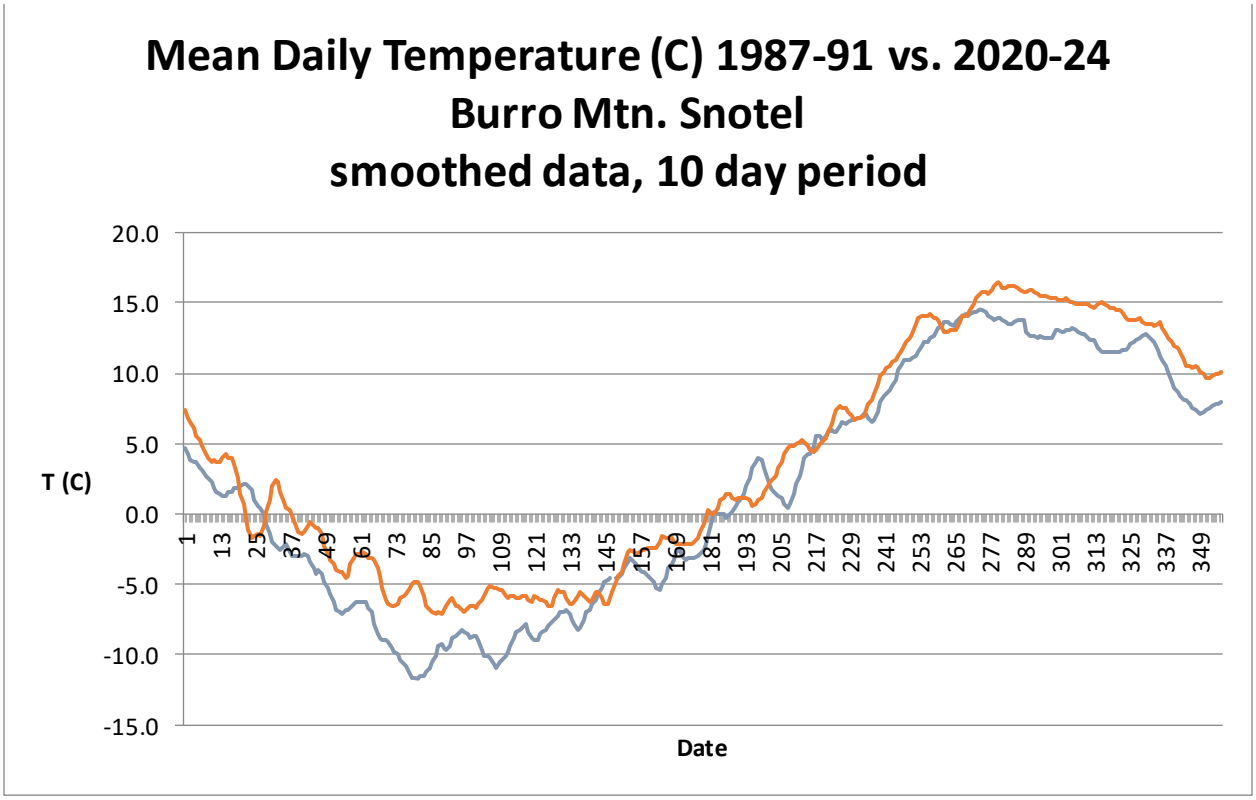
Mean daily temperatures on the Flat Tops have increased significantly from 1987 to the present (Figures 1 and 2).

Cumulative yearly precipitation on the Flat Tops is decreasing. (Figure 3). Snowmelt trends earlier (Figure 4).

Peak runoff in the White River occurs earlier in the Spring and is trending toward lower volume. (Figures 5, 6 and 7.) April runoff is increasing (Figure 8). June runoff is trending downward (Figure 9), and September runoff has dropped dramatically (Figure 10). See comments accompanying the Figures for further analysis.

The patterns in temperature, precipitation, and runoff reported here are consistent with global and regional climate trends. See, for example, the *5th National Climate Assessment* (link in references at the end of this report). Global average temperatures are rising. Polar and alpine regions are changing more rapidly than global averages. The American Southwest is experiencing higher temperatures and more prolonged episodes of drought.

Figure 1a: Mean daily temperatures at Burro Mountain snotel, average of water years 1987-1991 (blue) vs. 2020-2024 (orange). The most recent 5-year average daily temperature is significantly greater than the 1987-91 average; t-stat = -11.6, $p \ll 0.001$, paired t-test, n = 365. Plot shows smoothed ten-day running mean.




Comment: Mean daily temperatures in recent years are significantly higher than when data collection began thirty-seven years ago. Other analyses of these data (not shown) document rising average daily mean temperatures at all three snotels in each successive five-year interval since 1987. The greatest increases in temperature occur in mid-winter and late summer. Temperature at Ripple Creek and Trappers show the same pattern as Burro Mountain. Higher summer temperatures at Trappers after 2000 may be confounded by snotel exposure after the fire.

Figure 1b: Mean daily temperatures at Ripple Creek snotel, average of water years 1987-1991 vs. 2020-2024. The most recent five-year average daily temperature is significantly greater than the 1987-91 average; t-stat = - 6.8, $p \ll 0.001$, paired t-test, n = 365. Plot shows smoothed ten-day running mean.

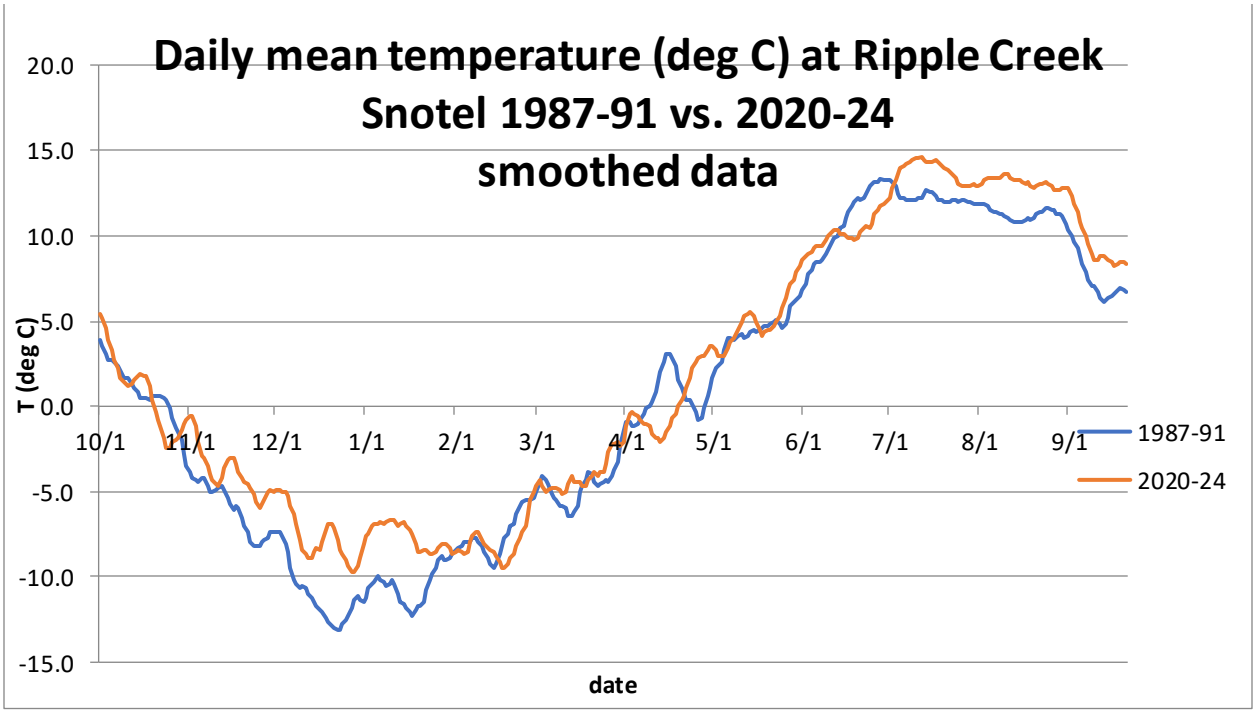
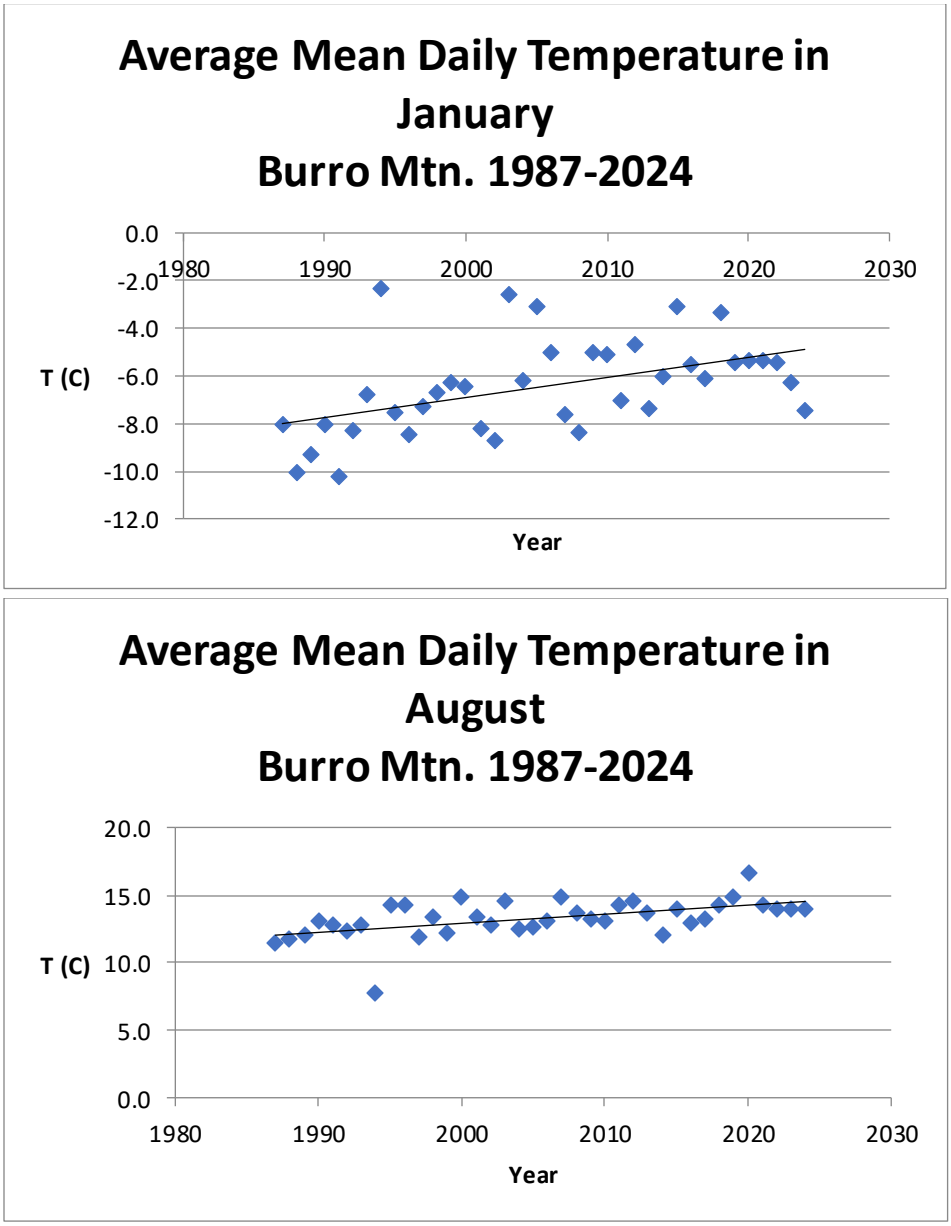
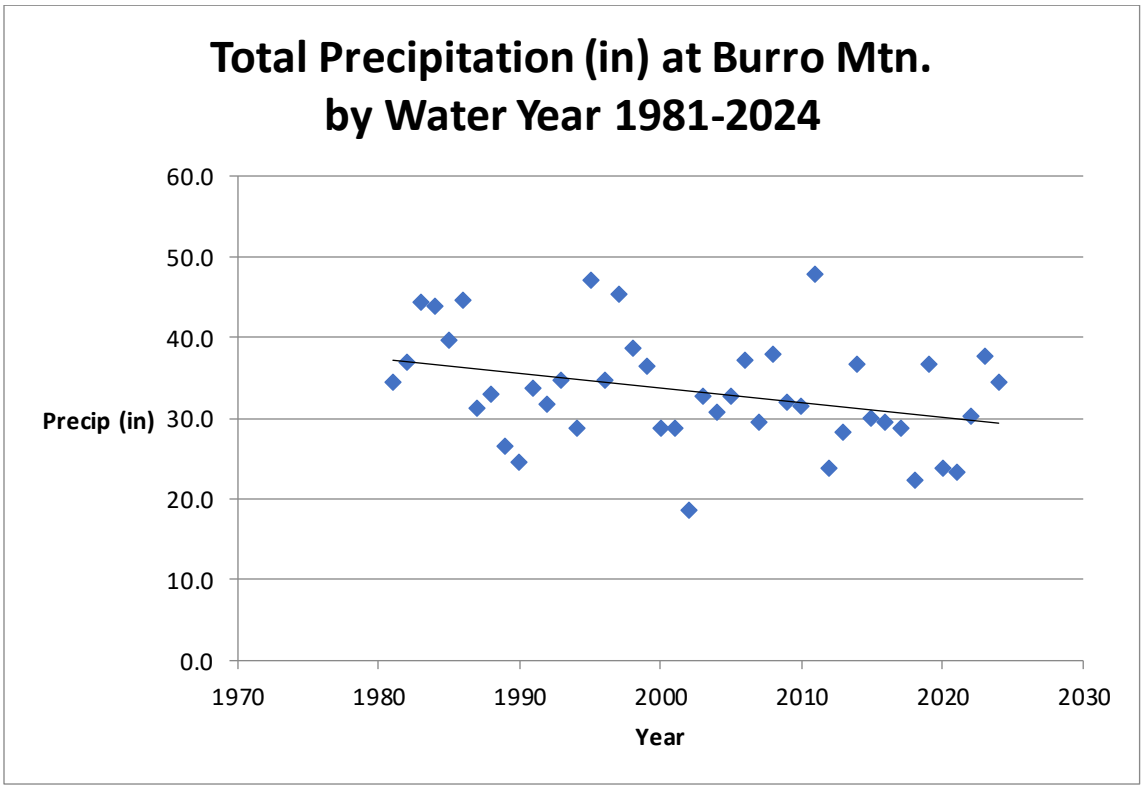


Figure 2. Mean daily temperatures in January and August at Burro Mtn, 1986 – 2024. Upward trend is significant; January Mann-Kendall S = 258, Z = 3.23, $Z_{critical}$ = 1.96, n = 39. August trend Mann-Kendall S = 285, Z = 3.57, n = 39. Trendline is best linear fit by least squares analysis. Ripple Creek and Trappers Lake show the same January and August temperature trends as at Burro Mtn, with similar statistically significant upward trends in daily temperature.



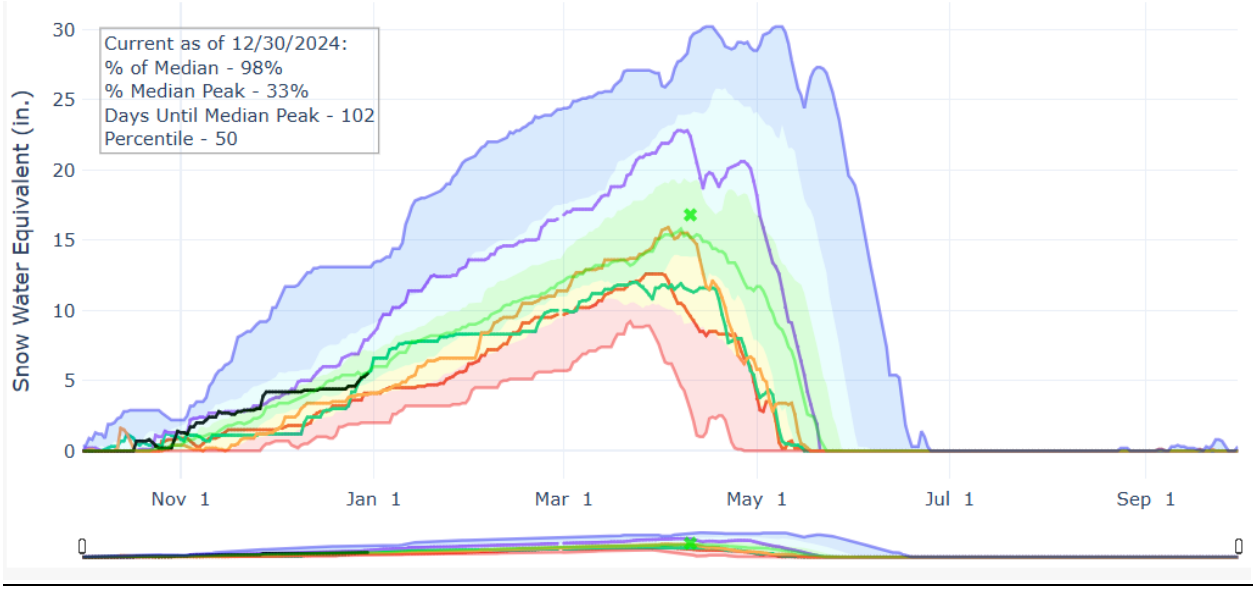

Comment: January and August mean daily temperatures in the Flat Tops are increasing. These observations are consistent with larger climate studies.

Figure 3. Cumulative yearly precipitation at Burro Mtn, water years 1981-2024. Precipitation is decreasing at all three snotels. Burro Mtn. Mann-Kendall S = -211, Z = -2.14, $Z_{critical}$ = -1.96, n = 45. Trappers Lake and Ripple Creek show similar trends and statistics. (Trappers Lake and Ripple Creek data not shown.)




Comment: Precipitation on the Flat Tops is decreasing. There is less water, primarily from snowpack, for runoff into the headwaters of the White River.

Figure 4a. Snow water equivalent (SWE) at Burro Mtn snotel water years 2021-24. Rainbow shading shows 20-percentile intervals for the period of record 1986-24: red shading (bottom 20th percentile) through blue (top 20th percentile). Legend below identifies years by line color. Water year 2023 (purple line) produced largest snowpack in the past five years. We're just starting water year 2025, black line at bottom left. Graph source: USDA Natural Resources Conservation Service, NWCC Interactive Map. Data from Burro Mtn snotel.



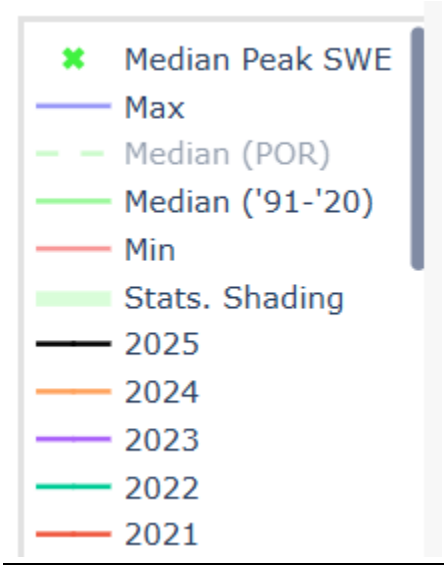
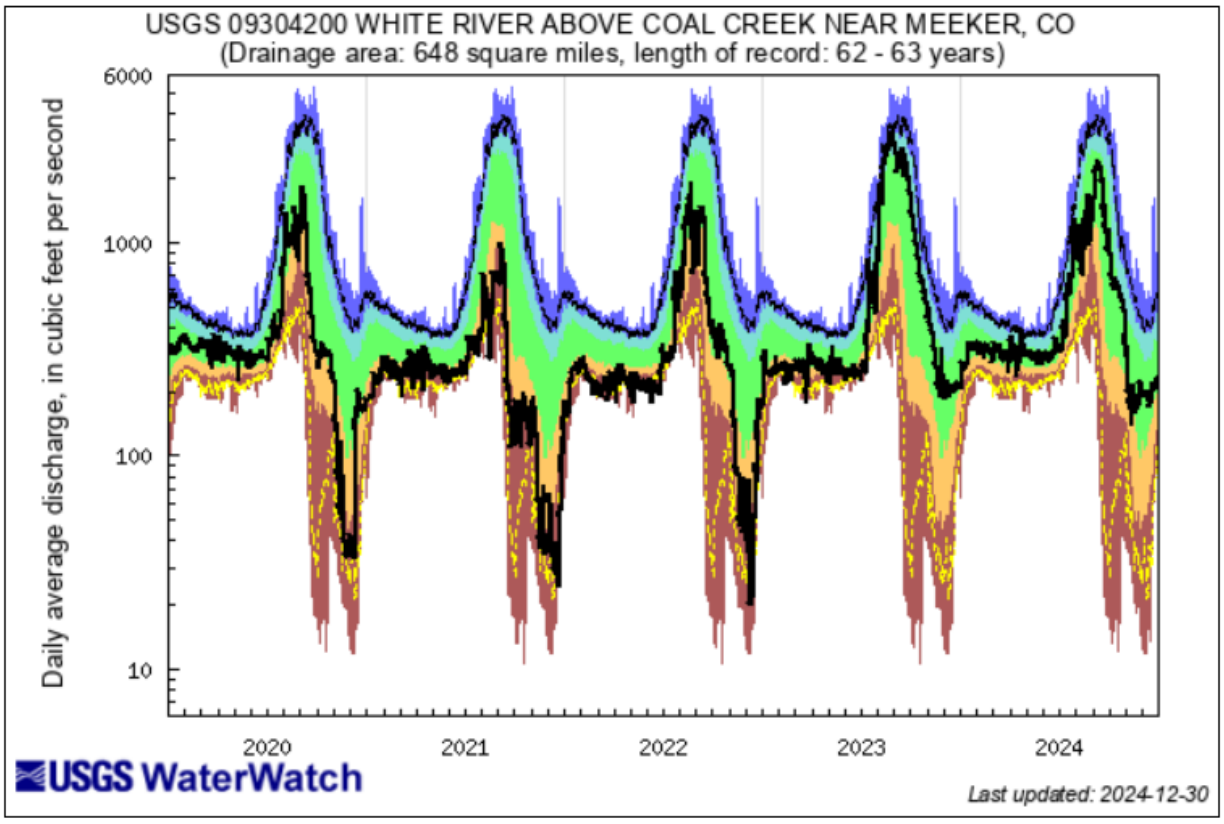
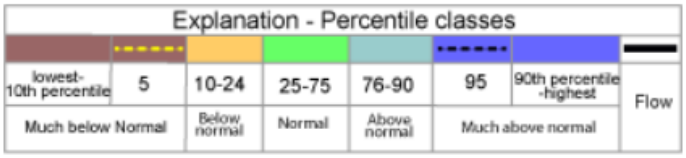



Figure 5a. Daily flow (black line) in the White River near Meeker vs. historical percentiles during water years 2020-24. See the Water Watch web page for historical record of streamflow.

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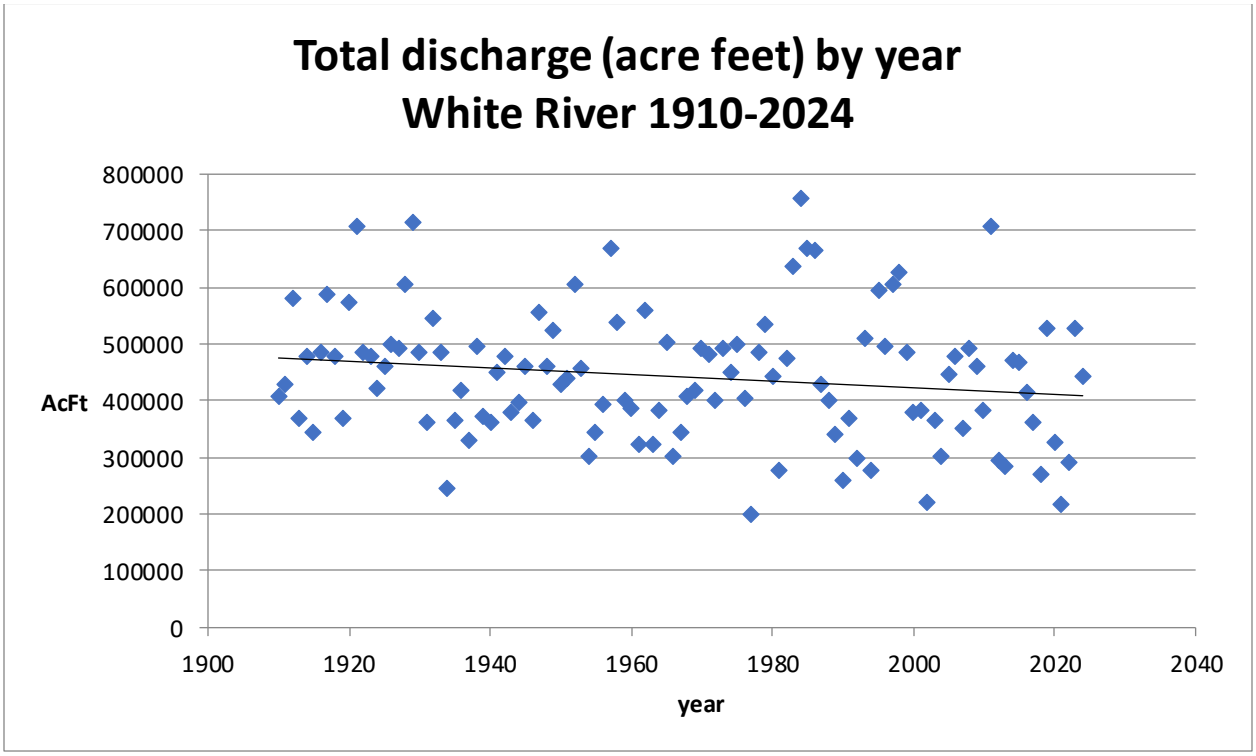
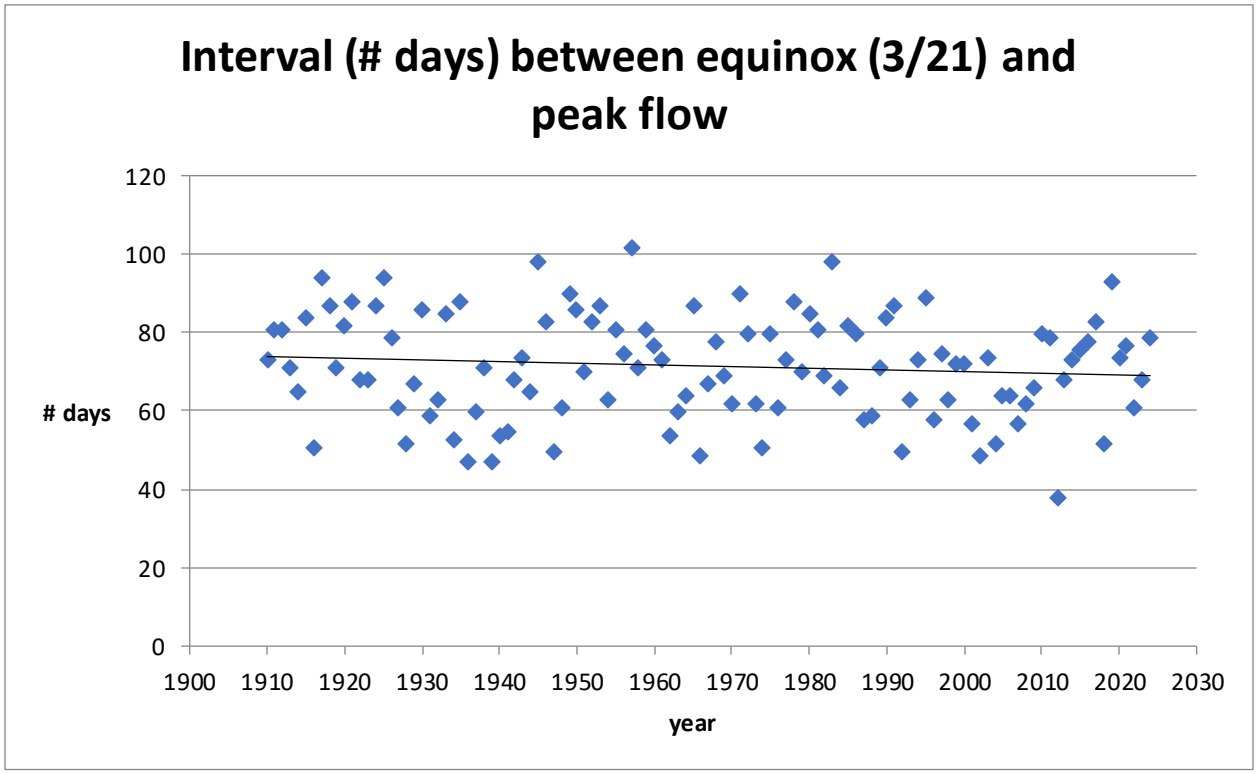
Comment: Overall, daily flow in the White River near Meeker ran below historical average over the past five years. The river peaked high in water year 2023 then ran about average on through water year 2024.

Figure 5b. Total runoff (acre feet) down the White River by year from 1910 to 2024. Trend is downward. Mann-Kendall $S = -787$, $Z = -1.90$. $Z_{crit} = -1.96$.



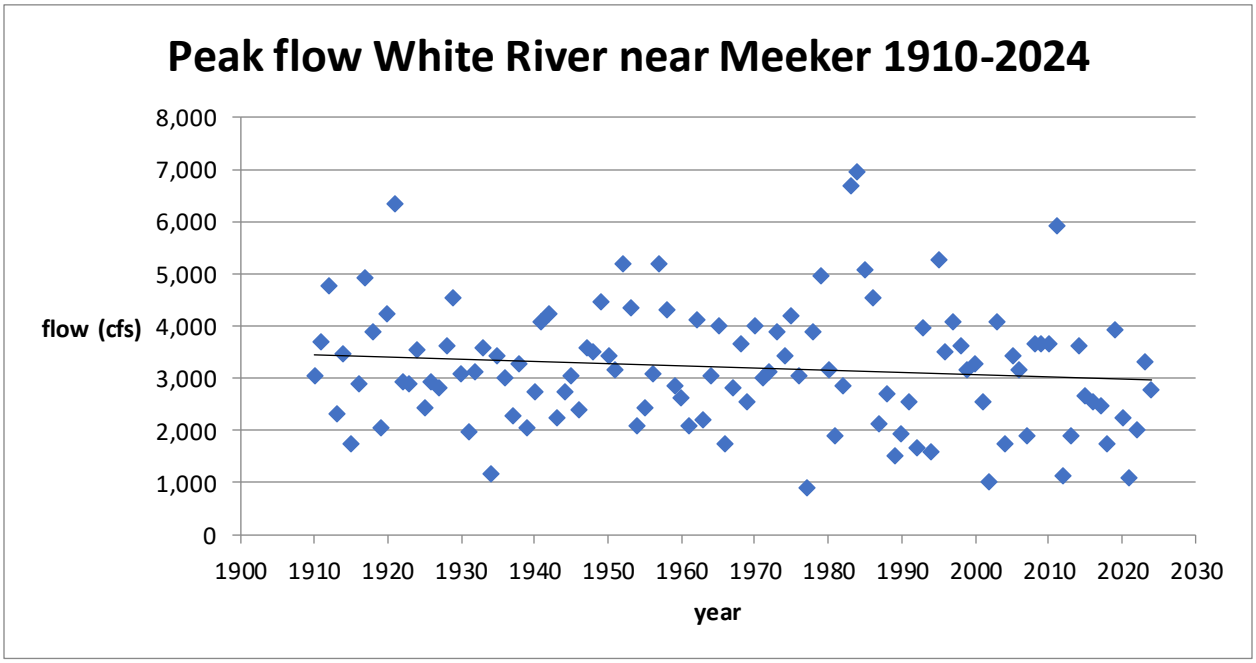

Comment: Total yearly runoff in the White River is decreasing, down by about 70,000 acre feet on average over the period of record. That represents about a 14% loss in water volume.

Figure 6. Date of peak flow in White River near the Town of Meeker (USGS gauging station 09304500) 1910-2024 plotted as interval number of days after the Spring equinox. Mann-Kendall S = -445, Z = -1.08, $Z_{critical}$ = -1.96, n = 115. Trendline is best linear fit by least squares analysis.



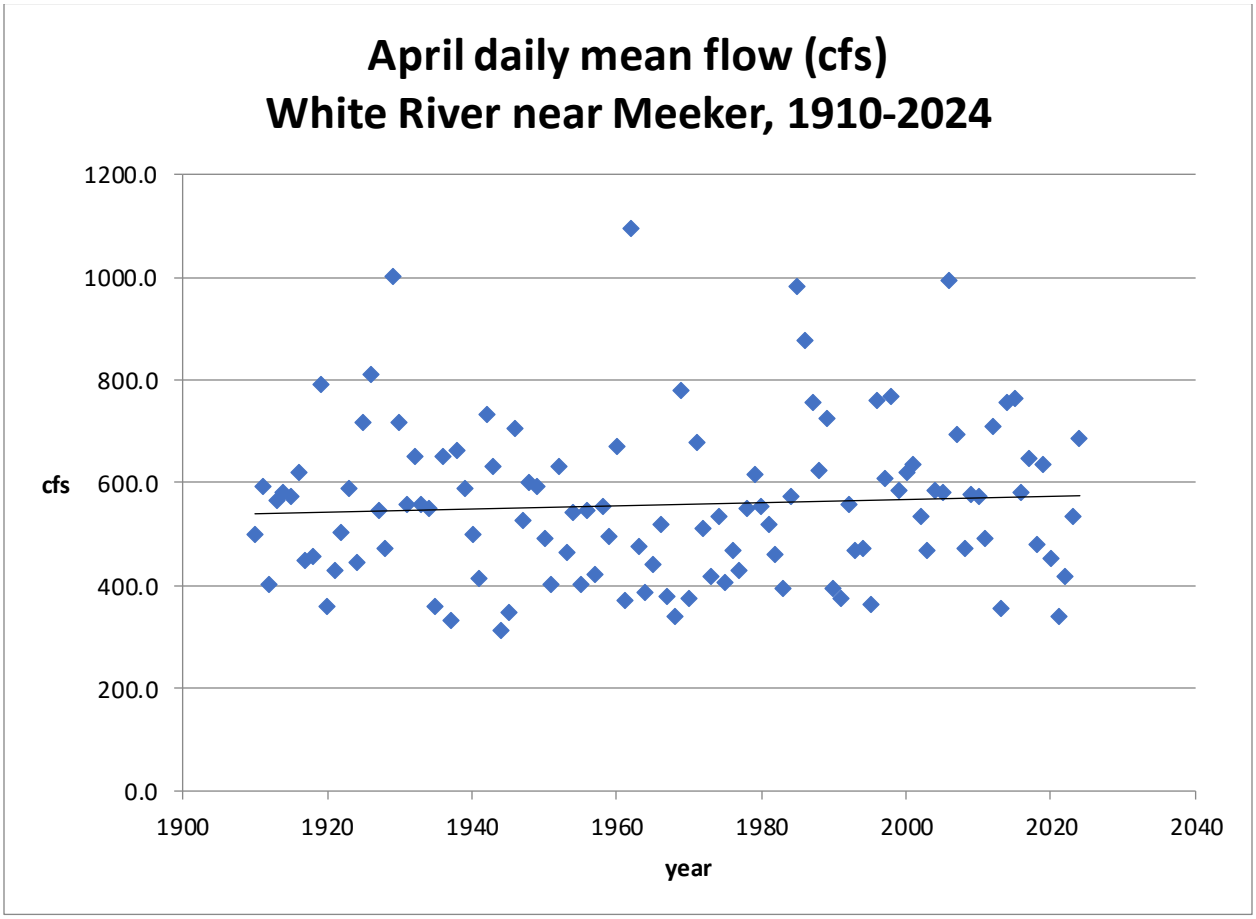

Comment: Spring runoff today occurs earlier than it did in the past. Earlier peak flow results in longer period of low flow in the summer and, potentially, higher water temperatures. Both effects may contribute to algae bloom and to fish stress.

Figure 7. Peak flow (cfs) in White River near Meeker (USGS gauging station 09304500) water years 1910-2024. Mean flow for the period is 3209 cfs. Mann-Kendall S = -559, Z = -1.35, $Z_{critical}$ = -1.96, n = 115. Trendline is best linear fit by least squares analysis.




Comment: Peak flow is decreasing, now roughly 500 cfs lower on average than it was in 1910. Lower peak flow is less effective at scouring algae off the stream bed, and decreased flow changes sediment transport and fish habitat.

Figure 8. Daily mean flow in the White River near the Town of Meeker in the month of April, water years 1910-2024. Mann-Kendall S = 278. Z = 0.670, $Z_{critical}$ = 1.96, n = 115 . Trendline is best linear fit by least squares analysis.




Comment: April flows are increasing. This reflects earlier Spring runoff. As shown in Figure 8, the tradeoff is lower flow in June and on into the summer.

Figure 9. Daily mean flow in the White River near the Town of Meeker in the month of June, water years 1910-2024. Mann-Kendall S = -792, Z = -1.92, $Z_{critical}$ = -1.96, n = 115. Trendline is best linear fit by least squares analysis.

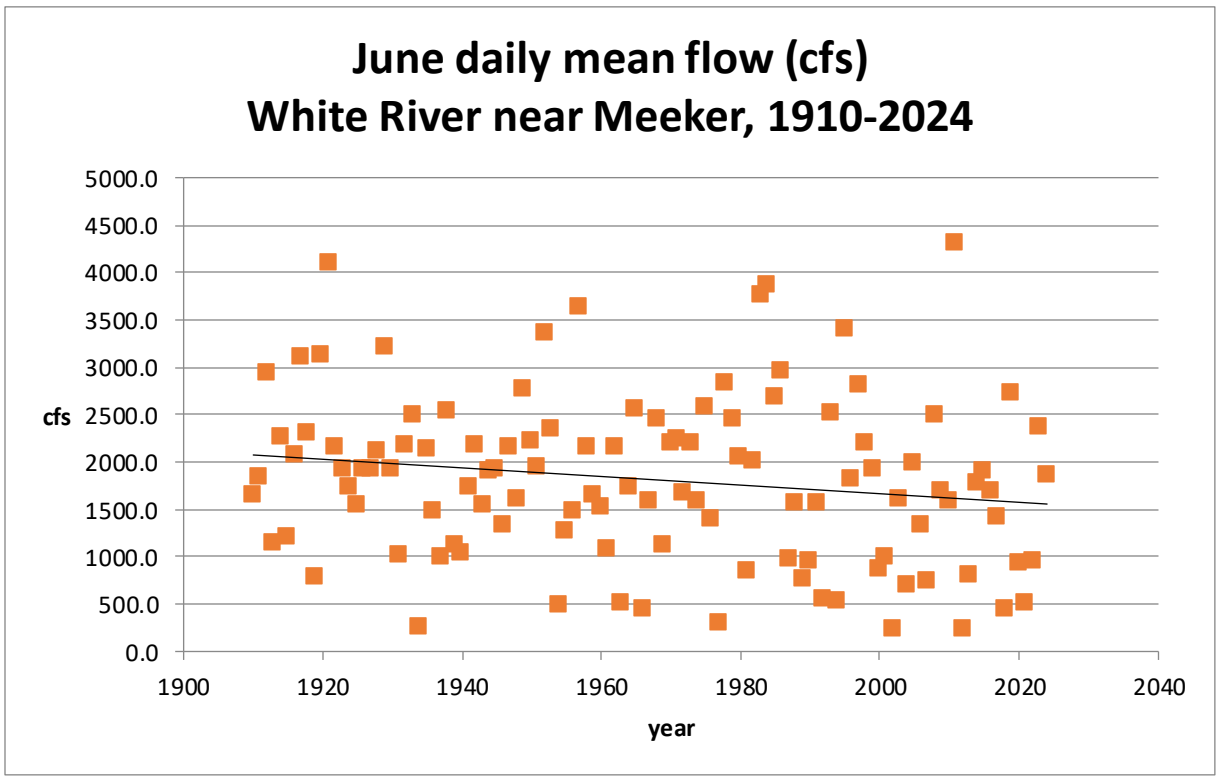
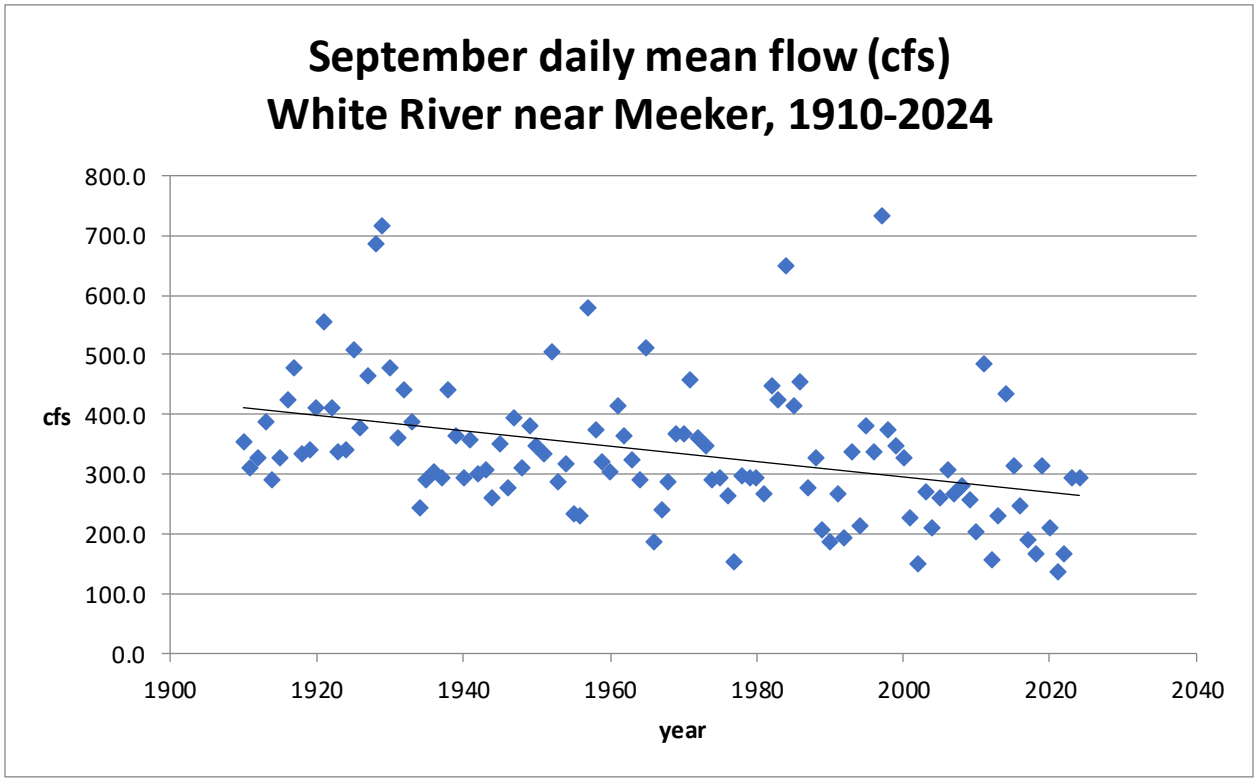


Figure 10. Mean flow in the White River near the Town of Meeker in the month of September, water years 1910-2024. Mann-Kendall S = -2038, Z = -4.93, $Z_{critical}$ = -1.96, n = 115. Trendline is best linear fit by least squares analysis.




Comment: Peak runoff historically occurred in early June, but peak is trending earlier. Downward trend is particularly evident in late summer, as the river returns to base flow. Longer periods of low flow in the summer provide favorable conditions for algae growth, increase stress on fish, and decrease available irrigation and municipal water supplies.

References:

Snotels:
Burro Mountain Snotel. https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=378
Ripple Creek Snotel. https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=717
Trappers Snotel. https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=827

USDA Natural Resources Conservation Service. iMap. https://nwcc-apps.sc.egov.usda.gov/imap/

USGS Gauging Station: White River Near Meeker. https://waterdata.usgs.gov/co/nwis/uv?site_no=09304500

USGS Water Watch. https://waterwatch.usgs.gov/

U.S. Global Change Research Program. 2023. 5th National Climate Assessment. https://nca2023.globalchange.gov/