# 2025 Wind River Range Water Supply Forecasting: June 2025

Mountain Hydrology LLC presents the 2025 delivery of Wind River Range remotely sensed snow data and experimental seasonal water supply forecasts as part of the Bureau of Reclamation's Snow Water Supply Forecasting Project.

A key component of this project is the collection of airborne lidar data by Airborne Snow Observatories, Inc. (ASO) and snow density field measurements by Mountain Hydrology to estimate full-watershed snowpack storage at 3 meter spatial resolution. The first of three annual full-watershed snow water equivalent (SWE) maps is presented below. These data are assimilated into a physical water supply forecasting model, DHSVM-WSF (refer to supplementary setup materials) to generate probabilistic runoff forecasts. This report discusses the snowpack survey and runoff forecasting results.

Best, Eli Boardman
Chief Scientist and Founder, Mountain Hydrology LLC
Eli Boardman

*Delivered: June 7th, 2025*

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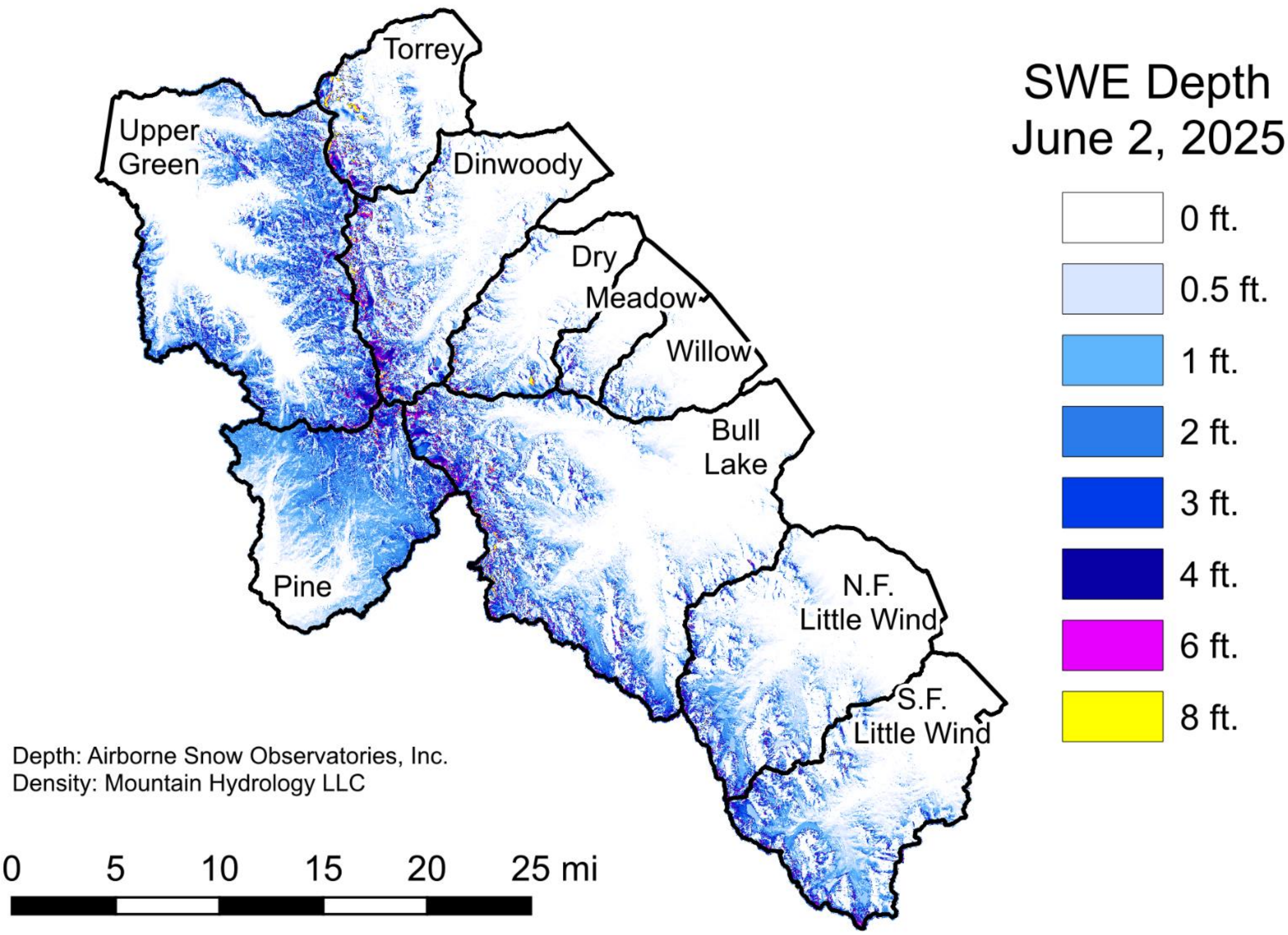


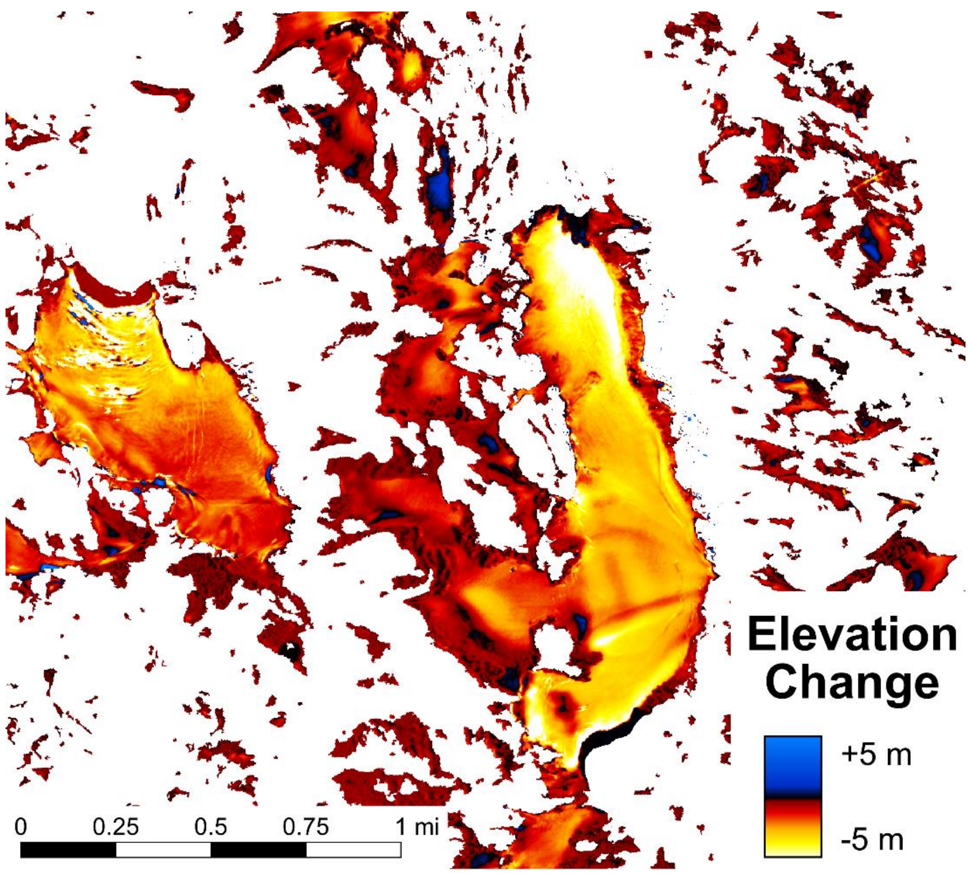

Note: ASO's official version of the snow depth map can be found at https://data.airbornesnowobservatories.com/.

## Snow Depth Survey

Mountain Hydrology contracted with Airborne Snow Observatories, Inc. (ASO) to obtain high resolution lidar-based snow depth maps for 10 key sub-watersheds in the Wind River Range. The survey was targeted for late May based on local knowledge of snowmelt runoff timing and communication with managers, who noted that the SNOTELs typically melt out around late May, thus causing water management decisions to be made "in the dark." This year, the survey was acquired over multiple aircraft flights on June 1-2, and the ASO team processed and delivered the data by the afternoon of June 5.

One key improvement to the snow depth survey is the inclusion of updated topographic data over persistent snowfields and glaciers, which are rapidly melting and changing elevation. Previously, the ablation of glaciers between 2019 (USGS lidar acquisition) and 2022 (first Wyoming ASO acquisition) caused negative snow depths in most glaciated areas, which were masked to zero or imputed. Thanks to a generous in-kind commitment by ASO to help acquire updated glacier lidar data in October of 2024, this year the snow-off topography was freshly updated and the snow depth measurements on top of the glaciers were meaningful.

Additional information on the ASO survey can be found in the ASO report available from the portal linked above.



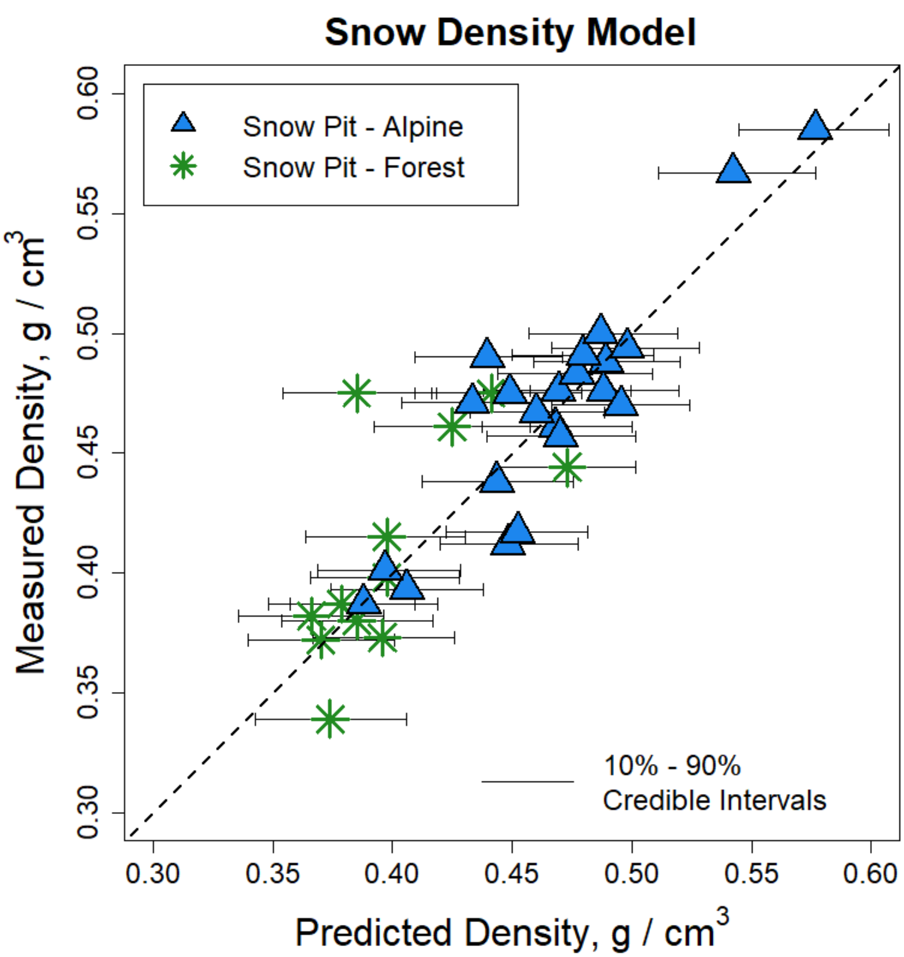

Glacier Ablation (2023 - 2024)

# Snow Density Survey

To estimate how much total water is stored in the snowpack, Mountain Hydrology collaborated with the University of Nevada, Reno, to organize a field crew to measure snow pit density profiles that can be used to constrain density variations across the landscape. The snow pit measurements funded by this project were located on the Shoshone and Bridger-Teton National Forests under special use permits. Fieldwork was conducted between May 24 and June 1, with a total of 6 backcountry fieldwork days (23 person-days).

A total of 36 snow pit profiles were available from the current year (within a few days before the ASO flight). These snow pit data constrain densities from below 9,000 ft. to above 13,000 ft. and from just over 1 ft. of snow depth to more than 19 ft. of snow depth in deep drifts, including several major pits (8-13 ft. deep) at high elevations (11,500-12,600 ft.) and numerous pits in the forest. Observed heterogeneity in bulk (vertically integrated) snow density varied from 0.339 g/cm$^3$ in the shallow forested snowpack to 0.585 g/cm$^3$ in deep drifts at lower elevations.

Using 34 of the 36 snow density measurements (excluding 2 non-representative pits from drift edges), Mountain Hydrology constructed a Bayesian regression model as a function of elevation, snow depth, canopy cover, north slope aspect, and east slope aspect, which explained 77% of total variability and 94% of variability across the 8 snow pits deeper than 2 m. The root-mean-square-error is 0.026 g/cm$^3$, or 6% uncertainty relative to the mean of 0.447 g/cm$^3$. This model was used to infer snow density across the ASO flight domain with the same variables. Multiplying the density map by the depth map produces a spatially complete estimate of snow water equivalent (SWE), as shown on the cover page.



## SWE Map Results

Across the 2,200 $km^2$ (850 $mi^2$) survey domain, the total SWE volume was 355,125 acre-ft. (355 TAF) of liquid water equivalent. The area-averaged mean SWE depth was 20 cm (0.65 ft.). Considering only snow-covered areas, the SWE depth $90^{th}$ percentile was 125 cm (4.1 ft.) and a $99^{th}$ percentile of 261 cm (8.6 ft.) at 3 meter horizontal resolution.

The following table gives estimated SWE volumes and area-averaged SWE depths for each sub-watershed:

| Watershed | Airborne Snow Survey Date | SWE Volume | Mean SWE Depth |
|---|---|---|---|
| **Torrey Creek** | June 1-2, 2025 | 18 TAF | 18 cm (0.60 ft.) |
| **Dinwoody Creek** | June 1-2, 2025 | 39 TAF | 21 cm (0.70 ft.) |
| **Dry Creek** | June 1-2, 2025 | 11 TAF | 9 cm (0.30 ft.) |
| **Meadow Creek** | June 1-2, 2025 | 3 TAF | 3 cm (0.11 ft.) |
| **Willow Creek** | June 1-2, 2025 | 3 TAF | 3 cm (0.08 ft.) |
| **Bull Lake Creek** | June 1-2, 2025 | 77 TAF | 20 cm (0.65 ft.) |
| **N.F. Little Wind R.** | June 1-2, 2025 | 27 TAF | 11 cm (0.37 ft.) |
| **S.F. Little Wind R.** | June 1-2, 2025 | 32 TAF | 17 cm (0.55 ft.) |
| **Upper Green River** | June 1-2, 2025 | 84 TAF (At Roaring Fork confluence) | 26 cm (0.85 ft.) (At Roaring Fork confluence) |
| **Pine Creek** | June 1-2, 2025 | 52 TAF | 33 cm (1.07 ft.) |

Note that the area-averaged SWE depths are affected by the position of stream gages, reservoirs, etc., since a larger low-elevation snow-free area will reduce the apparent mean SWE depth for a given watershed. Thus, the SWE volumes are more indicative of the amount of snow stored in a particular watershed.

Note also that the sum of sub-watershed SWE volumes is less than the total surveyed SWE volume because the total survey area extends slightly beyond the bounds of each watershed.

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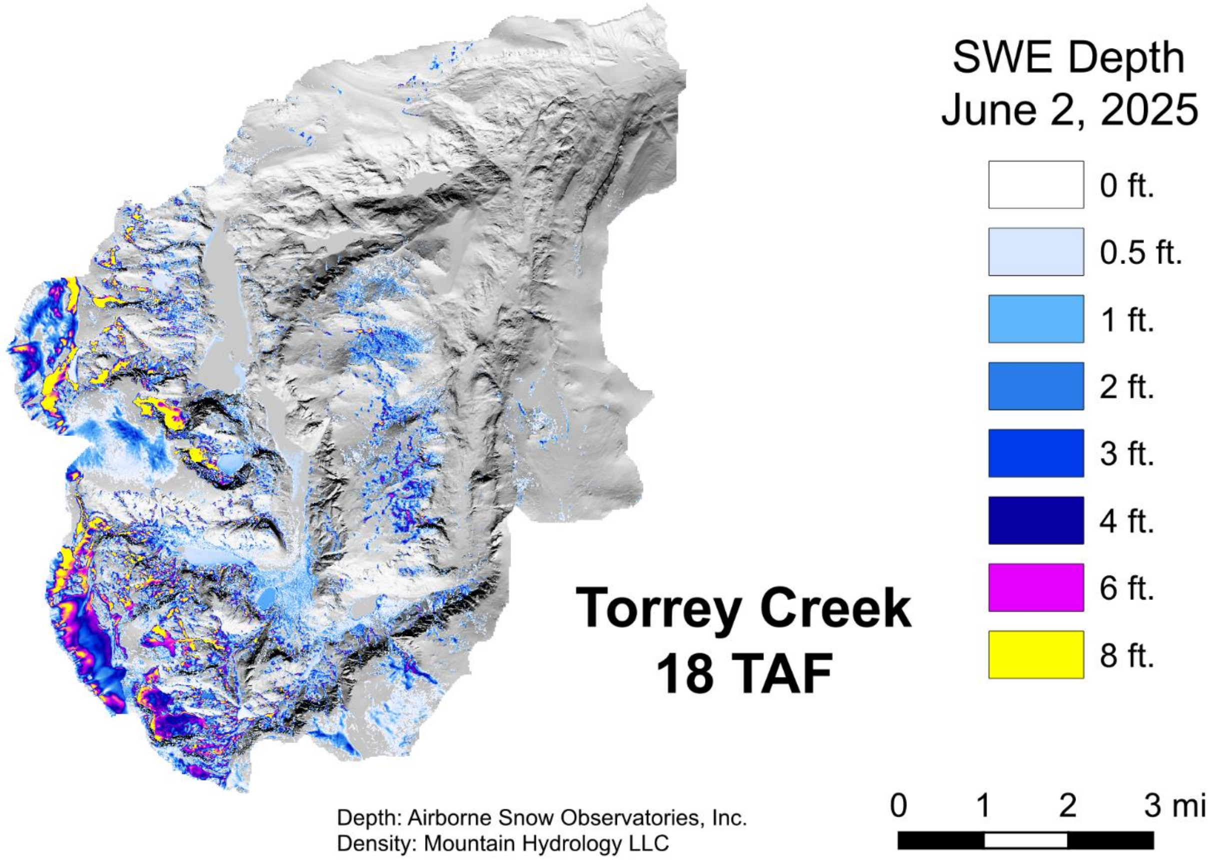
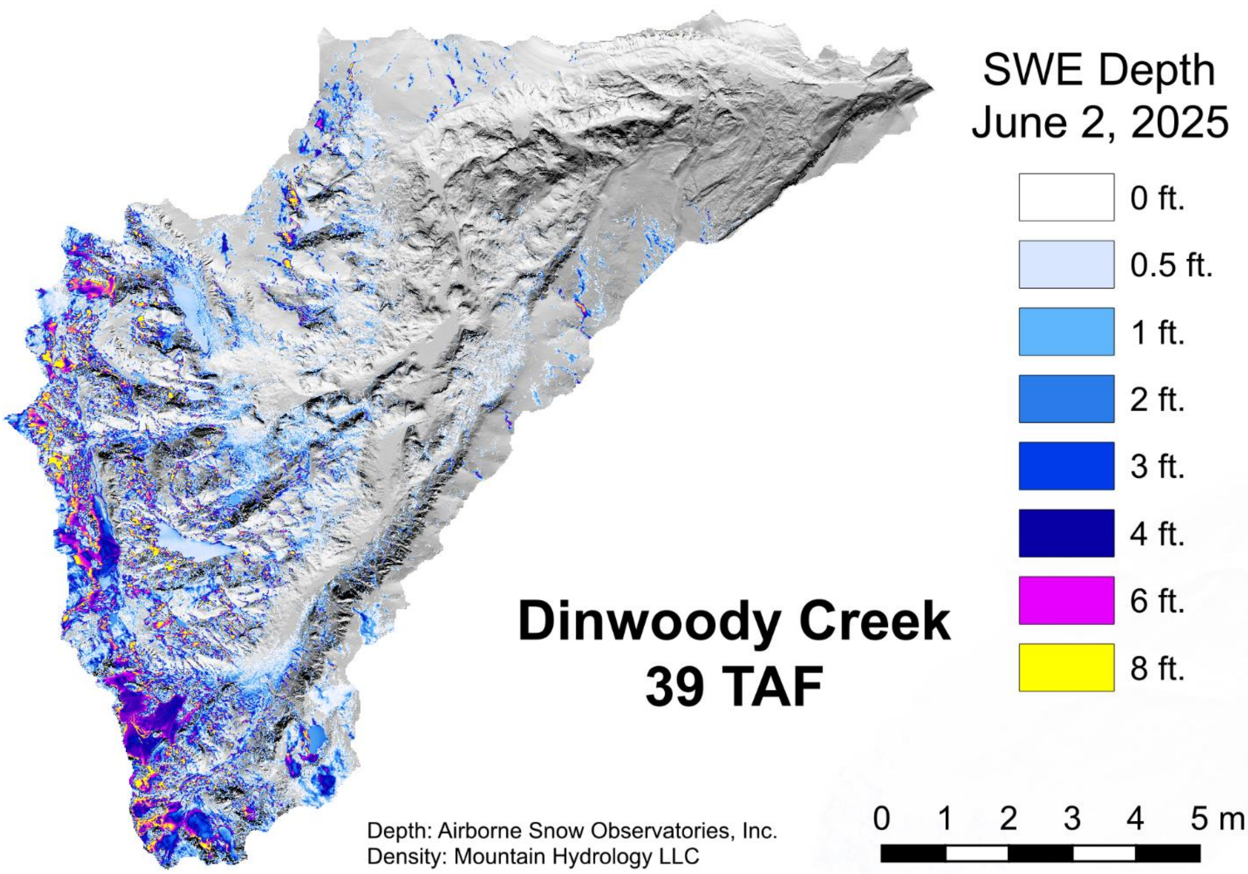
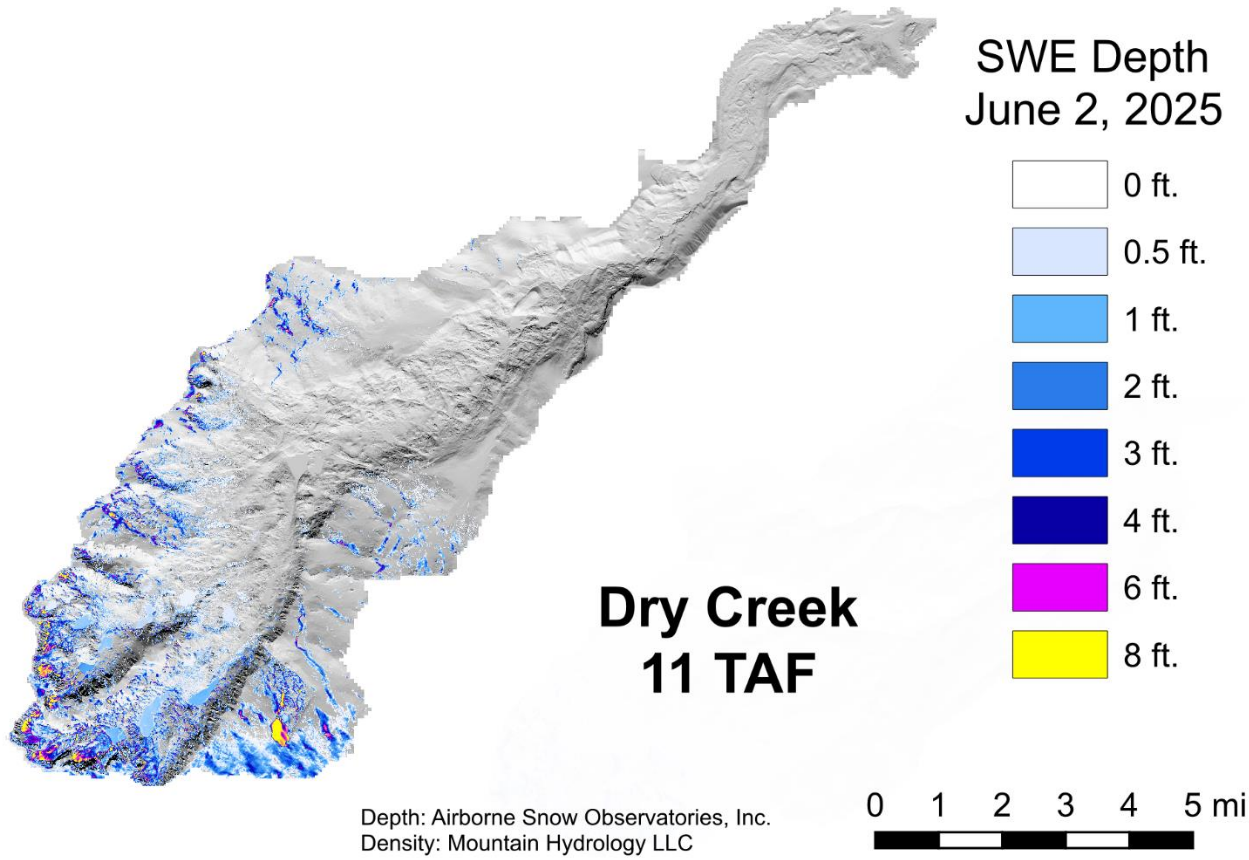
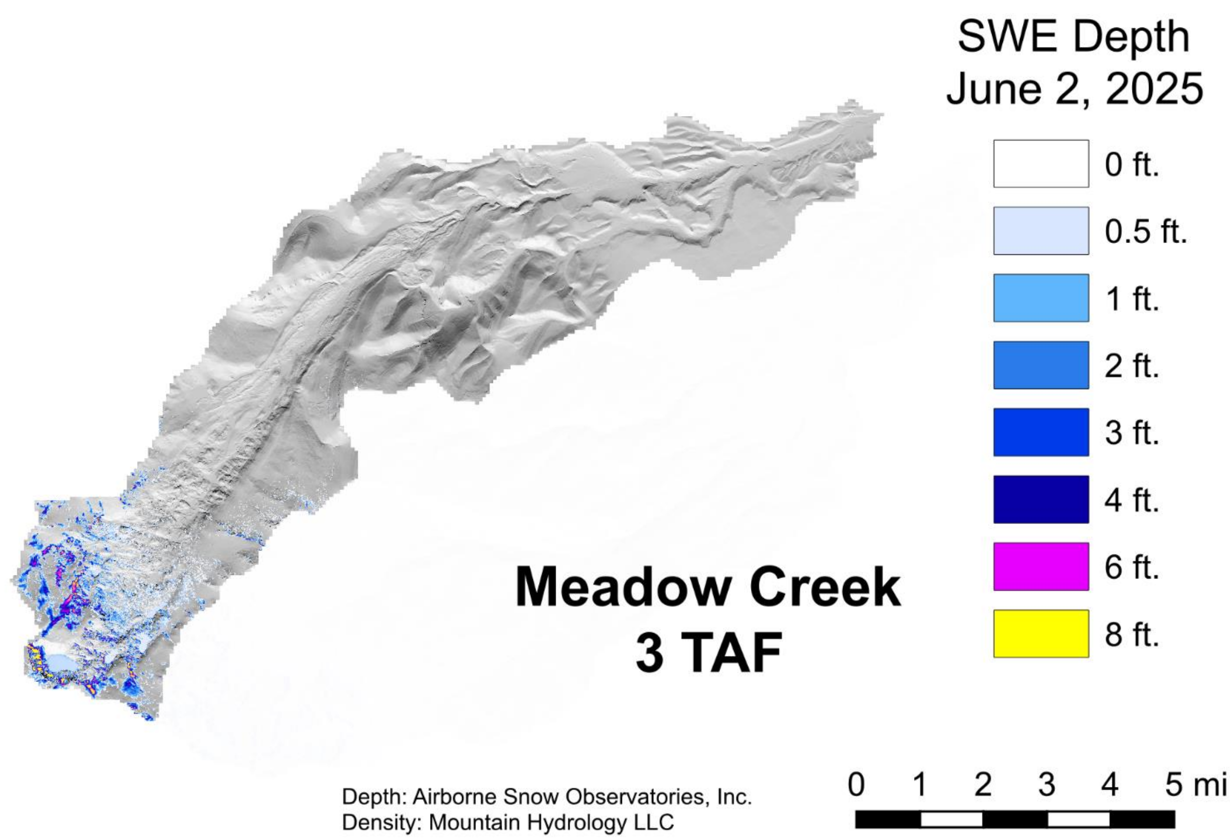



SWE Depth
June 2, 2025
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
Dry Creek
11 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 mi


SWE Depth
June 2, 2025
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
Meadow Creek
3 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 mi

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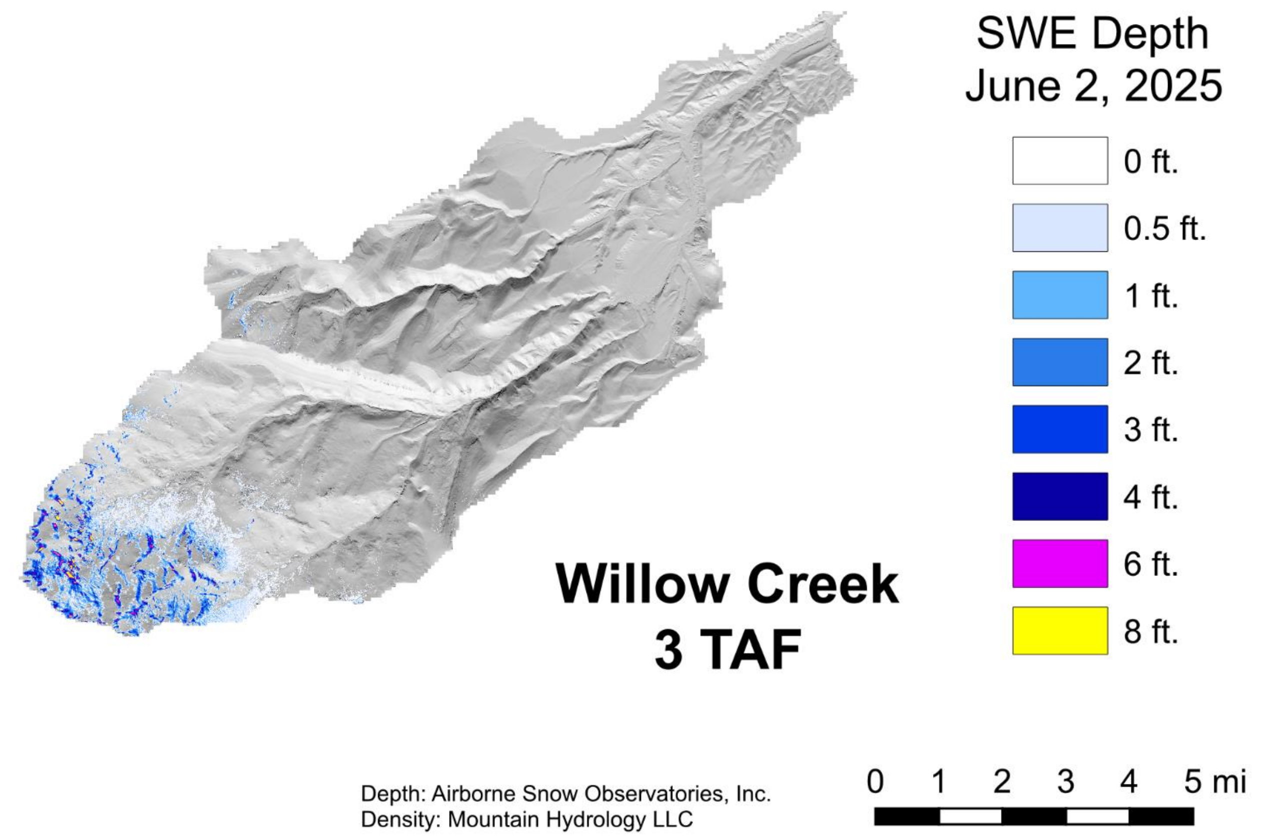
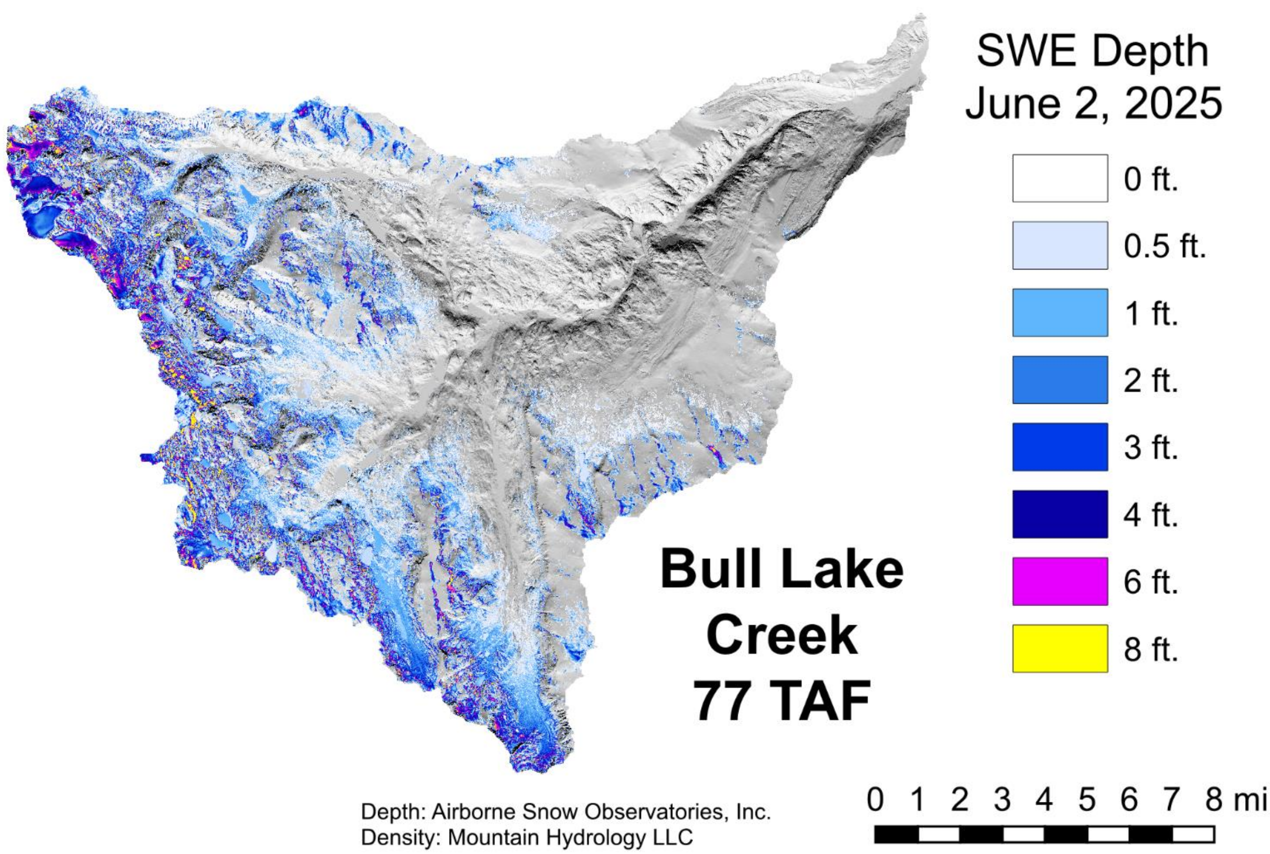
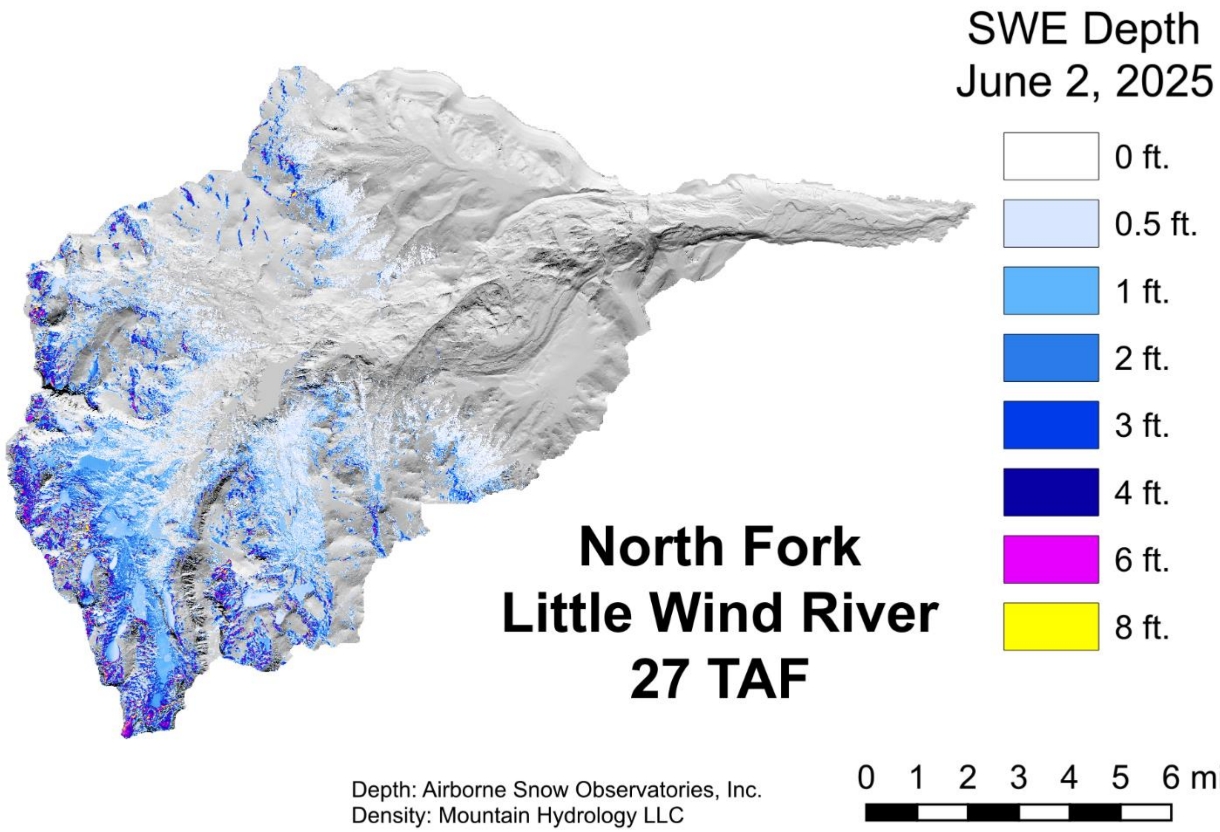
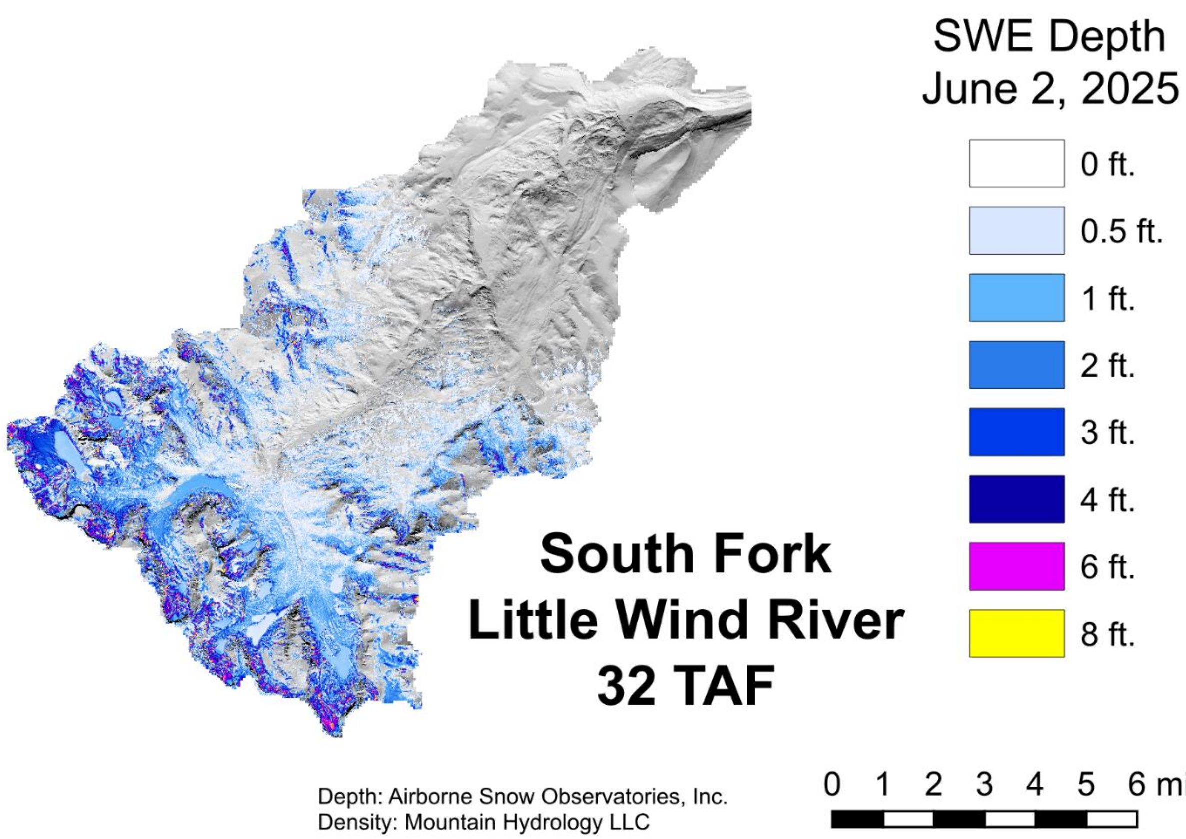
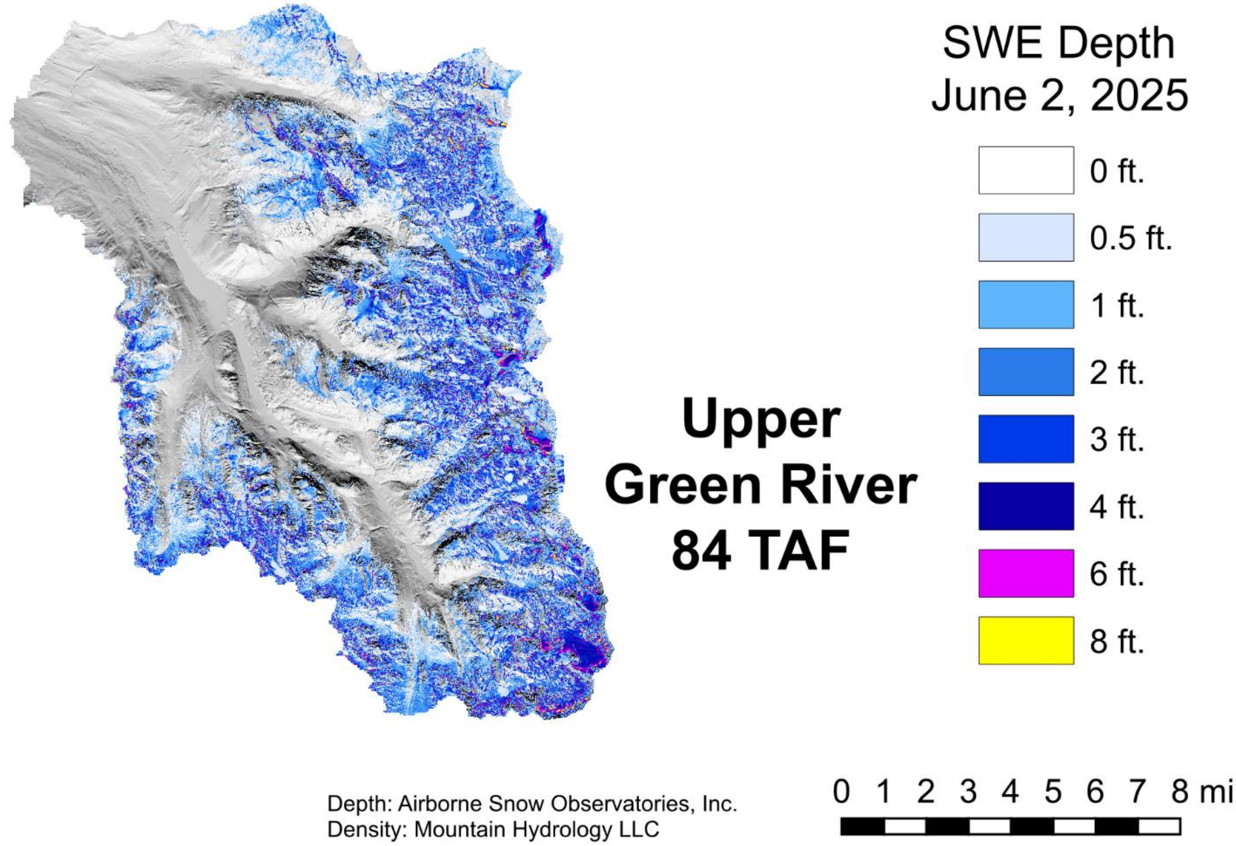
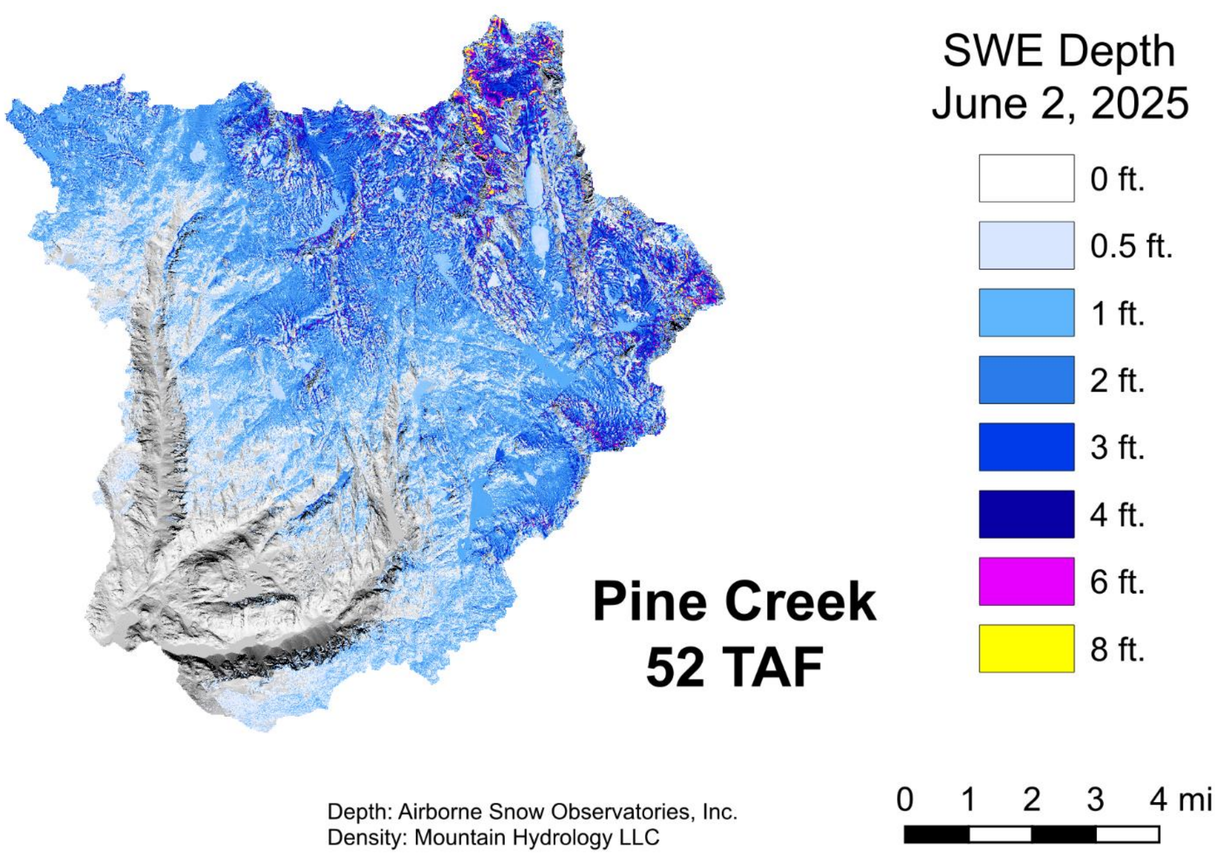



SWE Depth
June 2, 2025
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
North Fork
Little Wind River
27 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 6 mi


SWE Depth
June 2, 2025
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
South Fork
Little Wind River
32 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 6 mi


SWE Depth
June 2, 2025
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
Upper
Green River
84 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 6 7 8 mi


SWE Depth
June 2, 2025
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
Pine Creek
52 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 mi

## DHSVM-WSF Forecast Summary

The 3 meter SWE map captures the snowpack water storage and distribution on a particular date, but additional variables like rain, evapotranspiration, and groundwater are also important for predicting runoff. The SWE data are aggregated to 90 m resolution and assimilated into the DHSVM-WSF hydrological model using a patented process-based assimilation method (cf. Western Snow Conference proceedings, 2024). Water supply forecasts are generated using a Bayesian ensemble of multiple models with 30-day subseasonal weather forecasts and 40 years of historical climatology (refer to DHSVM-WSF white paper for details: https://mountainhydrology.com/mountainhydrology_wp2_dhsvm-wsf/.

**All forecasts listed below are for the June-September forecast period (inclusive), with issue date June 6th, 2024.**

| Watershed | Forecast Point | Airborne Snow Survey Date | Snowpack Water Storage | Runoff: 90% Exceedance | Runoff: 50% Exceedance | Runoff: 10% Exceedance |
|---|---|---|---|---|---|---|
| **Torrey Creek** | Gage (Private) | June 2, 2025 | 18 TAF | 22 TAF | 28 TAF | 34 TAF |
| **Dinwoody Creek** | Gage USGS 06221400 | June 2, 2025 | 39 TAF | 48 TAF | 62 TAF | 77 TAF |
| **Dry Creek** | Canal USGS 06222500 | June 2, 2025 | 11 TAF | 10 TAF | 15 TAF | 20 TAF |
| **Meadow Creek** | Canal USGS 06223000 | June 2, 2025 | 3 TAF | 2.4 TAF | 3.6 TAF | 5.0 TAF |
| **Willow Creek** | Canal USGS 06223500 | June 2, 2025 | 3 TAF | 2.1 TAF | 3.4 TAF | 4.9 TAF |
| **Bull Lake Creek** | Reservoir USGS 06224000 | June 2, 2025 | 77 TAF | 94 TAF | 115 TAF | 138 TAF |
| **N.F. Little Wind R.** | Gage USGS 06228800 | June 2, 2025 | 27 TAF | 32 TAF | 42 TAF | 53 TAF |
| **S.F. Little Wind R.** | Reservoir USGS 06228350 | June 2, 2025 | 32 TAF | 33 TAF | 45 TAF | 58 TAF |
| **Upper Green River** | Gage USGS 09188500 | June 2, 2025 | 84 TAF (At Roaring Fork confluence) | 106 TAF (At Gage) | 130 TAF (At Gage) | 157 TAF (At Gage) |
| **Pine Creek** | Gage USGS 09196500 | June 2, 2025 | 52 TAF | 61 TAF | 73 TAF | 87 TAF |

An exceedance probability of X% indicates that on average over many years, there is roughly an X% chance that the actual volumetric water supply in any particular year will be larger than the forecast exceedance value.

## DHSVM-WSF Forecasts: Historical Comparison

For contextual interpretation, current forecasts for several key watersheds are shown here in a relative ranking with the most recent decade of observed runoff volumes:

| Dinwoody Creek | | |
|---|---|---|
| **Water Year** | **Water Yield (June – September)** | **Value Type** |
| 2025 | 48 | Forecast – 90% Exceedance |
| 2025 | 62 | Forecast – 50% Exceedance |
| 2024 | 70 | Historical |
| 2021 | 72 | Historical |
| 2016 | 73 | Historical |
| 2025 | 77 | Forecast – 10% Exceedance |
| 2022 | 81 | Historical |
| 2018 | 84 | Historical |
| 2015 | 85 | Historical |
| 2020 | 87 | Historical |
| 2019 | 90 | Historical |
| 2023 | 93 | Historical |
| 2017 | 126 | Historical |

| Bull Lake Creek | | |
|---|---|---|
| **Water Year** | **Water Yield (June – September)** | **Value Type** |
| 2025 | 94 | Forecast – 90% Exceedance |
| 2025 | 115 | Forecast – 50% Exceedance |
| 2021 | 120 | Historical |
| 2020 | 125 | Historical |
| 2016 | 127 | Historical |
| 2024 | 130 | Historical |
| 2015 | 133 | Historical |
| 2025 | 138 | Forecast – 10% Exceedance |
| 2022 | 146 | Historical |
| 2018 | 157 | Historical |
| 2019 | 172 | Historical |
| 2023 | 182 | Historical |
| 2017 | 285 | Historical |

## DHSVM-WSF Forecasts: Historical Comparison

| South Fork Little Wind River | | |
|---|---|---|
| **Water Year** | **Water Yield (June – September)** | **Value Type** |
| 2025 | 33 TAF | Forecast – 90% Exceedance |
| 2020 | 39 TAF | Historical |
| 2021 | 44 TAF | Historical |
| 2025 | 45 TAF | Forecast – 50% Exceedance |
| 2015 | 49 TAF | Historical |
| 2024 | 57 TAF | Historical |
| 2018 | 58 TAF | Historical |
| 2025 | 58 TAF | Forecast – 10% Exceedance |
| 2022 | 59 TAF | Historical |
| 2016 | 65 TAF | Historical |
| 2023 | 78 TAF | Historical |
| 2019 | 79 TAF | Historical |
| 2017 | 129 TAF | Historical |

| Upper Green River | | |
|---|---|---|
| **Water Year** | **Water Yield (June – September)** | **Value Type** |
| 2025 | 106 | Forecast – 90% Exceedance |
| 2025 | 130 | Forecast – 50% Exceedance |
| 2021 | 146 | Historical |
| 2016 | 155 | Historical |
| 2025 | 157 | Forecast – 10% Exceedance |
| 2024 | 170 | Historical |
| 2015 | 180 | Historical |
| 2022 | 185 | Historical |
| 2020 | 208 | Historical |
| 2023 | 218 | Historical |
| 2019 | 224 | Historical |
| 2018 | 248 | Historical |
| 2017 | 414 | Historical |

## DHSVM-WSF Forecasts: Monthly

Runoff timing is more uncertain than total runoff volume, but monthly values are given here for key watersheds:

| Watershed | Month | Runoff: 90% Exceedance | Runoff: 50% Exceedance | Runoff: 10% Exceedance |
|---|---|---|---|---|
| **Dinwoody Creek** | June | 17 TAF | 23 TAF | 28 TAF |
| **Dinwoody Creek** | July | 13 TAF | 18 TAF | 24 TAF |
| **Dinwoody Creek** | August | 10 TAF | 14 TAF | 19 TAF |
| **Dinwoody Creek** | September | 5 TAF | 7 TAF | 10 TAF |

| Watershed | Month | Runoff: 90% Exceedance | Runoff: 50% Exceedance | Runoff: 10% Exceedance |
|---|---|---|---|---|
| **Bull Lake Creek** | June | 50 TAF | 61 TAF | 74 TAF |
| **Bull Lake Creek** | July | 21 TAF | 28 TAF | 35 TAF |
| **Bull Lake Creek** | August | 12 TAF | 17 TAF | 22 TAF |
| **Bull Lake Creek** | September | 6 TAF | 9 TAF | 14 TAF |

| Watershed | Month | Runoff: 90% Exceedance | Runoff: 50% Exceedance | Runoff: 10% Exceedance |
|---|---|---|---|---|
| **South Fork Little Wind River** | June | 22 TAF | 30 TAF | 39 TAF |
| **South Fork Little Wind River** | July | 6 TAF | 9 TAF | 12 TAF |
| **South Fork Little Wind River** | August | 2 TAF | 3 TAF | 5 TAF |
| **South Fork Little Wind River** | September | 2 TAF | 3 TAF | 4 TAF |

| Watershed | Month | Runoff: 90% Exceedance | Runoff: 50% Exceedance | Runoff: 10% Exceedance |
|---|---|---|---|---|
| **Upper Green River** | June | 61 TAF | 74 TAF | 89 TAF |
| **Upper Green River** | July | 21 TAF | 27 TAF | 36 TAF |
| **Upper Green River** | August | 12 TAF | 16 TAF | 23 TAF |
| **Upper Green River** | September | 8 TAF | 12 TAF | 16 TAF |

## Snowpack Analysis

Overall, there is much less snow storage in the Wind River Range compared to the same time last year. Compared to the May 31, 2024, survey, the June 1-2, 2025 survey has:

- 42% less snow storage in the Bull Lake Creek watershed
- 54% less snow storage in the Little Wind River watersheds
- 38% less snow storage in the Green River headwaters

In other words, there is roughly **half** as much snow stored in the mountains compared to the same timeframe last year. For reference, last year's report can be downloaded here:
https://mountainhydrology.com/snowwatersupplyforecastreport_windriverrange_2024-june/

Summer (June-September) precipitation can vary from approximately 5-20 cm (2-8 inches) of rain across the mountains, which is the same order of magnitude as the area-average snow storage at the start of June this year (20 cm / 8 inches). Thus, uncertainty in the summer precipitation contributes to substantial fractional uncertainty in the total runoff, since future precipitation could be anywhere from 20% to 50% of the total water balance input.

**What to watch:** summer precipitation trends and subseasonal weather forecasts should help reduce the impact of future precipitation on runoff volume uncertainty over the next 1-2 months. Summer precipitation will have outsized importance for determining total runoff, since this year's snowpack arguably qualifies as a "snow drought."

## Forecast Comparison

Operational statistical forecasts are issued by the Natural Resources Conservation Service (NRCS), which are useful for comparison with the physically based DHSVM-WSF forecasts with snow data assimilation provided in this report.

Considering only the June-July forecast period, the NRCS June 1 issue date forecasts indicate the following volumes at standard 90 / 50 / 10% exceedance probability levels:

- 39 / 46 / 53 for Dinwoody Creek, compared to 32 / 41 / 50 TAF from DHSVM-WSF (this report)
- 70 / 87 / 106 for Bull Lake Creek, compared to 74 / 89 / 106 TAF from DHSVM-WSF (this report)
- 119 / 150 / 180 for the Upper Green River, compared to 84 / 101 / 121 TAF from DHSVM-WSF (this report)
- 48 / 63 / 79 TAF for Pine Creek, compared to 53 / 64 / 76 TAF from DHSVM-WSF (this report)

Overall, the NRCS forecasts show a similar range of likely below-normal conditions for key watersheds, with particularly similar values in Dinwoody, Bull Lake, and Pine Creek. However, the NRCS forecast is much higher (+42% to +49%) in the Upper Green River. This could be a result of snow drought conditions that are not adequately reflected in low-elevation monitoring station data. As such, the physically based snow data assimilation forecast system deployed here indicates a potentially underappreciated risk of significant drought conditions in the Green River headwaters.

## DHSVM-WSF Comparison to Empirical Estimates

Finally, a back-of-the-envelope empirical forecast can be derived by calculating either the difference or ratio of runoff in 2024 relative to the 2024 SWE map, and extrapolating these relationships (from last year) to the current year.

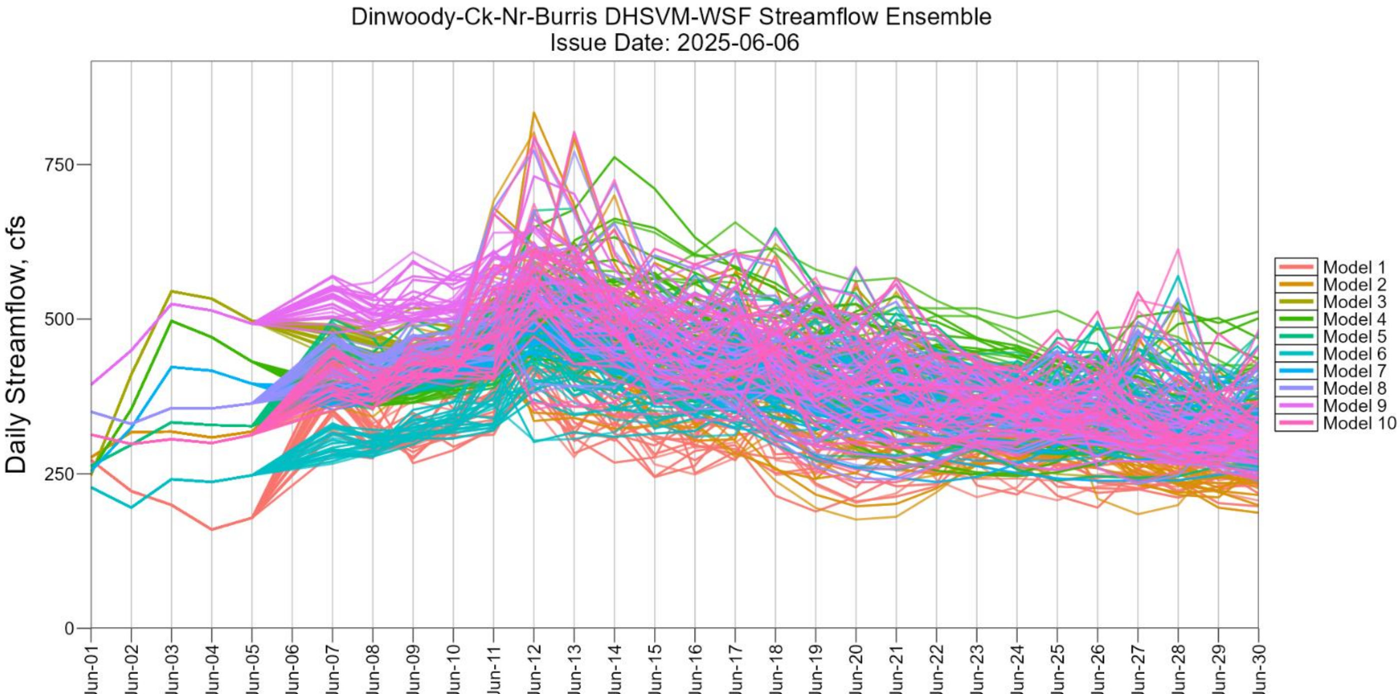
The table below compares different back-of-the-envelope scenarios for the relationship between snow water equivalent (SWE) and cumulative runoff (Q) for the June-September period.

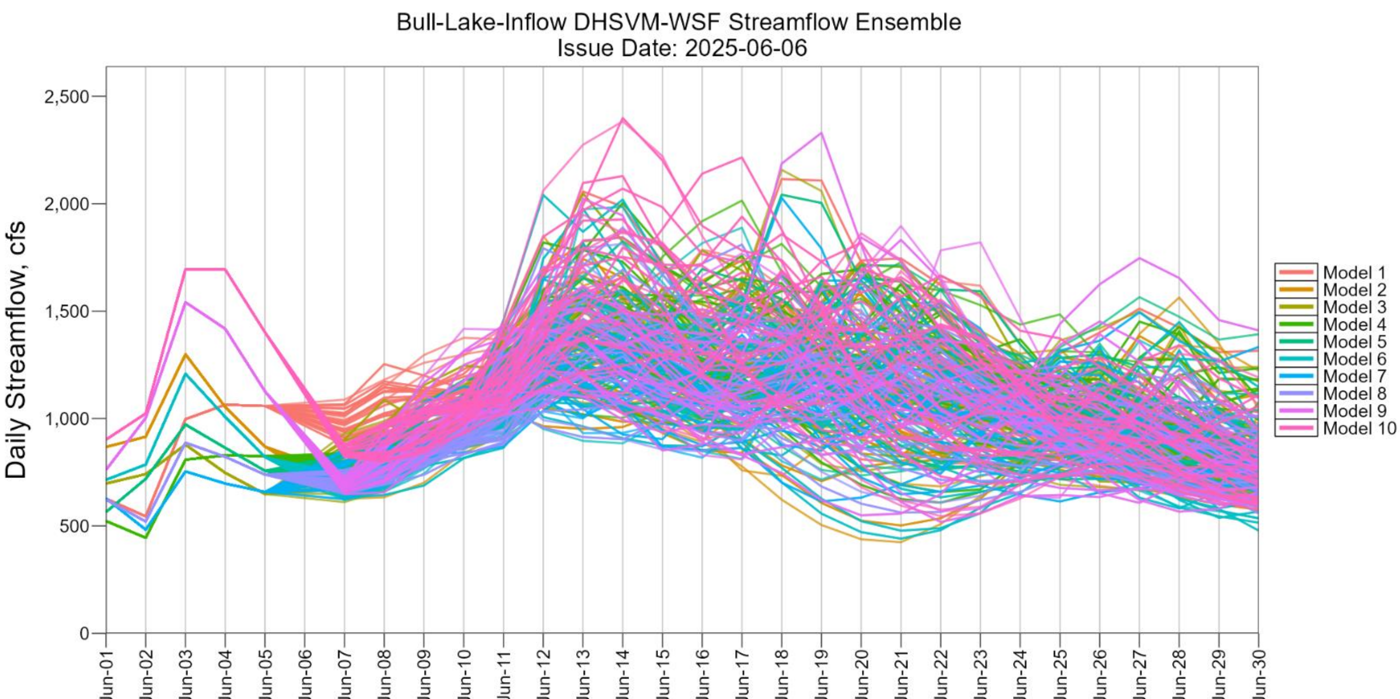
**Important:** these back-of-the-envelope metrics do not account for variable weather! The 2024 summer was remarkably dry, with very little precipitation. Thus, the DHSVM-WSF forecast medians are considerably higher than the simple Q vs. SWE relationships, because historical climatology shows that summer precipitation is likely to contribute a substantial fraction of the total runoff.

| Watershed | SWE Volume: May 31, 2024 | SWE Volume: June 2, 2025 | Relation 1: Q / SWE, 2024 | Relation 2: Q – SWE, 2024 | Relation 1: Q pred. 2025 | Relation 2: Q pred. 2025 | DHSVM-WSF Median Q pred. 2025 |
|---|---|---|---|---|---|---|---|
| **Torrey Creek** | 29 TAF | 18 TAF | 1.0 | 1 TAF | 18 TAF | 19 TAF | 28 TAF |
| **Dinwoody Creek** | 63 TAF | 39 TAF | 1.1 | 7 TAF | 43 TAF | 46 TAF | 62 TAF |
| **Dry Creek** | 22 TAF | 11 TAF | Q Not Meas. | Q Not Meas. | - | - | 15 TAF |
| **Meadow Creek** | 7 TAF | 3 TAF | Q Not Meas. | Q Not Meas. | - | - | 3.6 TAF |
| **Willow Creek** | 9 TAF | 3 TAF | Q Not Meas. | Q Not Meas. | - | - | 3.4 TAF |
| **Bull Lake Creek** | 133 TAF | 77 TAF | 0.98 | -3 TAF | 75 TAF | 74 TAF | 115 TAF |
| **N.F. Little Wind R.** | 64 TAF | 27 TAF | Q Not Meas. | Q Not Meas. | - | - | 42 TAF |
| **S.F. Little Wind R.** | 65 TAF | 32 TAF | 0.88 | -8 TAF | 28 TAF | 24 TAF | 45 TAF |
| **Upper Green River** | 135 TAF (At Roaring Fork confluence) | 84 TAF (At Roaring Fork confluence) | 1.26 (At Gage) | 35 TAF (At Gage) | 106 TAF (At Gage) | 119 TAF (At Gage) | 130 TAF (At Gage) |
| **Pine Creek** | 76 TAF | 52 TAF | 0.94 | -5 TAF | 49 TAF | 47 TAF | 73 TAF |

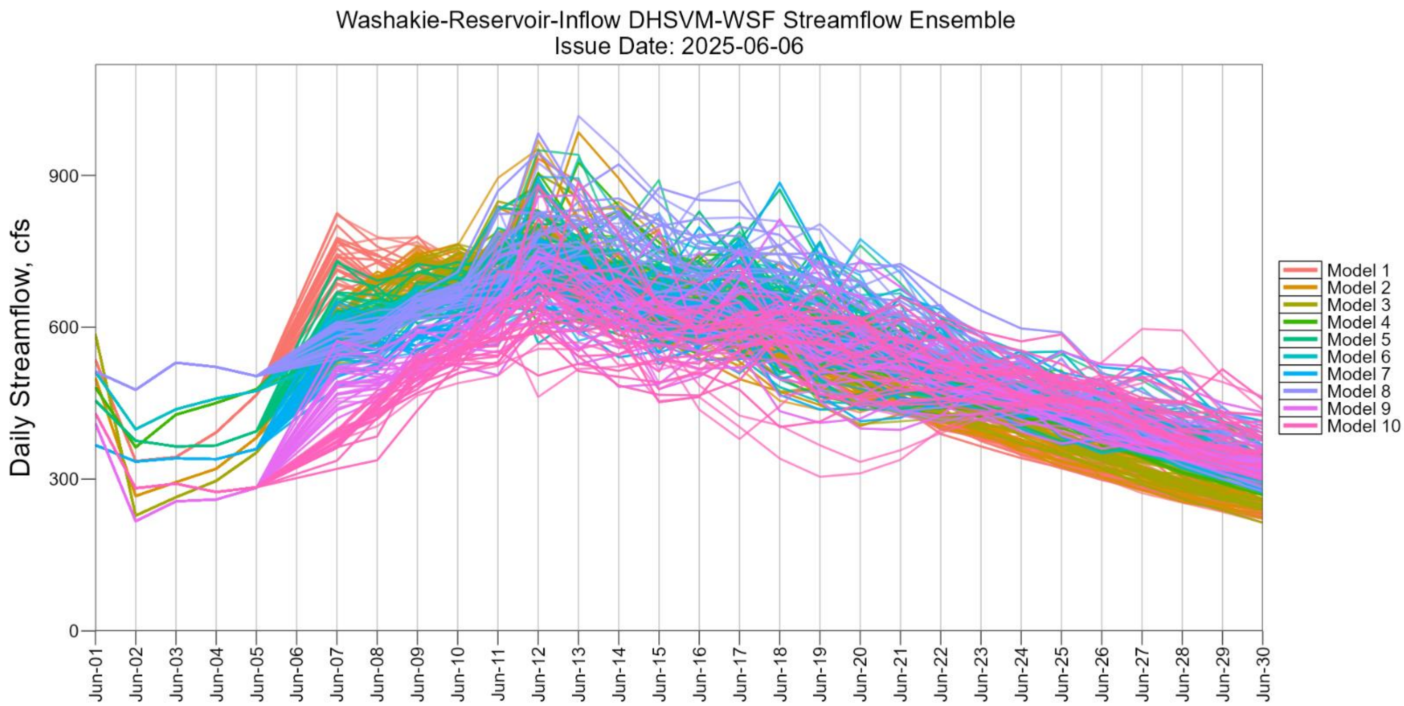
# DHSVM-WSF Peak Flows

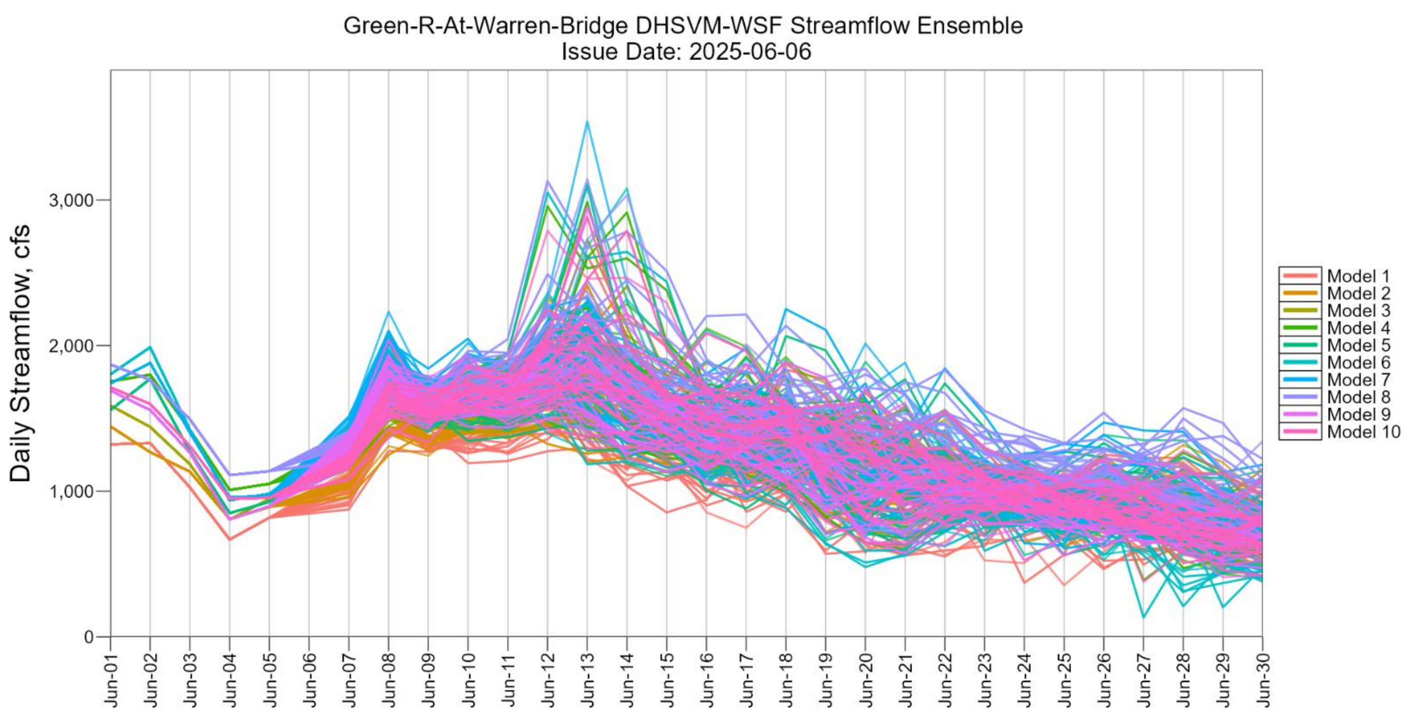
The low snowpack storage and abnormally warm late-May conditions have already led to elevated flows, and some watersheds may have already reached peak flow, while for other watersheds, the peak flow is expected in the next 1-2 weeks. The following plots summarize projected daily streamflow for key sub-watersheds. Note that streamflow magnitude and timing on a daily timestep is much more uncertain than seasonal cumulative volumes, and these projections are subject to change based on updated weather forecasts.



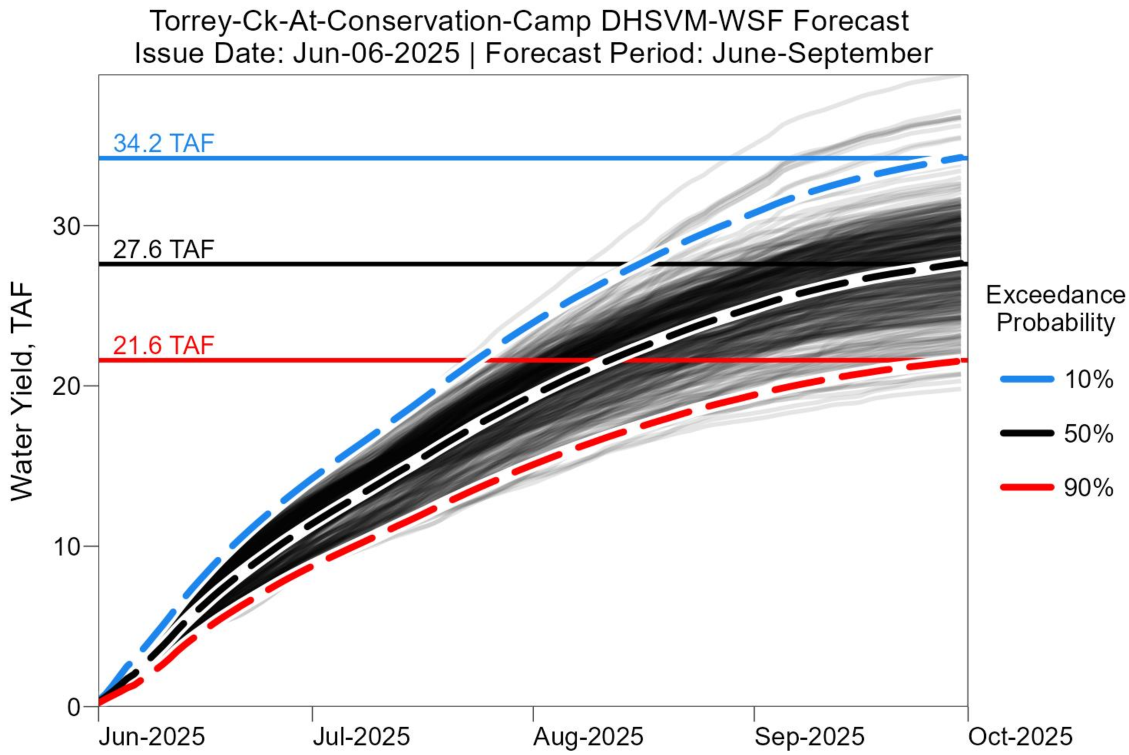



## DHSVM-WSF Peak Flows

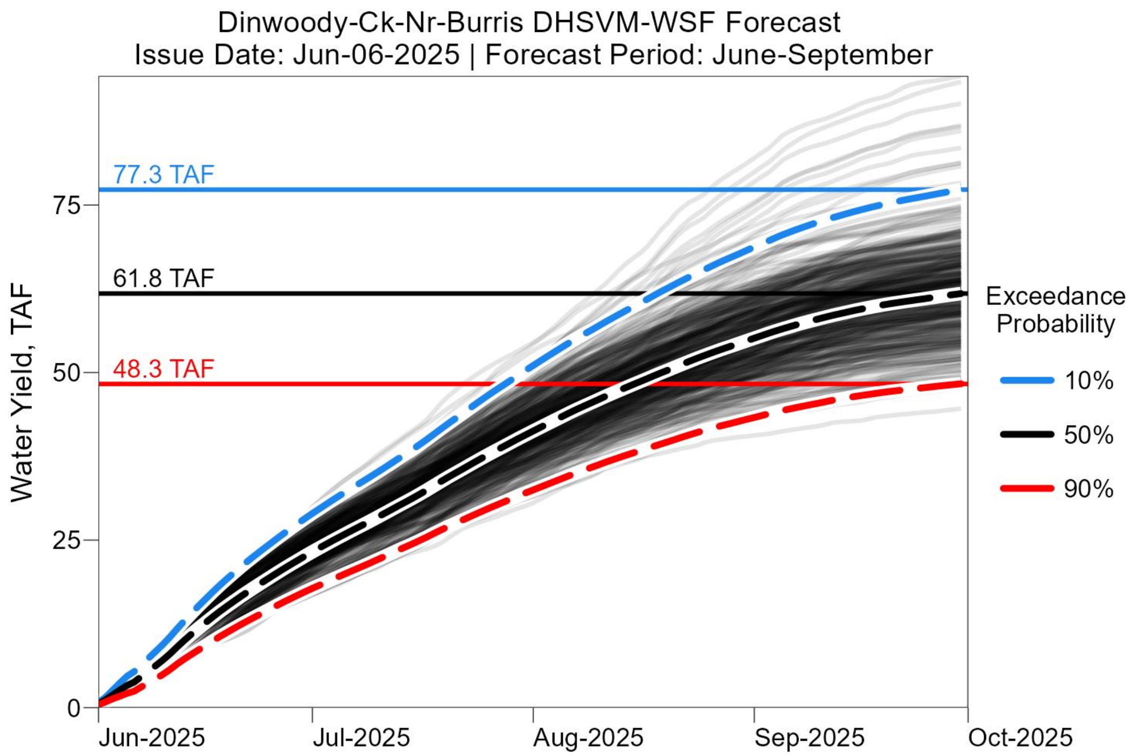


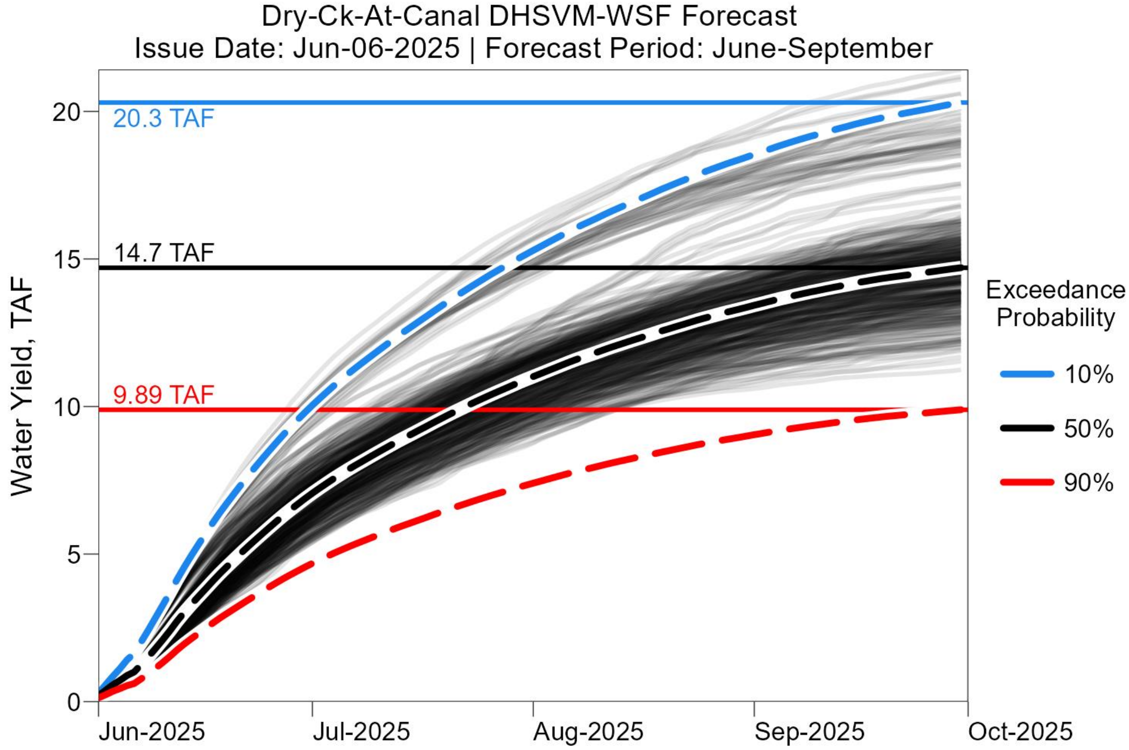
## DHSVM-WSF Forecast: Torrey Creek



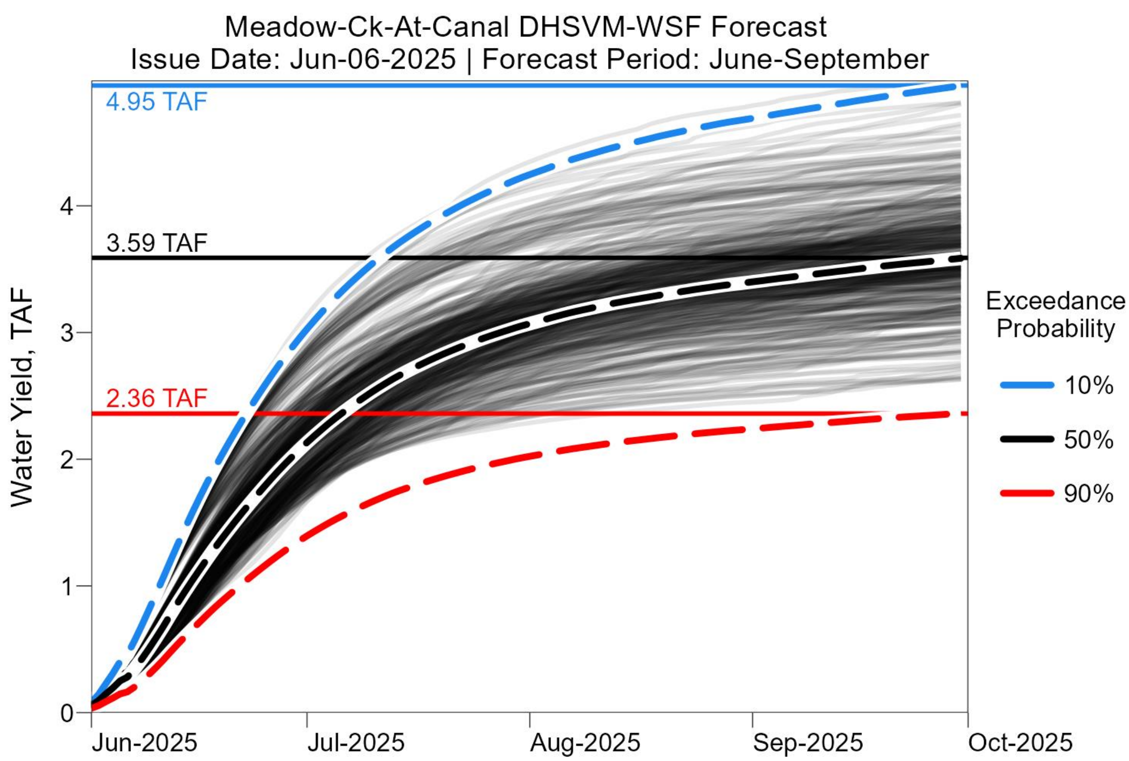

## DHSVM-WSF Forecast: Dinwoody Creek



## DHSVM-WSF Forecast: Dry Creek




## DHSVM-WSF Forecast: Meadow Creek



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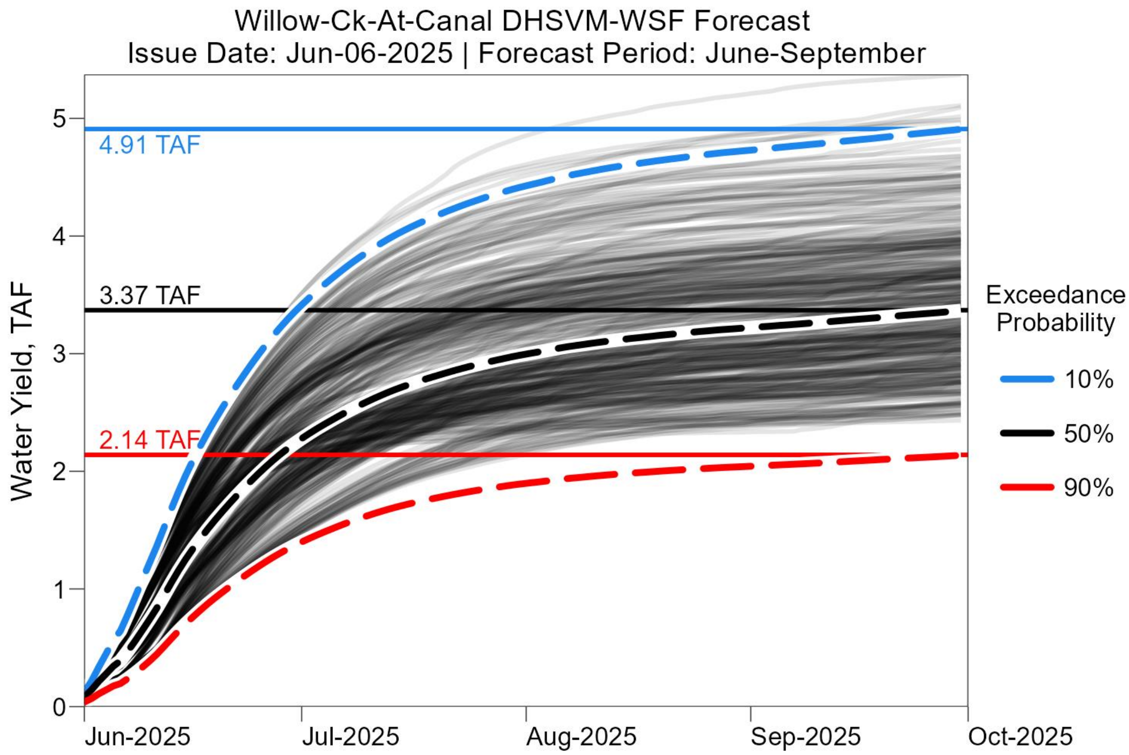
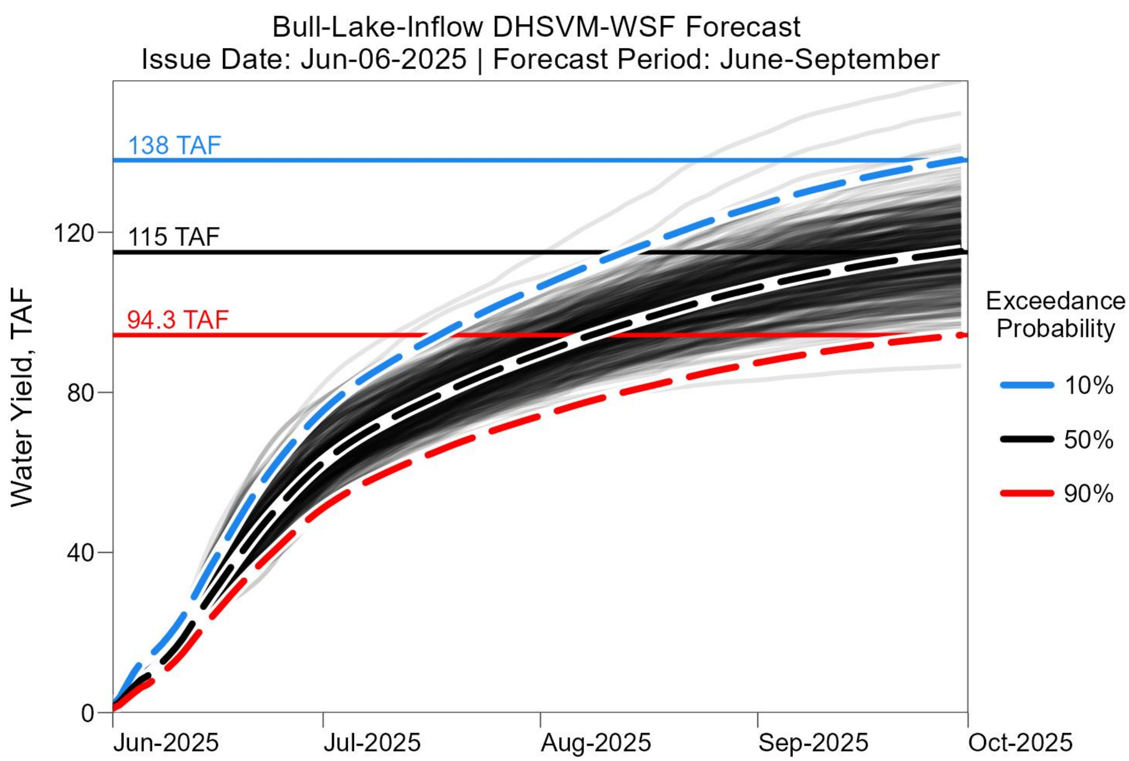
## DHSVM-WSF Forecast: Willow Creek




## DHSVM-WSF Forecast: Bull Lake Creek



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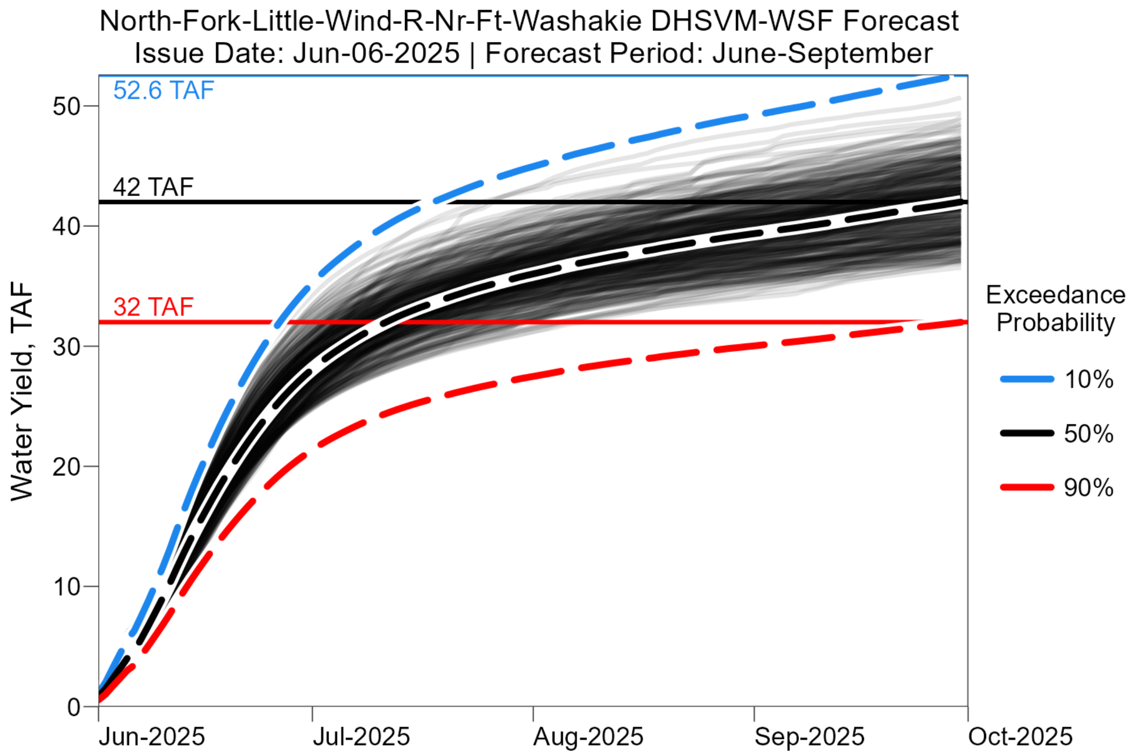
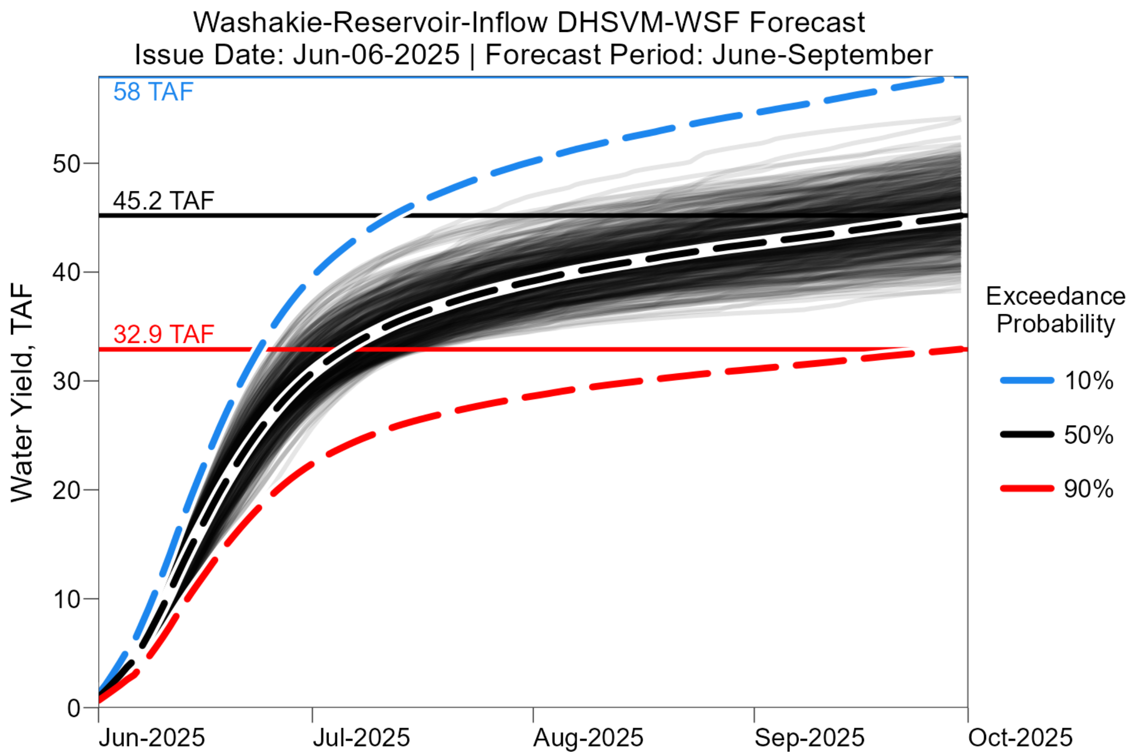
## DHSVM-WSF Forecast: North Fork Little Wind River




## DHSVM-WSF Forecast: South Fork Little Wind River



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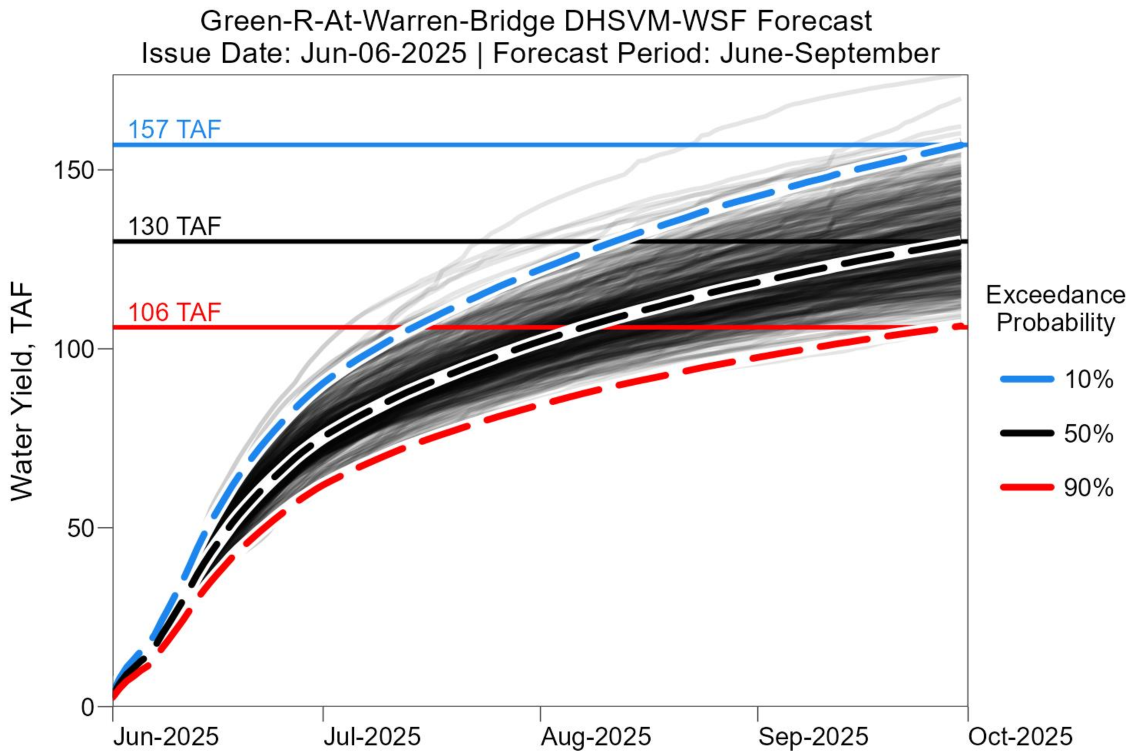
## DHSVM-WSF Forecast: Upper Green River




## DHSVM-WSF Forecast: Pine Creek