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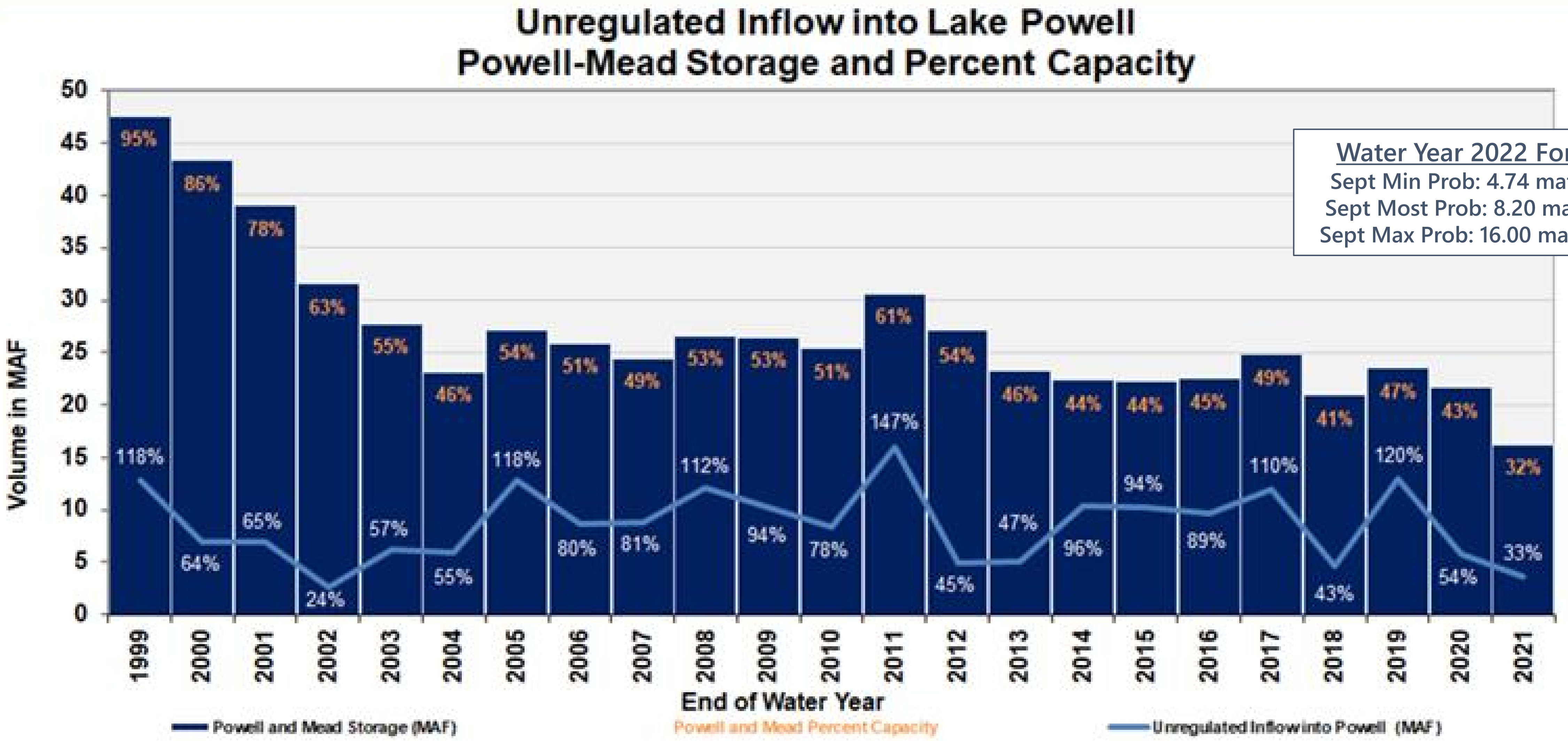
Long-Term Hydrologic Projections for the Colorado River Basin and Methods for Considering Uncertainty

GCD Adaptive Management Plan
October 13, 2021

James Prairie, PhD, Upper Colorado Basin Region

State of the System (Water Years 1999-2021)[1,2]



Water Year 2022 Forecast
Sept Min Prob: 4.74 maf (44%)
Sept Most Prob: 8.20 maf (76%)
Sept Max Prob: 16.00 maf (148%)

[1] Values for Water Year 2021 are projected. Unregulated inflow is based on the latest CBRFC forecast dated Septemer 16, 2021. Storage and percent capacity are based on the September 2021 24-Month Study.

[2] Percentages on the light blue line represent percent of average unregulated inflow into Lake Powell for a given water year. The percent of average is based on the period of record from 1981-2010.

Current Drought in a Historical Context

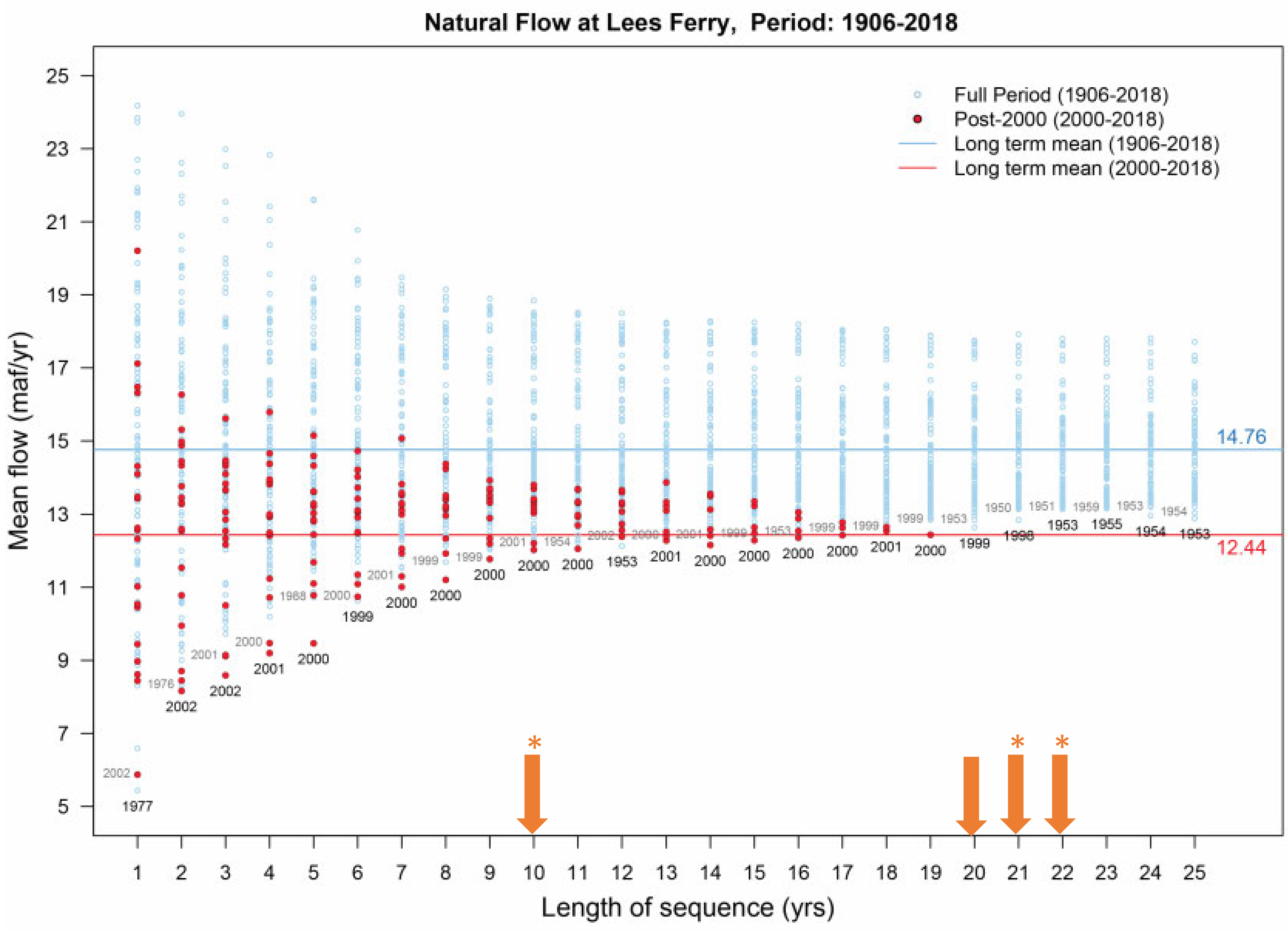


Figure 12 Sequence Average plot from Salehabadi, et al (2020) "The Future Hydrology of the Colorado River Basin" https://qcnr.usu.edu/coloradoriver/files/WhitePaper4.pdf

*based on August 2021 provisional natural flow calculations for 2020 & 2021 https://www.usbr.gov/lc/region/g4000/NaturalFlow/provisional.html

5-Year Probabilistic Projections and Beyond

Precipitation Variability

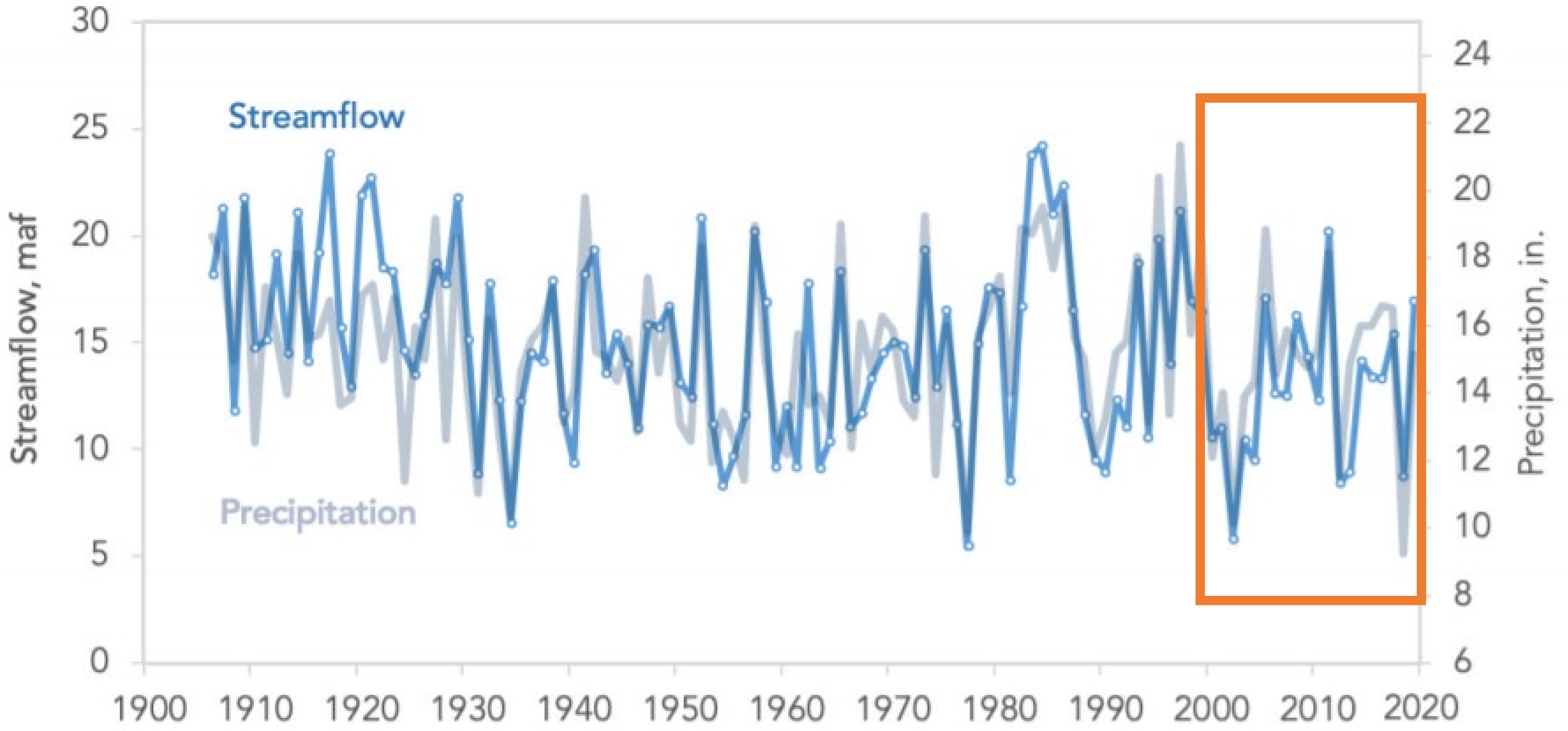
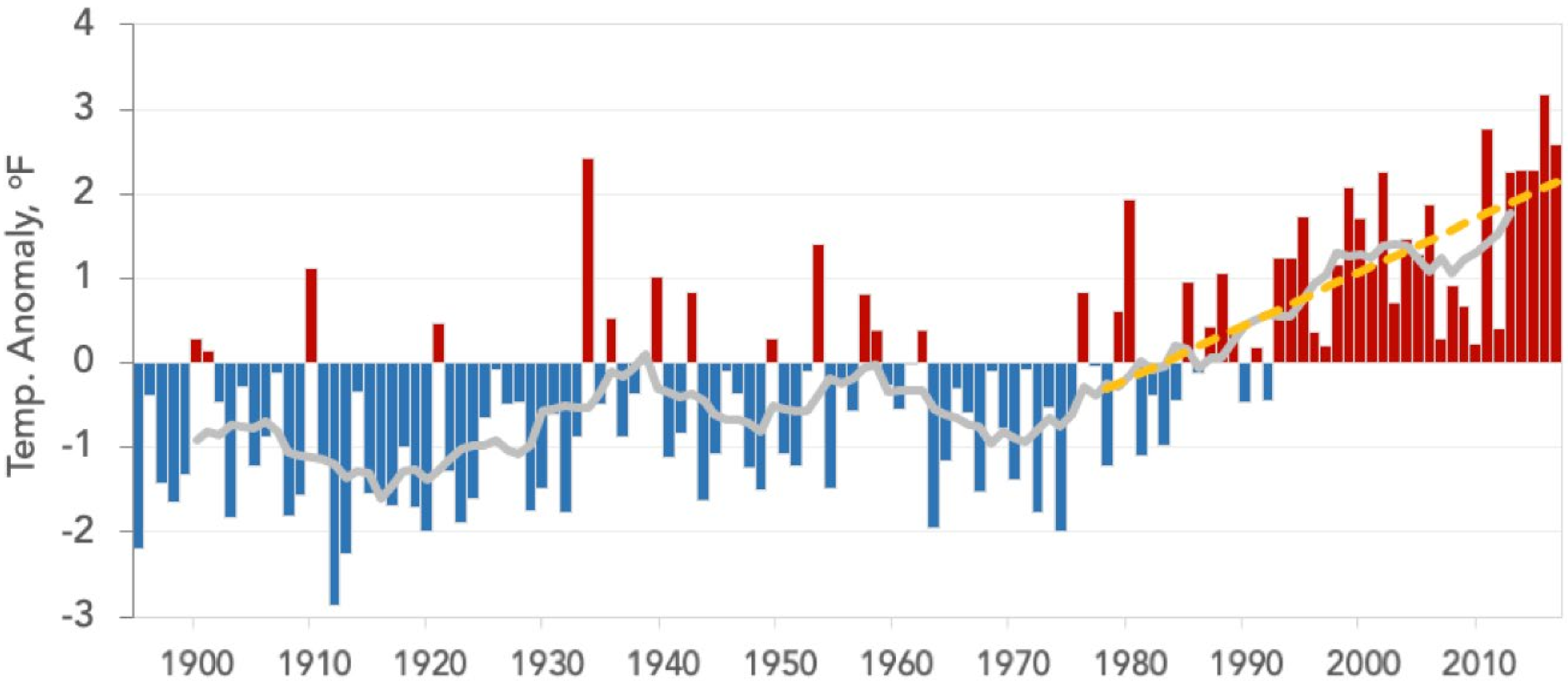


Figure 2.6: Upper Basin water-year precipitation compared with Colorado River at Lees Ferry water-year natural streamflow, 1906–2019. The correlation between the two time-series is 0.77 (R2 = 0.61) over the entire record, with higher correlations over more recent periods. (Data: precipitation, NOAA NCEI; streamflow, Reclamation)

"… the average annual precipitation over the past 20 years (2000–2019) does not stand out relative to periods of the same length earlier in the observed record." Ch.2 p.75 SoS Report

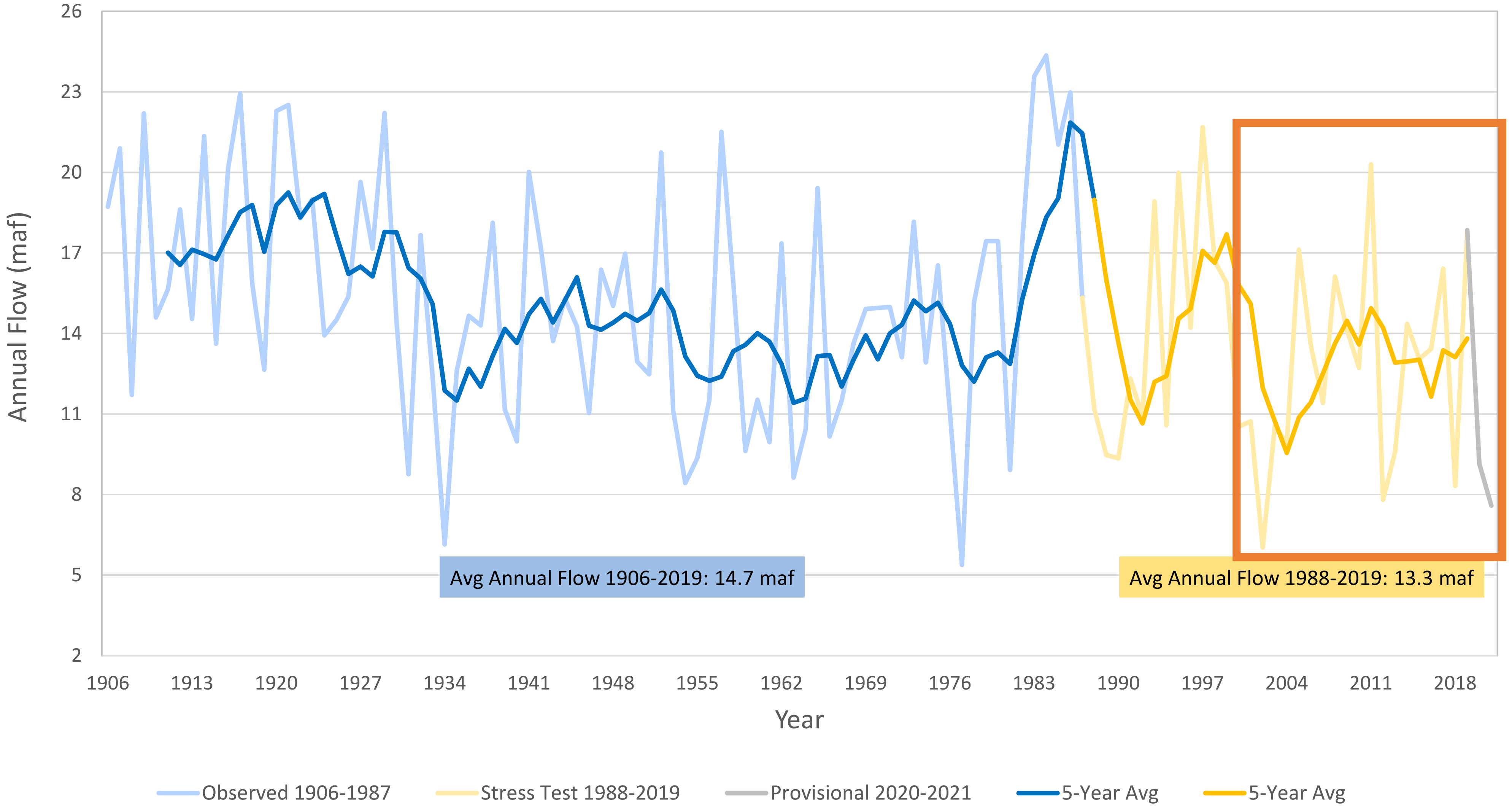
Figure taken from ***Colorado River Basin Climate and Hydrology—State of the Science Report:*** https://wwa.colorado.edu/publications/reports/CRBreport/ColoRiver_StateOfScience_WWA_2020_Chapter_2.pdf

Increasing Temperature Trend



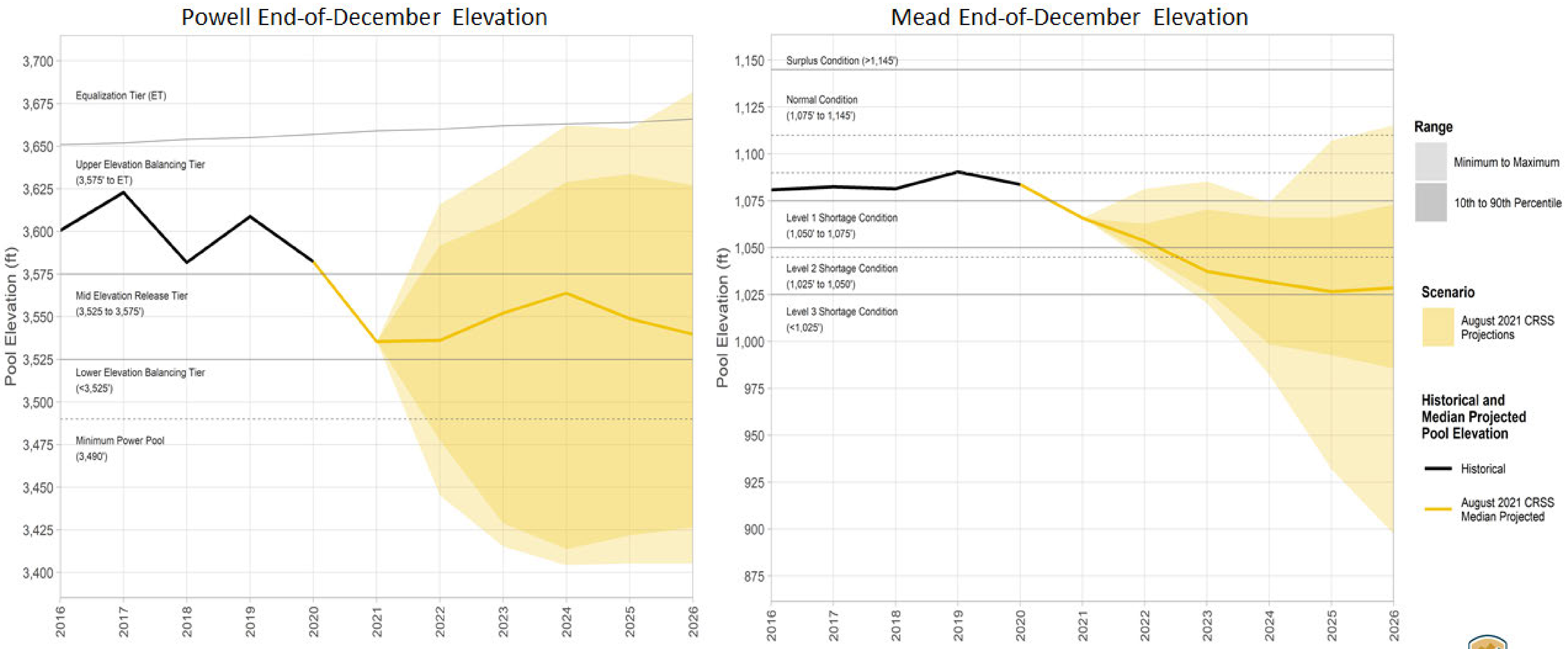
Annually-averaged temperature for the Colorado River Basin, 1895–2018, shown as departures from a 1970–1999 average. The gray line is a 10-year running average plotted on the 6th year. A 40-year linear trend (dashed yellow line) shows 2.4°F of warming from 1979–2018. Figure taken from forthcoming ***Colorado River Basin Climate and Hydrology—State of the Science Report****:* https://www.usbr.gov/lc/region/programs/research-reports-etc/Final_CRB_SoS_Project_Overview.pdf

Lees Ferry Observed Natural Flow Record (1906-2021)



Lake Powell and Lake Mead End-of-December Elevation

August 2021 CRSS Projections with 1988 – 2019 Resampled Hydrology



*Projections assume 1988-2019 resampled natuarl flows (Stress Test Hydrology). In contrast to the June 2021 projections, these results do not include Upper Basin Drought Response Operations beyond 2021. The range shown in this figure may not be representative of the full range of possible conditions that could occur with different modeling assumptions.

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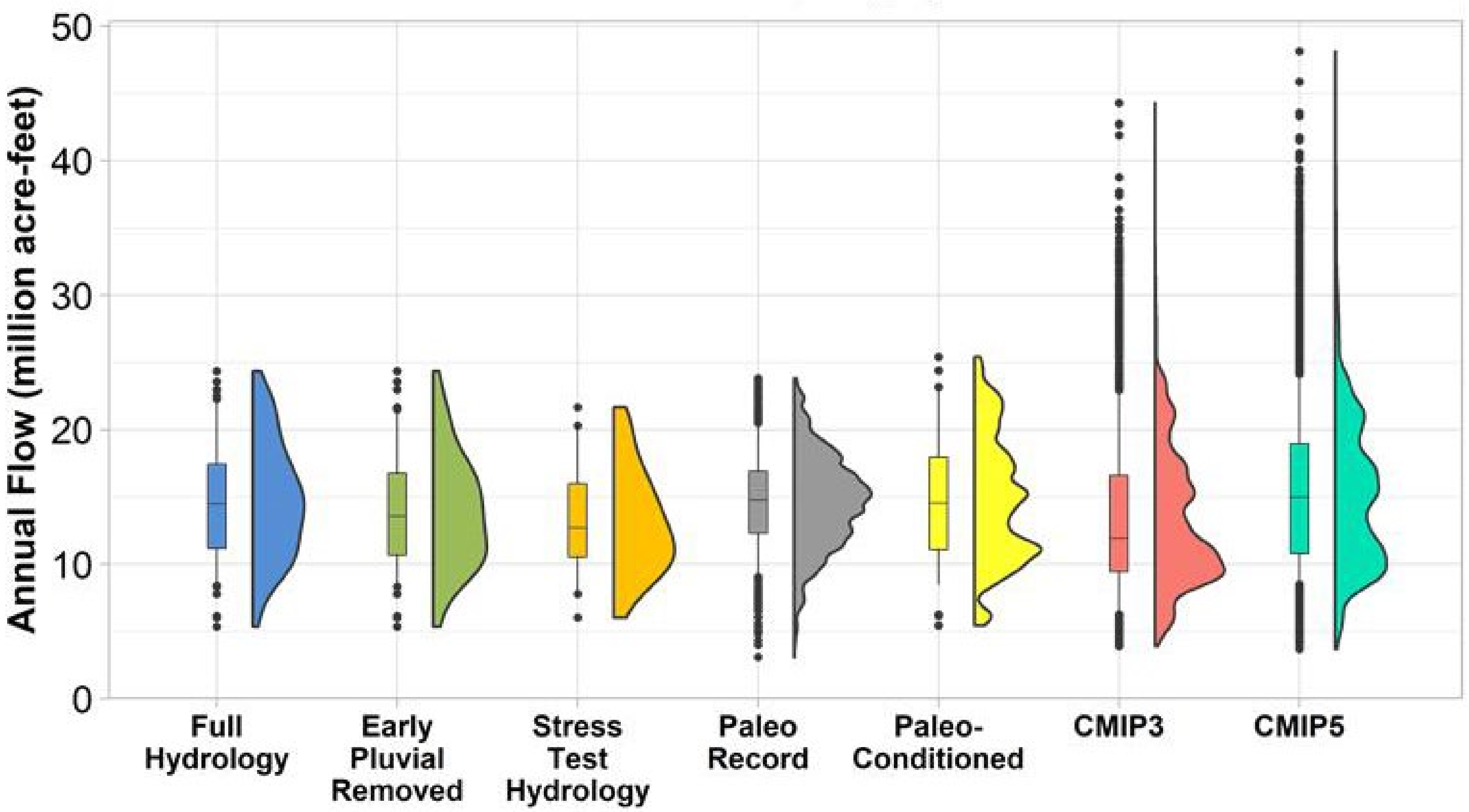
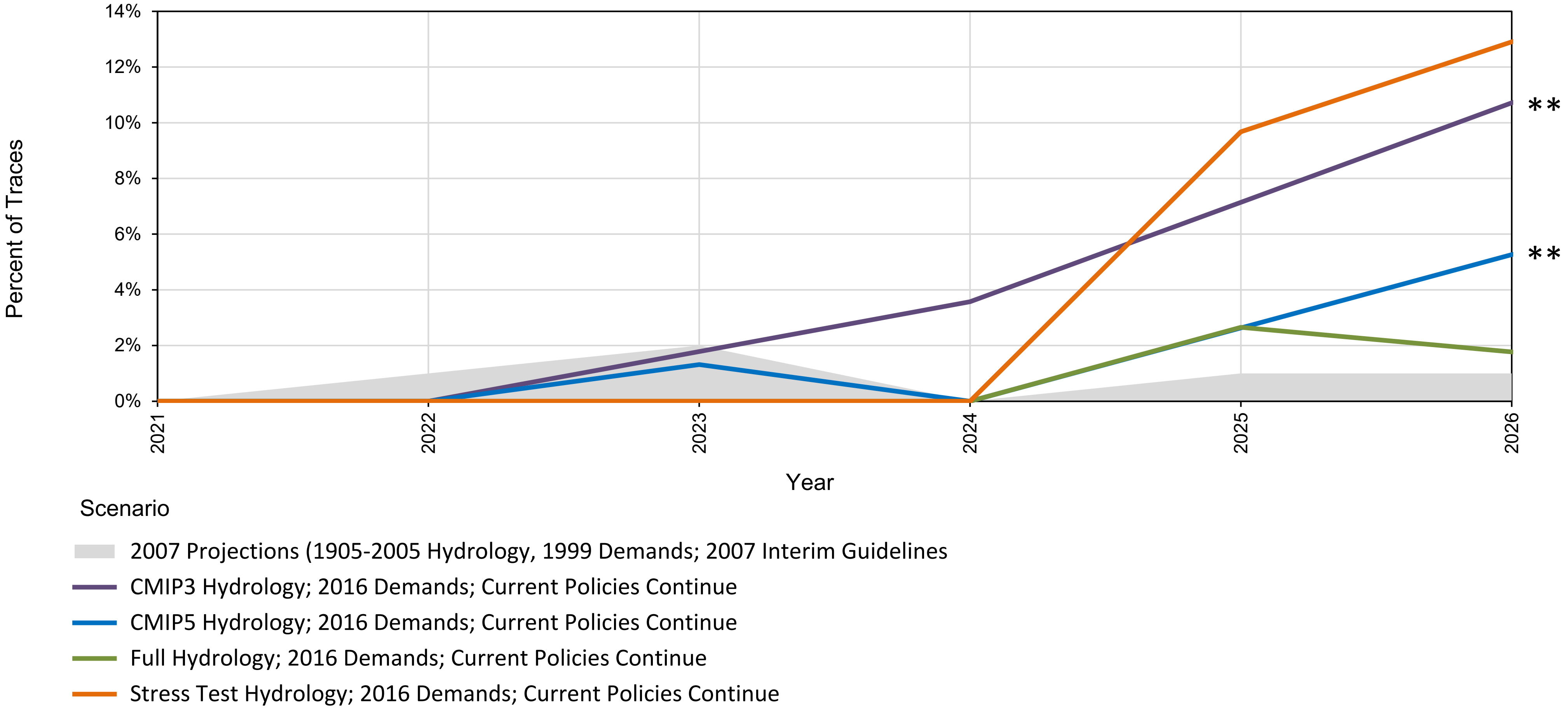
Now available at https://www.usbr.gov/lc/region/g4000/riverops/crss-5year-projections.html

Distributions of Alternative Hydrology Scenarios
Colorado River natural Flow at Lees Ferry Gaging Station



Shifting Risk*

Risk of Lake Powell dropping below 3,490 feet in any month



* Not official Projections,
based on August 2020 CRSS modeling with Lake Powell initial elevation of 3,592 feet. Lake Powell's 9/21/21 elevation is 3,547 feet

** CMIP3 and CMIP5 ensembles span 3 different emissions futures and were downscaled using Bias Correction Spatial Downscaling (BCSD)

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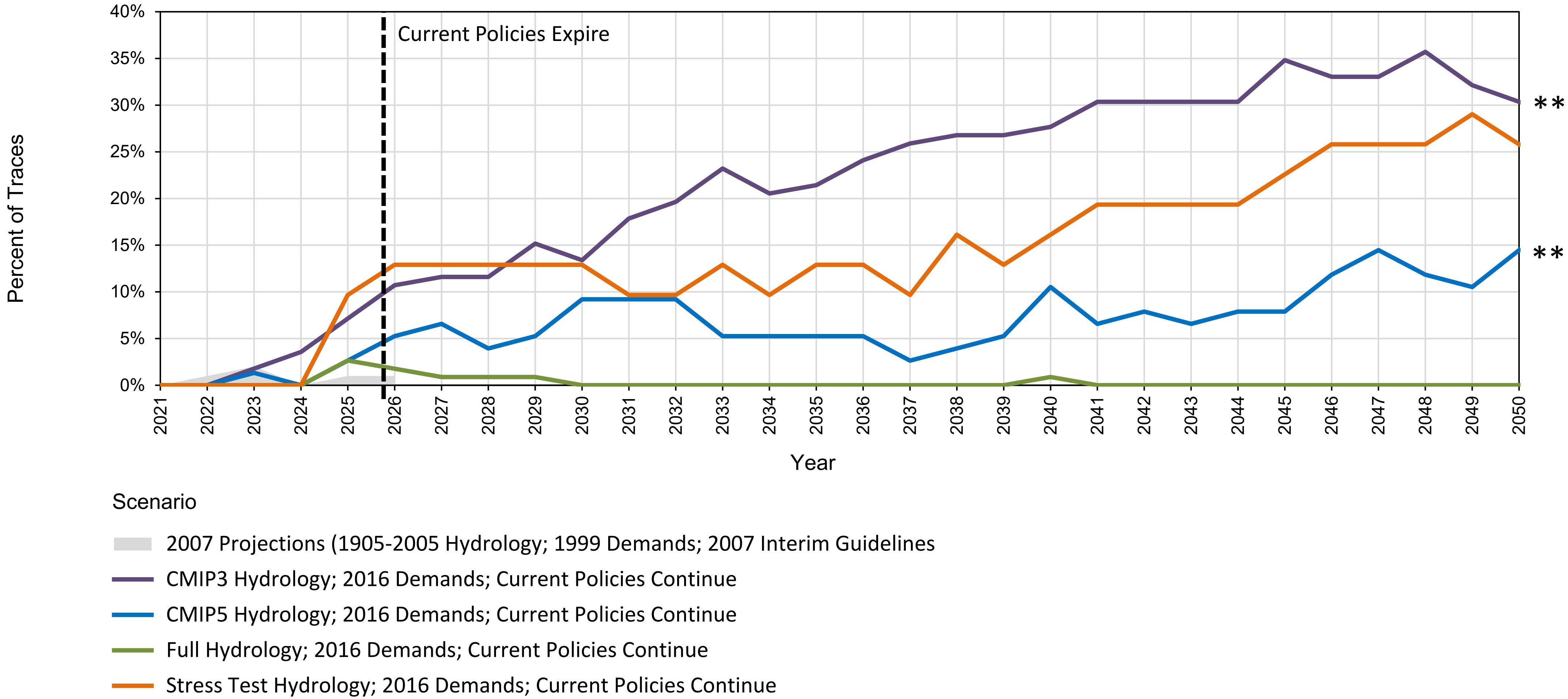

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Concerns with Planning under Deep Uncertainty

- Deep uncertainty occurs when probabilities of any given set of future conditions cannot be estimated with confidence
  - Translation: it is impossible to determine the most appropriate planning assumptions

- Choices of hydrologic ensemble and other assumptions about the future are likely to be controversial

- Statistics-based analysis may be unreliable as the sole basis for understanding system or planning for future
  - Risk = percent of traces; *completely dependent on the composition of the chosen ensemble of traces*
  - "acceptable" level of risk, risk reduction, etc. are common planning metrics but the implications of the underlying calculations are not well understood by stakeholders

Decision Making under Deep Uncertainty

- Decision Making under Deep Uncertainty (**DMDU**) methods incorporate concepts and techniques that help address the challenges of planning under climate change
- Shift away from statistics-based risk analysis
- Focus on **robustness**- performance is *good enough* in a wide range of futures
- Fundamental concepts
  - Wide range of futures, all equally likely
  - Vulnerability analysis based on observable conditions
  - Adaptation based on observable signposts as conditions evolve (and uncertainty decreases)


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