



— BUREAU OF —
RECLAMATION

Changing Climate: Looking Beyond Risk

Colorado Water Users Association

December 15, 2021

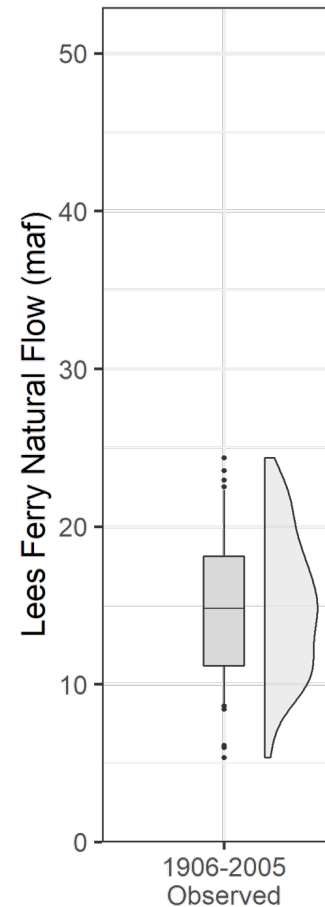
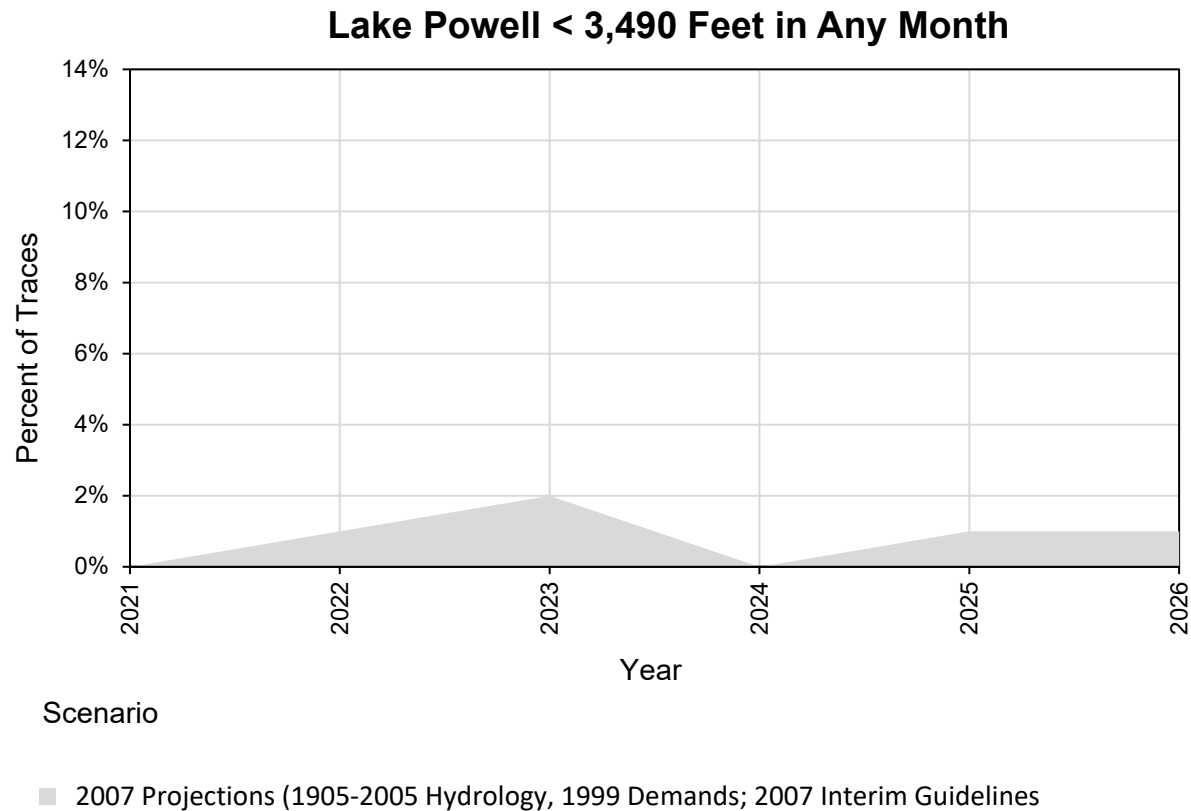
James Prairie, PhD, Upper Colorado Basin Region

Introduction

- How do people commonly talk about “risk” in the Basin?
 - An interpretation of “percent of traces” figures produced by Reclamation
 - Figures represent the probability of an event (e.g., Lake Powell falling below 3,490 feet, or minimum power pool) given specific modeling assumptions
- Limitations of thinking only in terms of risk
 - Number of traces/probability (i.e., perception of risk) depends on hydrology ensemble used and initial conditions
 - In a changing climate it is impossible to know the true probabilities of specific flows occurring in the future (deep uncertainty)
- Reframing the analysis provides information about vulnerability and robustness



What is the risk of Lake Powell dropping below 3,490 feet (minimum power pool) in any month? ^{1,2}

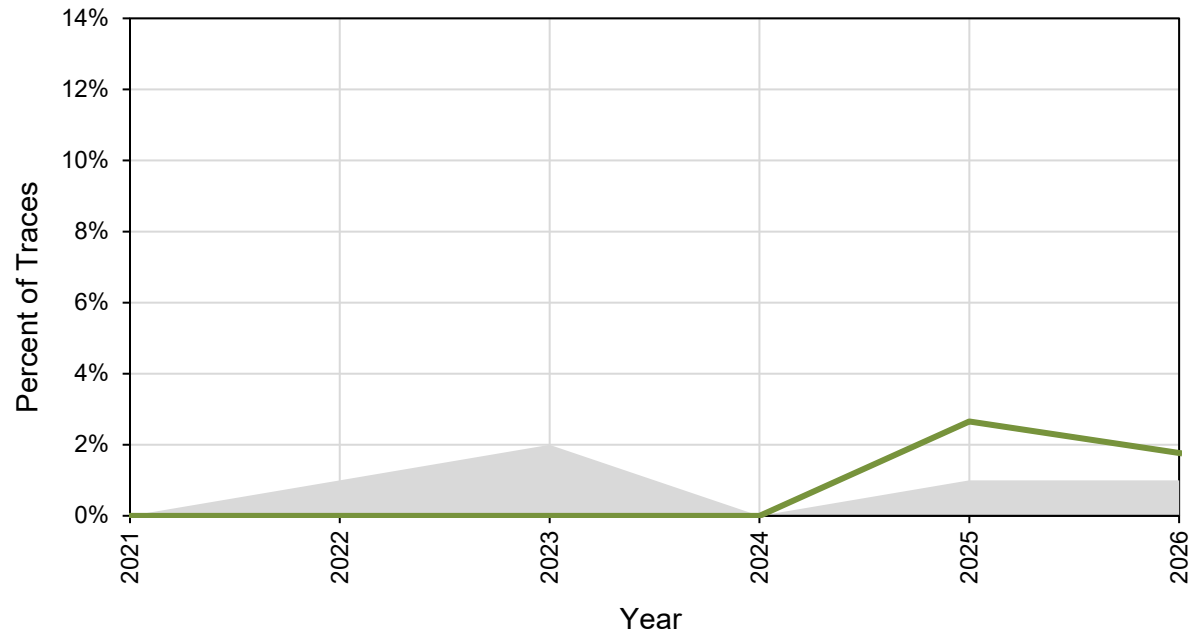


¹Not official projections; based on August 2020 CRSS modeling with Lake Powell initial elevation of 3,592 feet. ²Lake Powell's 12/13/21 elevation is 3,540 feet

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

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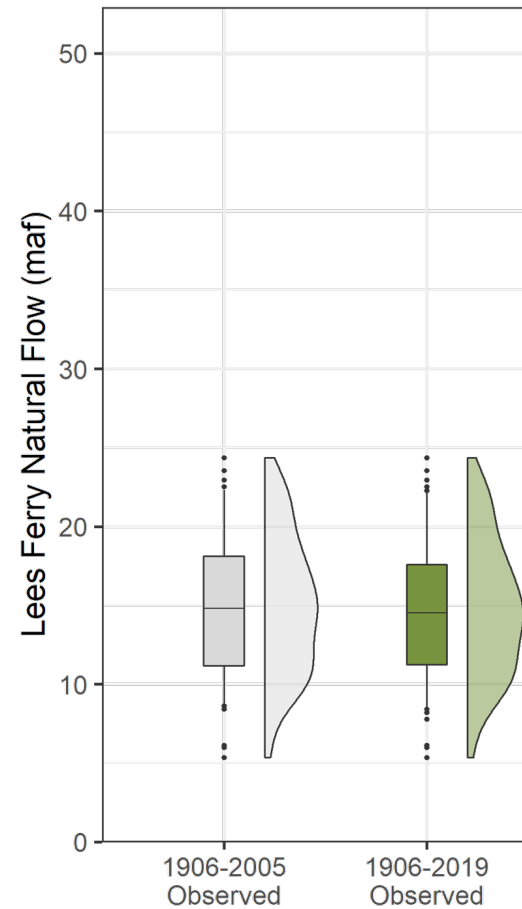
Lake Powell < 3,490 Feet in Any Month



Scenario

2007 Projections (1905-2005 Hydrology, 1999 Demands; 2007 Interim Guidelines)

Full Hydrology; 2016 Demands; Current Policies Continue; August 2020 Initial Conditions

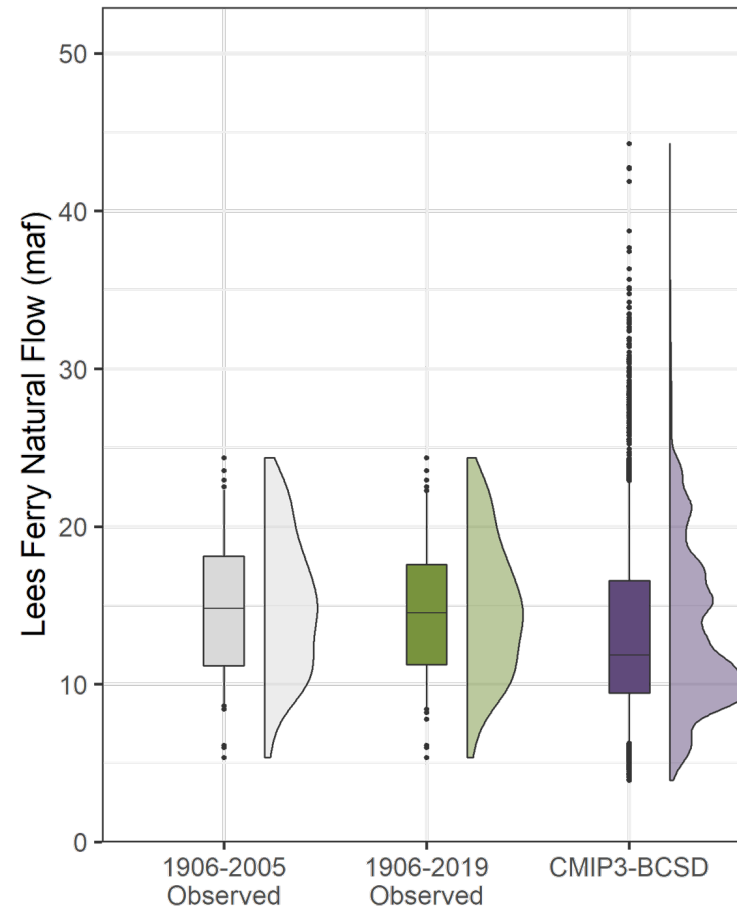
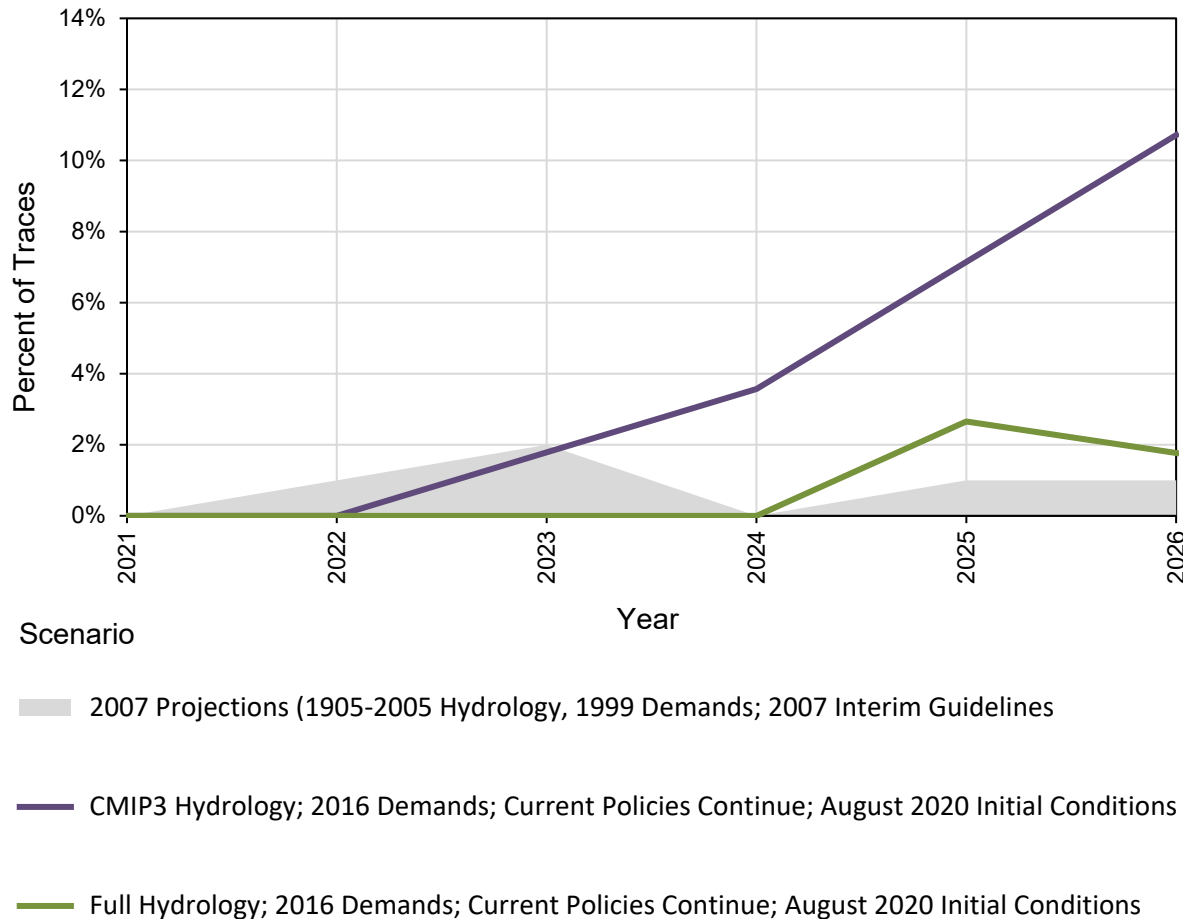


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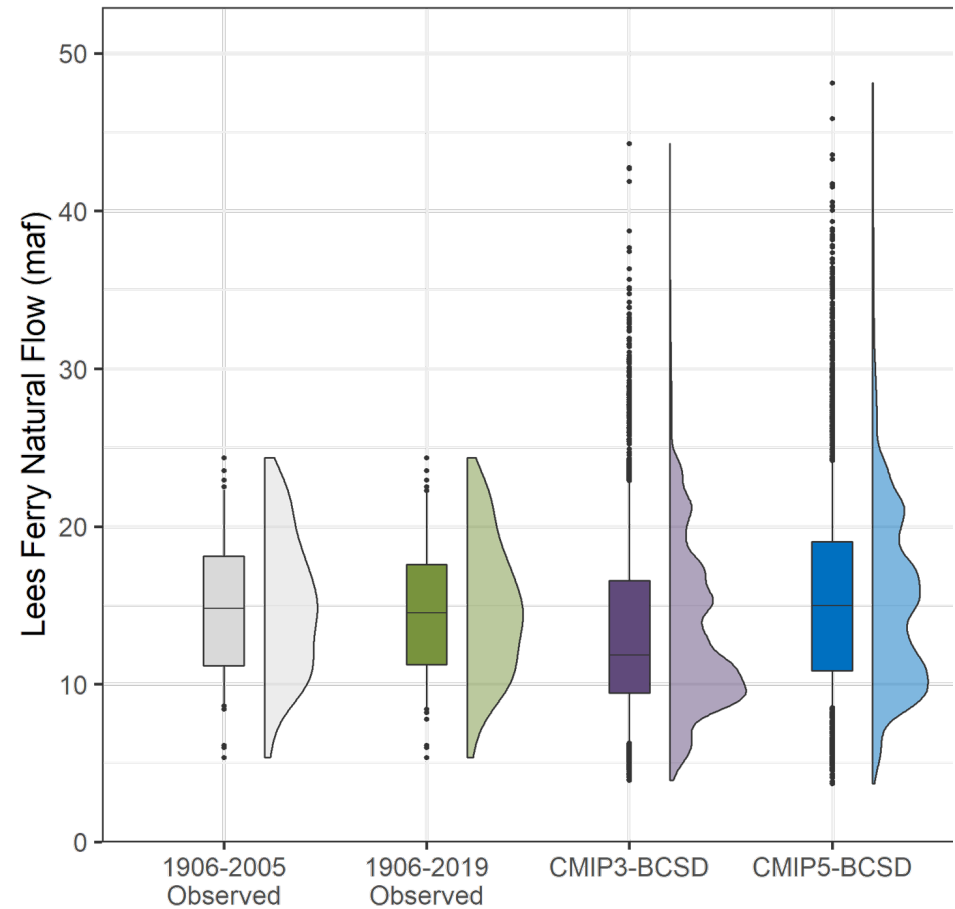
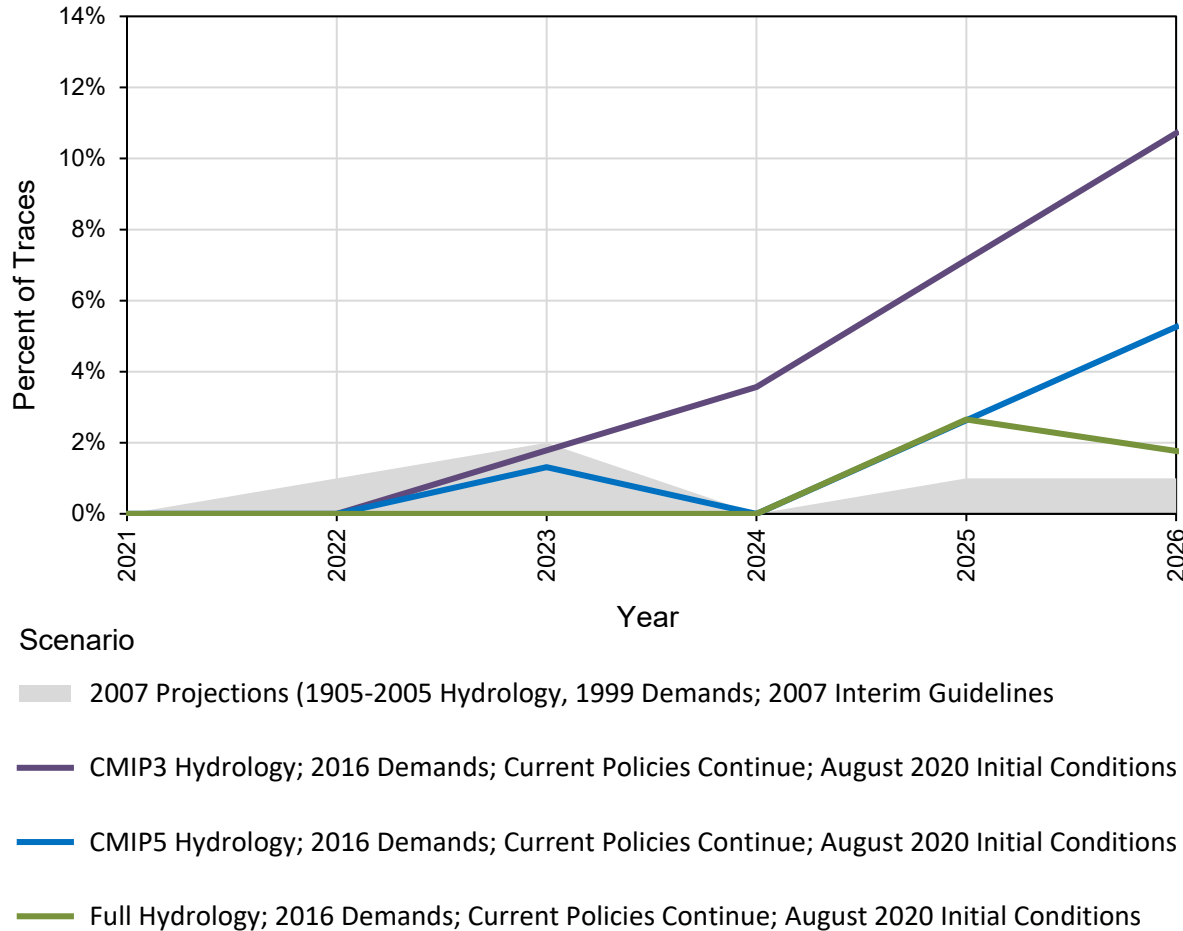
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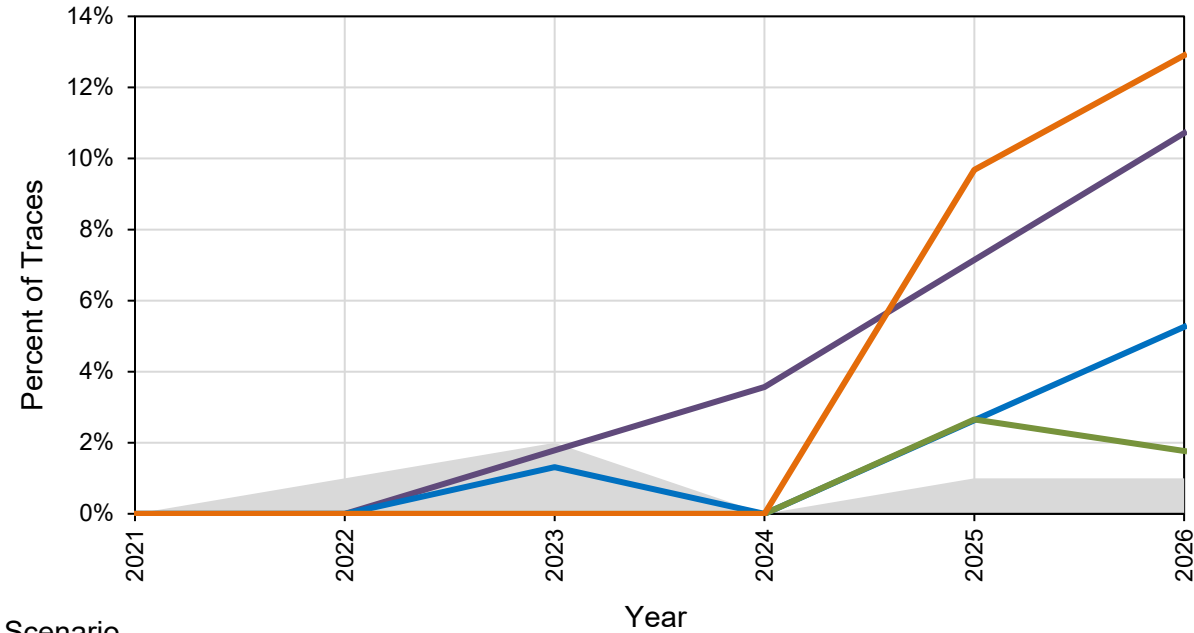
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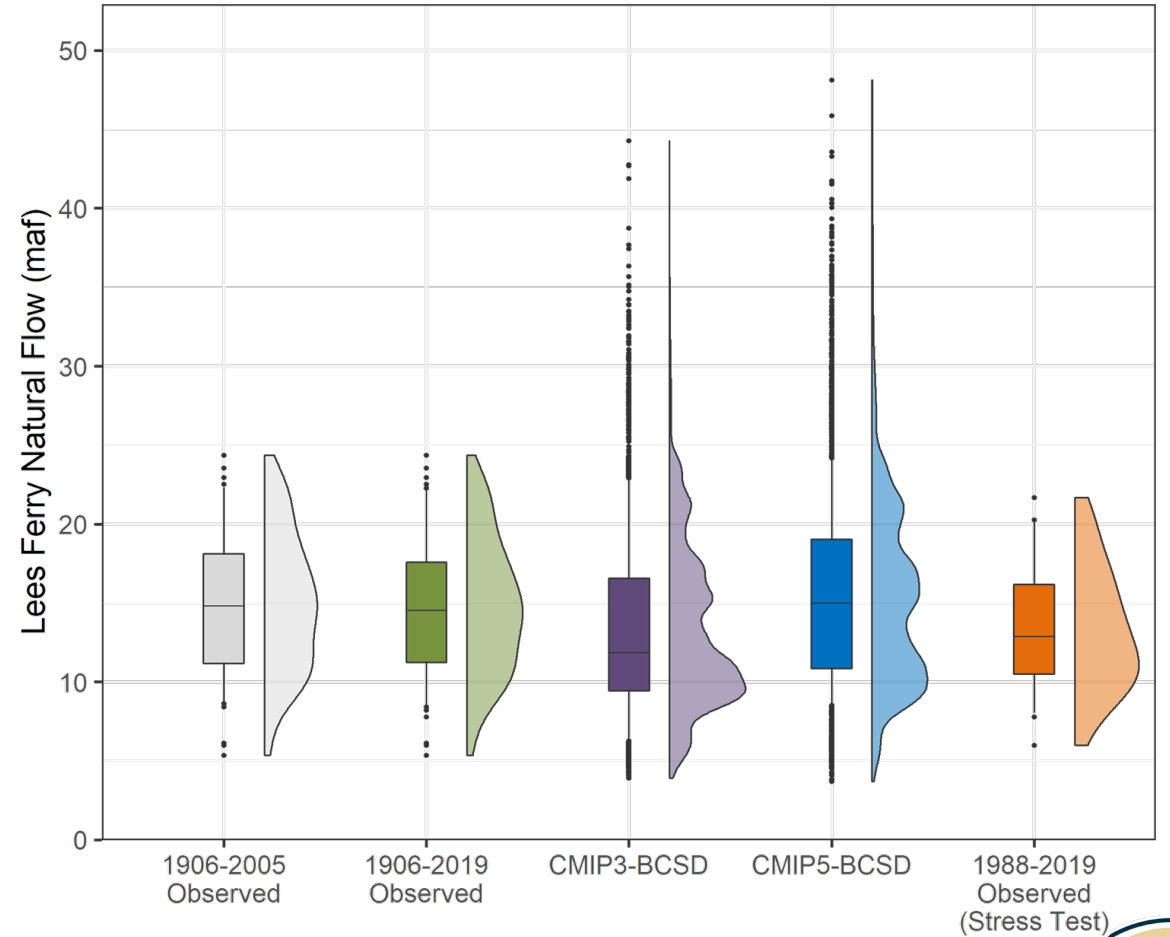
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- CMIP3 Hydrology; 2016 Demands; Current Policies Continue; August 2020 Initial Conditions
- CMIP5 Hydrology; 2016 Demands; Current Policies Continue; August 2020 Initial Conditions
- Full Hydrology; 2016 Demands; Current Policies Continue; August 2020 Initial Conditions
- Stress Test Hydrology; 2016 Demands; Current Policies Continue; August 2020 Initial Conditions



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Reframing the Analysis: Risk vs. Vulnerability

Risk: “What is the probability of Lake Powell falling below 3,490 feet?”

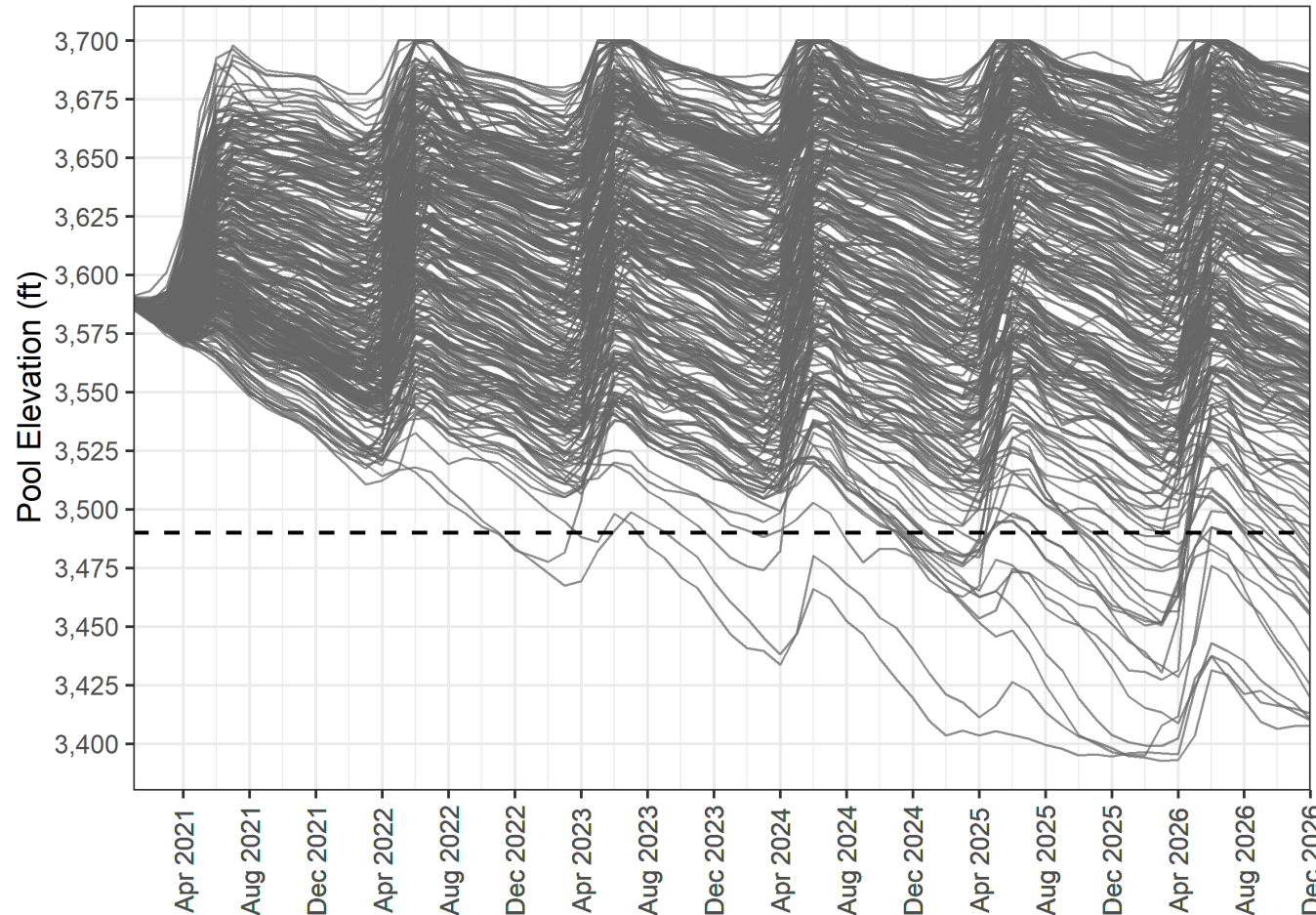
- Can change significantly in a short amount of time
- Highly dependent assumptions about uncertain future hydrology, water use, initial conditions, and policy

Vulnerability: “What conditions would likely cause Lake Powell to fall below 3,490 feet?”

- Based on observable conditions
- Provides objective basis for making decisions



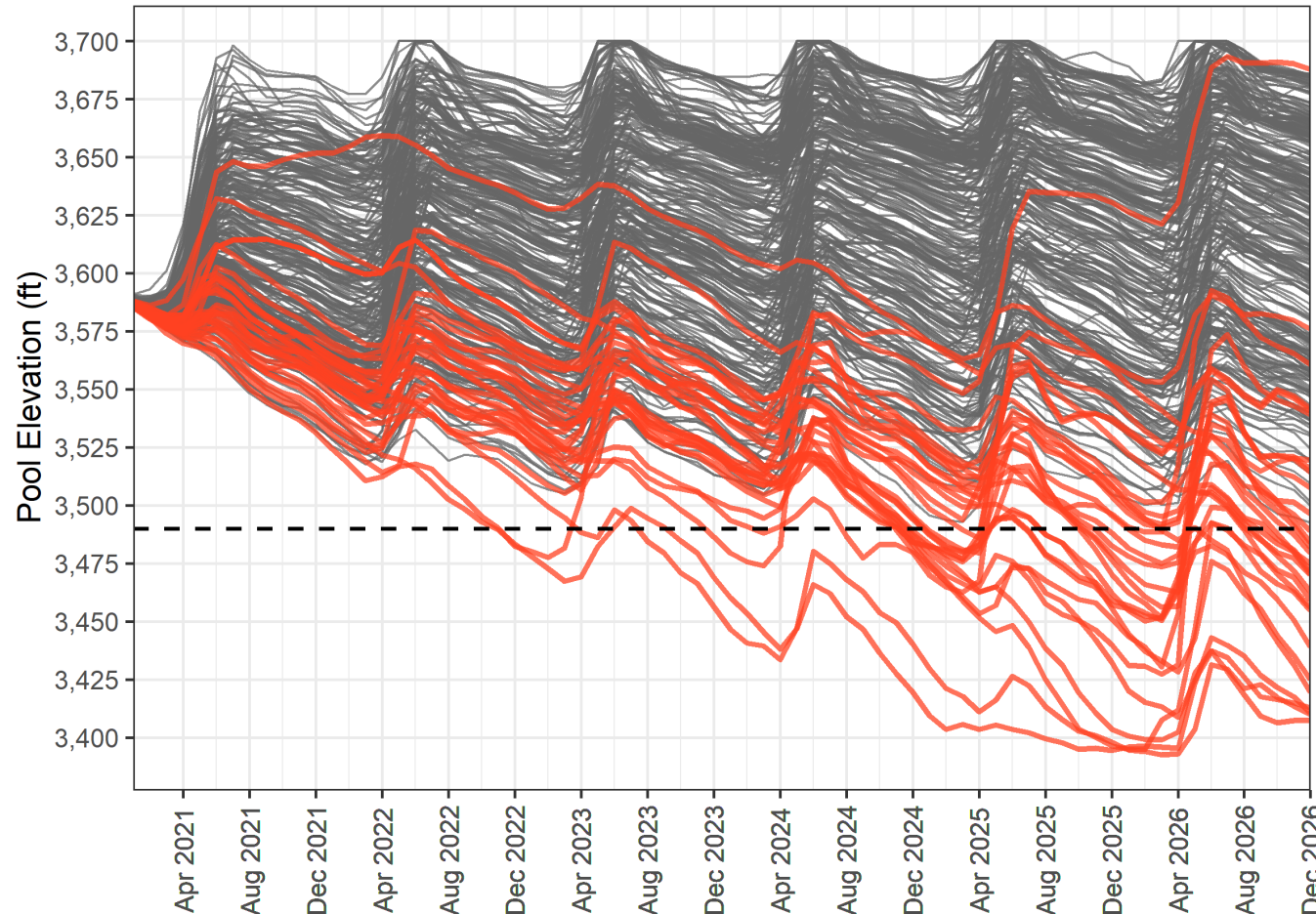
What conditions would likely cause Lake Powell to drop below 3,490 feet (minimum power pool) in any month?



- 332 hydrologic traces total across four ensembles
- Previously, each risk line summarized many modeling simulations
- Analyzing all the traces together without choosing one "best" scenario allows us to identify the conditions that could cause Lake Powell to be vulnerable



What conditions would likely cause Lake Powell to drop below 3,490 feet (minimum power pool) in any month?^{1,2}



- 332 hydrologic traces total
- 30 traces resulted in Lake Powell dropping below 3,490 feet at any time through 2026
- Analysis discovered that, with August 2020 reservoir contents, a 2021-2026 mean flow ≤ 11.4 maf would likely lead to vulnerability absent any additional actions
- Recent Lees Ferry annual flow context
 - 2017-2021 avg³ = 11.5 maf
 - 2000-2021 avg³ = 12.3 maf

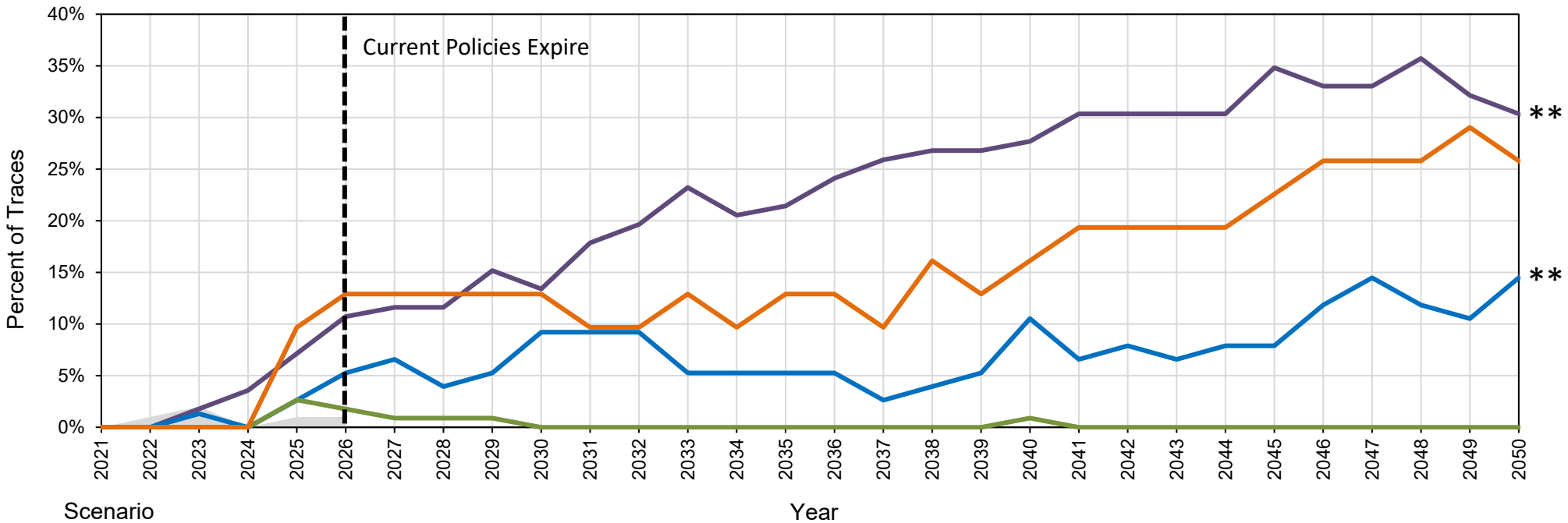
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³2021 Lees Ferry annual flow is provisional



What is the long-term risk of Lake Powell dropping below 3,490 feet (minimum power pool) in any month?^{1,2,3}

Lake Powell < 3,490 Feet in Any Month



- 2007 Projections (1906-2005 Hydrology, 1999 Demands; 2007 Interim Guidelines)
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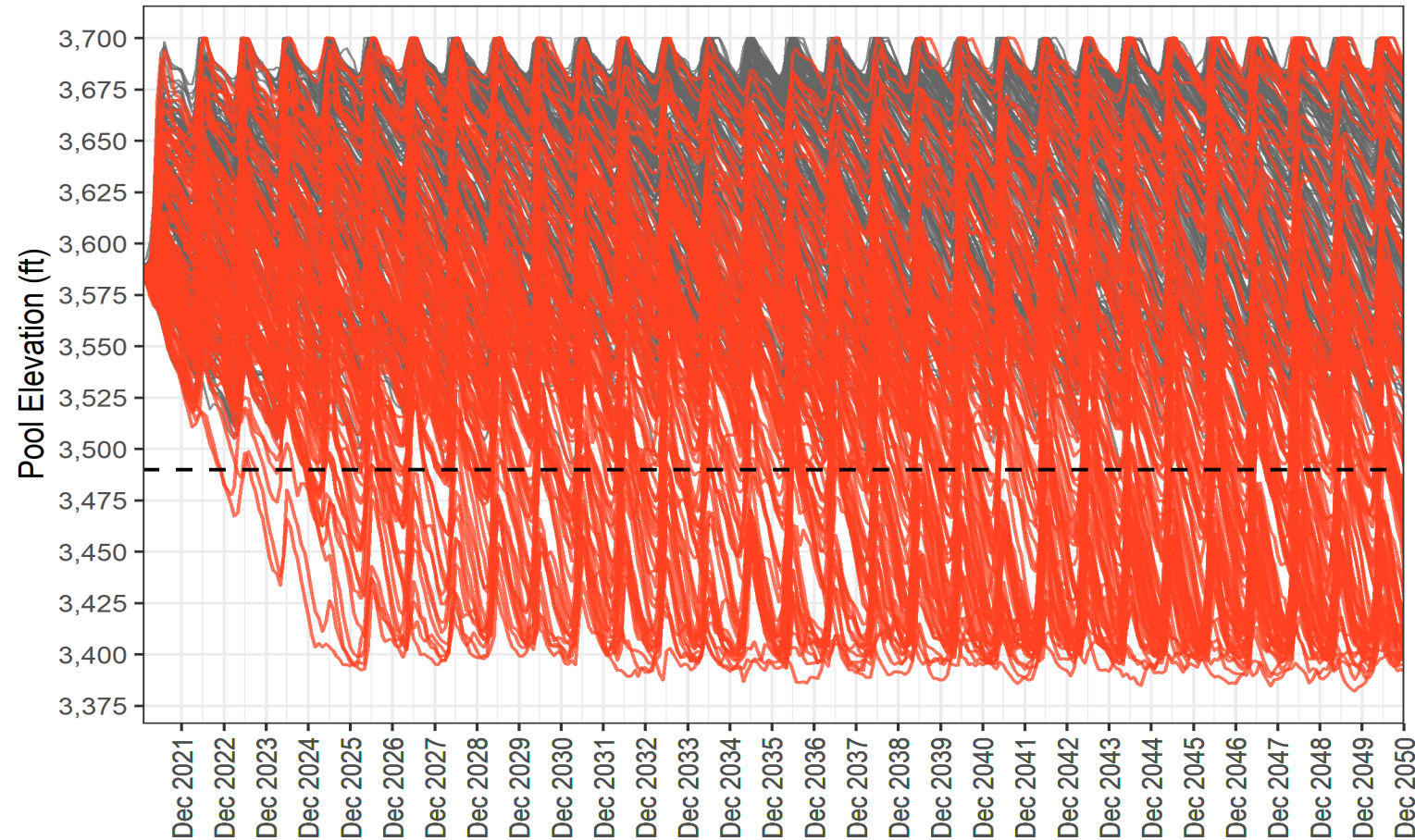
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³Assumes 2007 Interim Guidelines, DCP, and Minute 323 policies continue through 2050

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What conditions would likely cause Lake Powell to drop below 3,490 feet (minimum power pool) in any month?^{1,2,3}



- 113 traces out of 332 total resulted in vulnerability through 2050
- Analysis discovered that a 10-year mean flow ≤ 12.2 maf would likely lead to vulnerability absent any additional actions
- Recent Lees Ferry annual flow context
 - 2012-2021 avg³ = 11.8 maf
 - 2000-2021 avg³ = 12.3 maf



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Decision Making under Deep Uncertainty

- Challenges associated with probability-based **risk** compound when looking further into the future because of Deep Uncertainty
- Climate change and other uncertainties make it impossible to determine the best planning assumptions
- Decision Making under Deep Uncertainty (**DMDU**) methods incorporate concepts and techniques that focus on vulnerability and robustness instead of risk
 - Model potential policies in a wide range of future conditions, including those more dire than observed; no need to choose what future to plan for up front
 - Analyze data to identify which conditions cause policy to be vulnerable across a range of metrics
 - Think about whether we want to be robust to 11 maf or 9 maf or 14 maf after we have more info about system response and tradeoffs



Summary

- Projections of risk are always based on imperfect assumptions about the future
- “Low risk” \neq no risk – events that recently *appeared* to be low probability have occurred
- Including analyses that identify vulnerabilities and assess robustness can alleviate overreliance on assumption-dependent risk
- Decision Making under Deep Uncertainty (DMDU) methods are needed to approach long-term planning under climate change



James Prairie: jprairie@usbr.gov



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