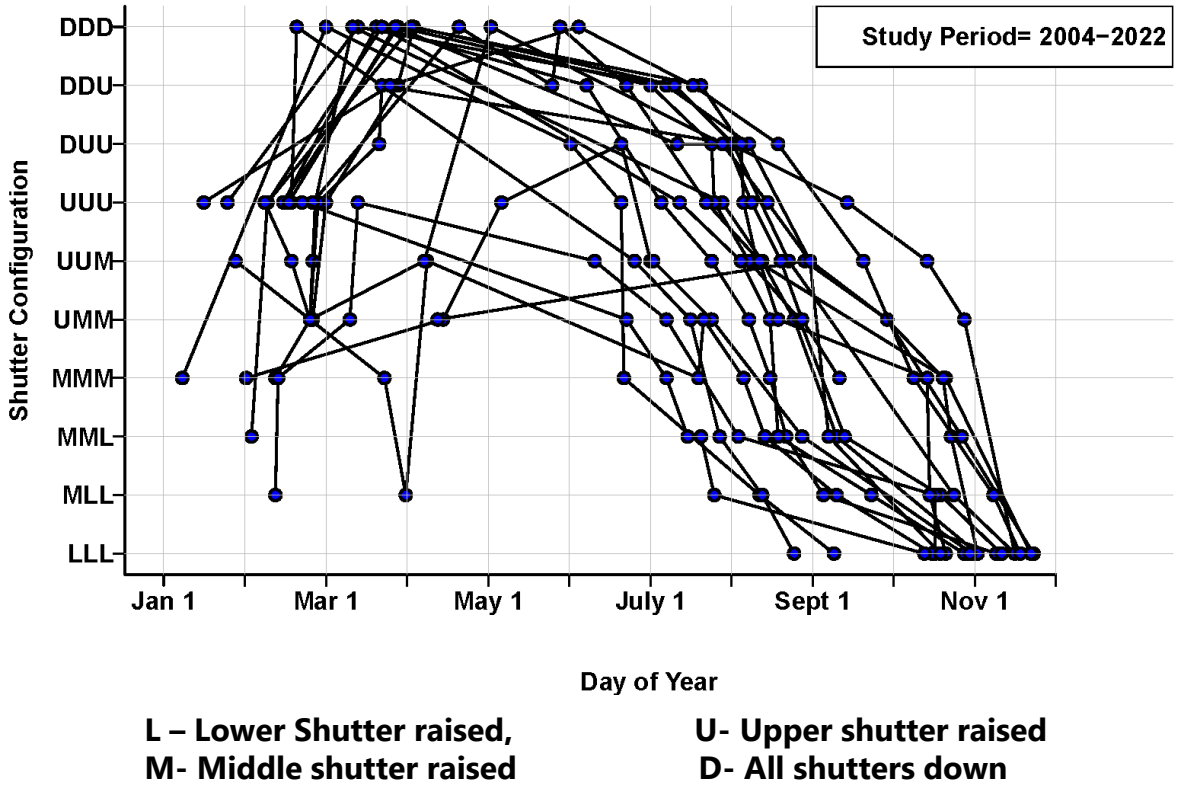
BUREAU OF RECLAMATION

Evaluating the Role of Shutter Elevation and Leakage Efficiency on the Performance of TCS Units at Folsom Dam

Mussie T. Beyene and Drew Loney

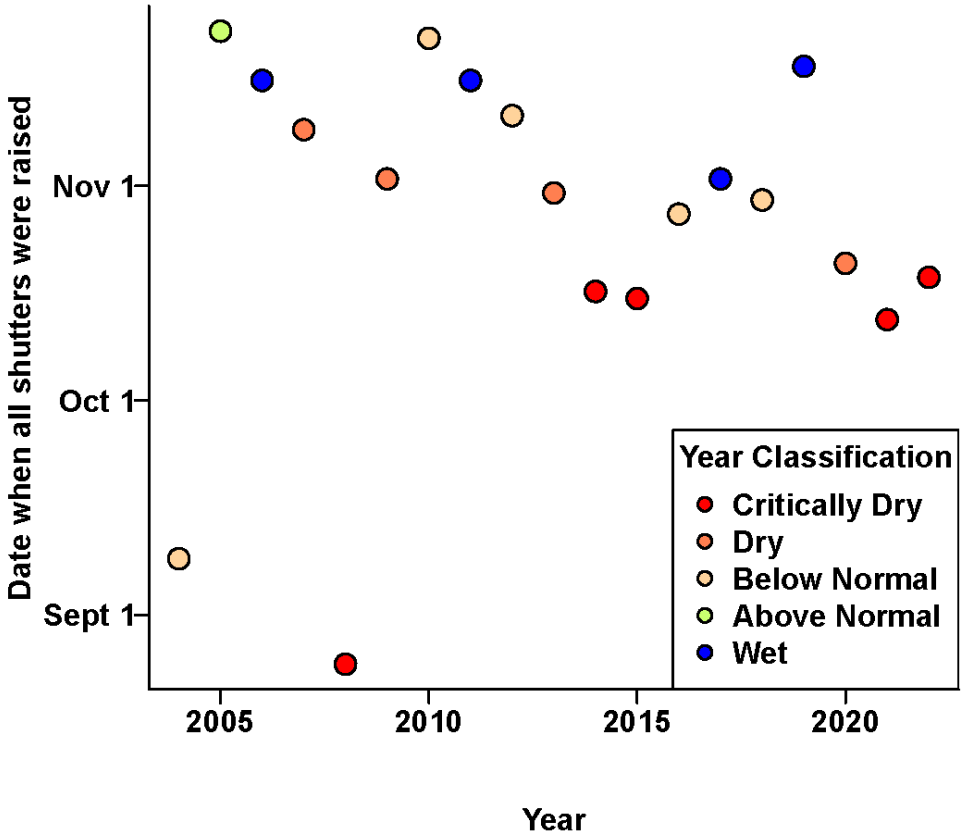
September 25, 2024

Motivation



L – Lower Shutter raised,
M- Middle shutter raised

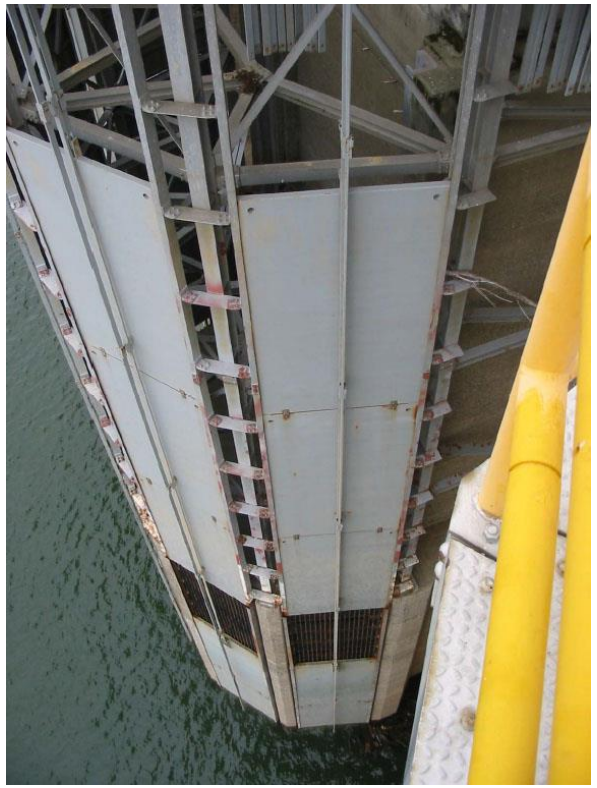
U- Upper shutter raised
D- All shutters down



Historical TCS shutter configurations indicate a trend towards earlier dates when all three lower shutters are raised (cold water store depleted)

Motivation

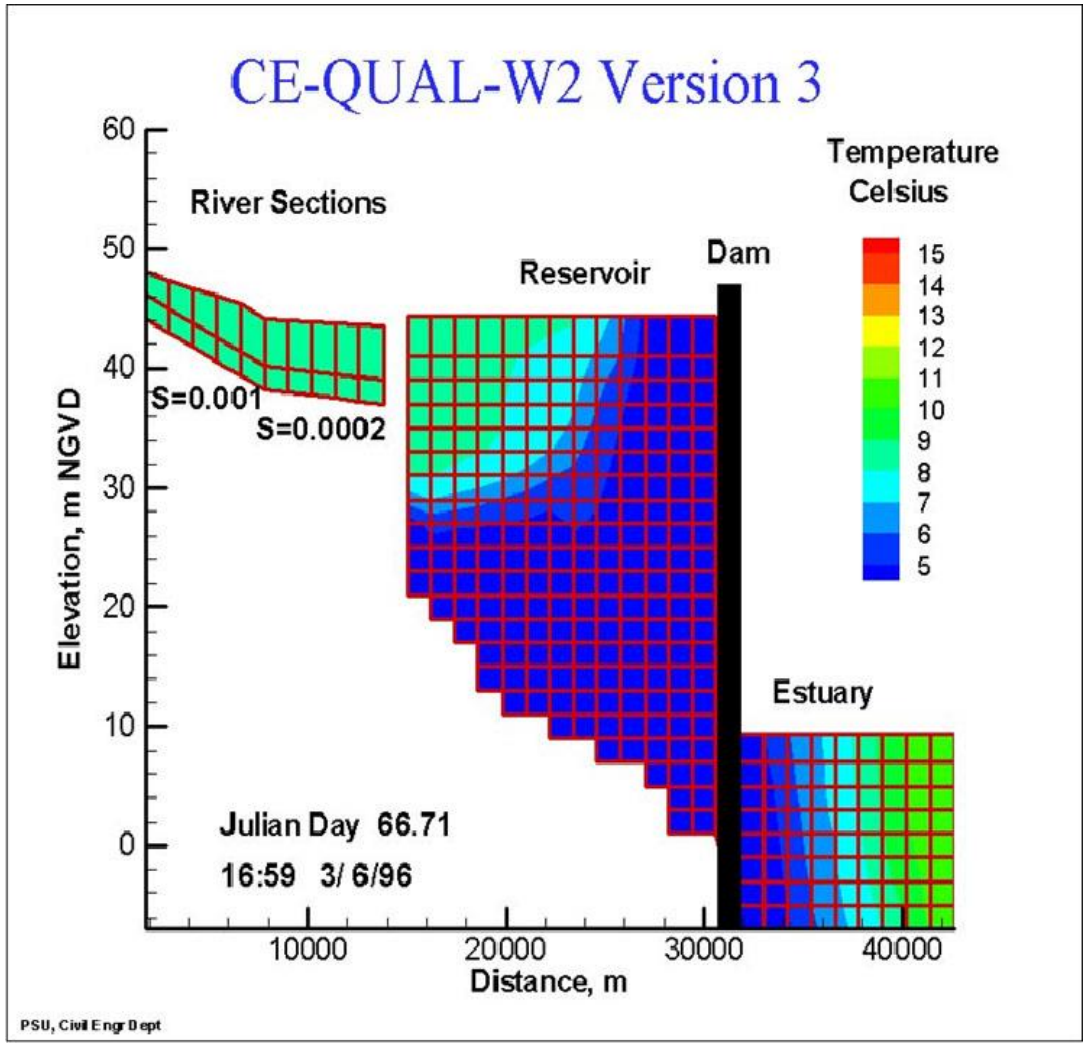
Location of the existing temperature control device and other nearby features at Folsom Dam (USACE)



Close-up on one of the three piers that make up the existing temperature control device (USACE)

- TCS at Folsom Reservoir is being refurbished
- Variety of designs are being proposed that may impact performance
- Goal: Evaluate effect of release elevation and leakage on TCS performance

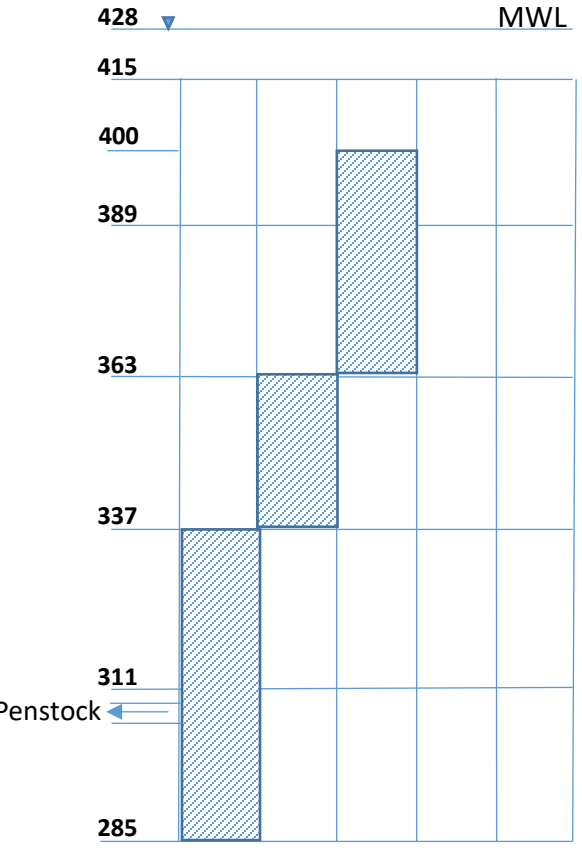
Approach



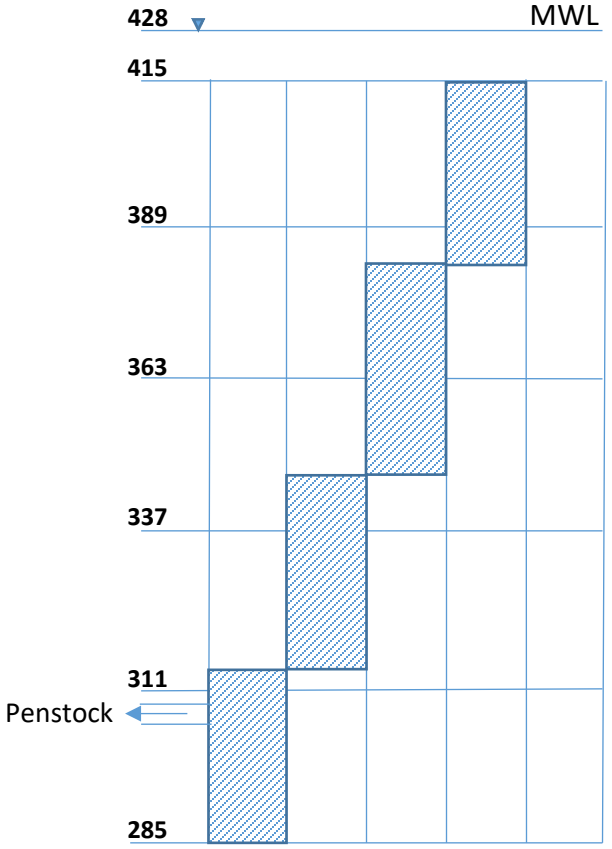
Longitudinal view of temperature output for a riverine section, reservoir, and estuary from a CEQUAL-W2 application (USACE)

- Comparative analysis of simulated water temperatures across designs.
- CE-QUAL-W2 model to simulate daily release water temperatures at Folsom Dam under existing and alternative TCS design.
- Calibration period (2001-10) and validation period (2011 - 2020).
- Shutter elevations are represented as release elevations and leakage efficiency is represented as the proportion of release flow from leakage.

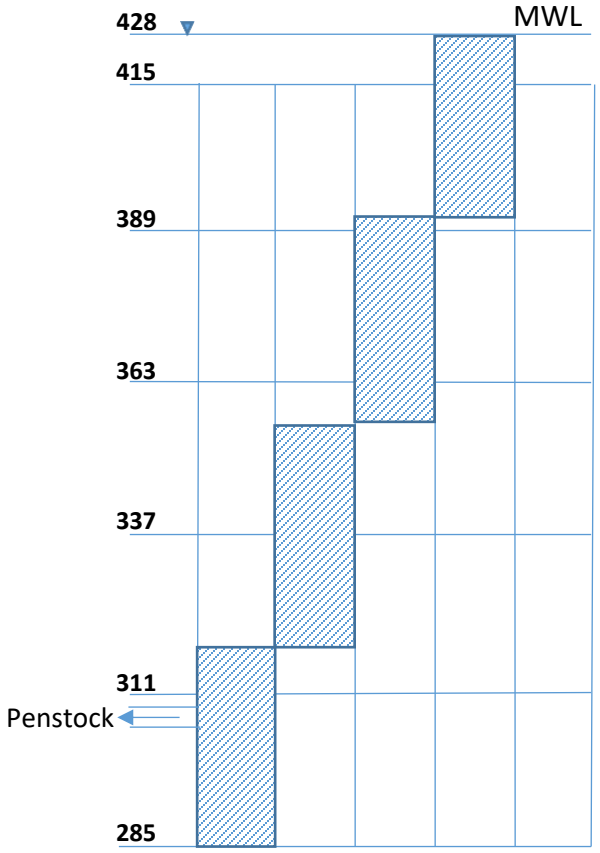
Approach: TCS Designs Considered



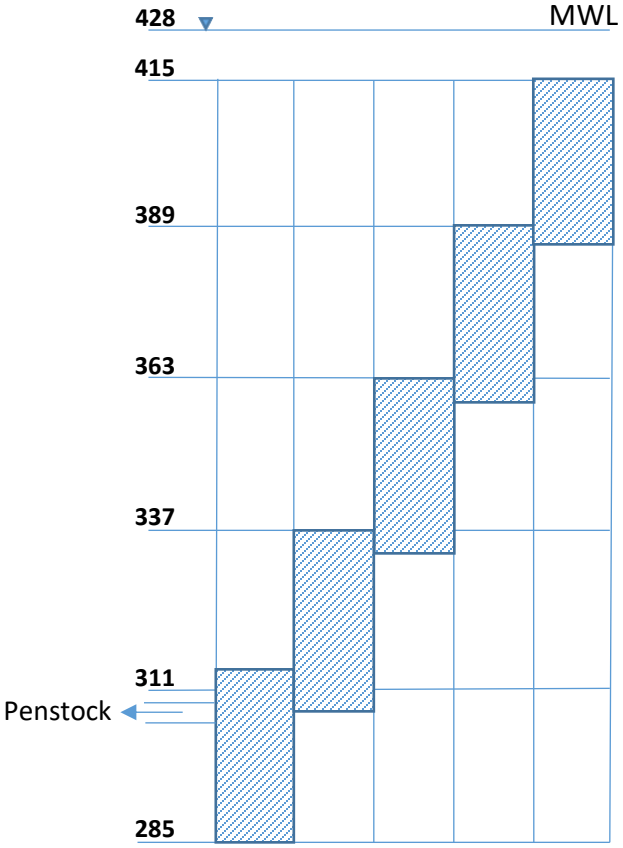
3 shutters/release elevations (Existing)



4 shutters

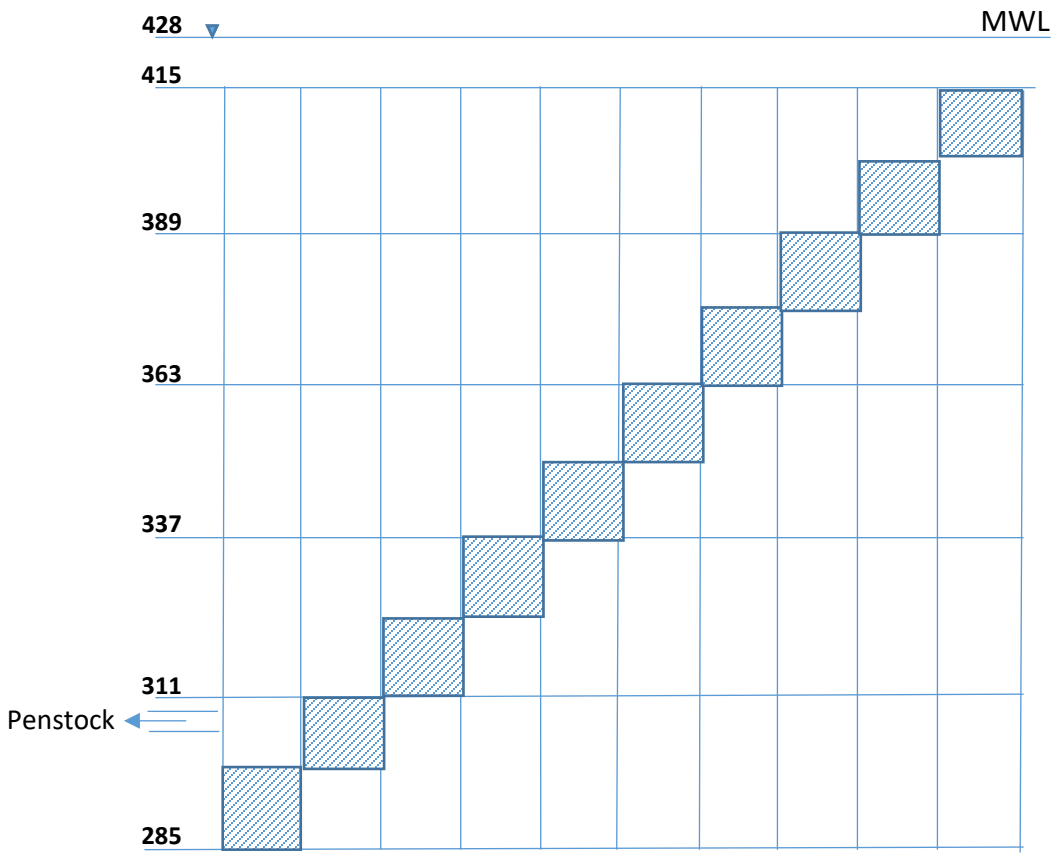


4+ shutters



5 shutters

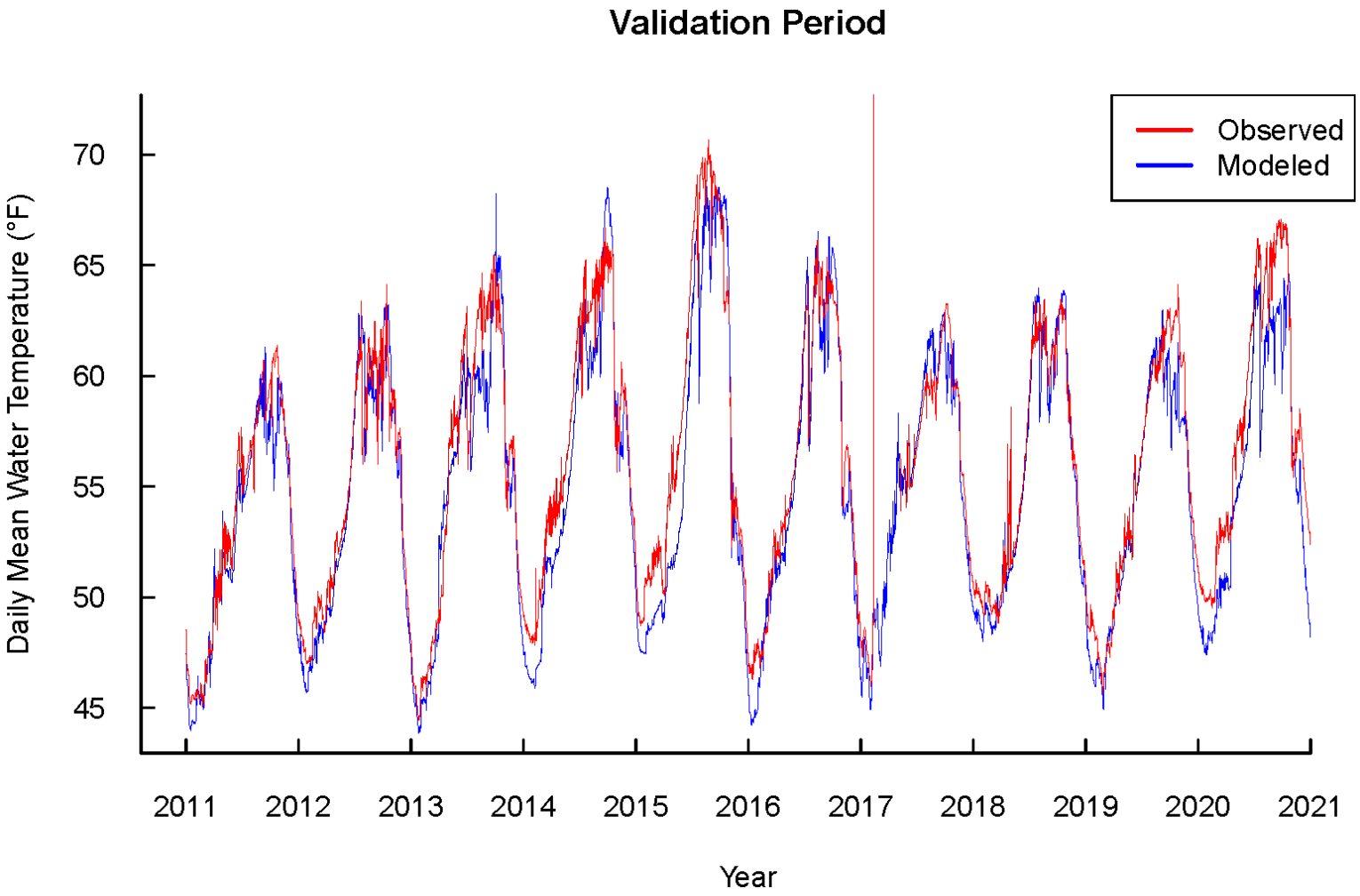
Approach: TCS Designs Considered



10 and 11 shutters

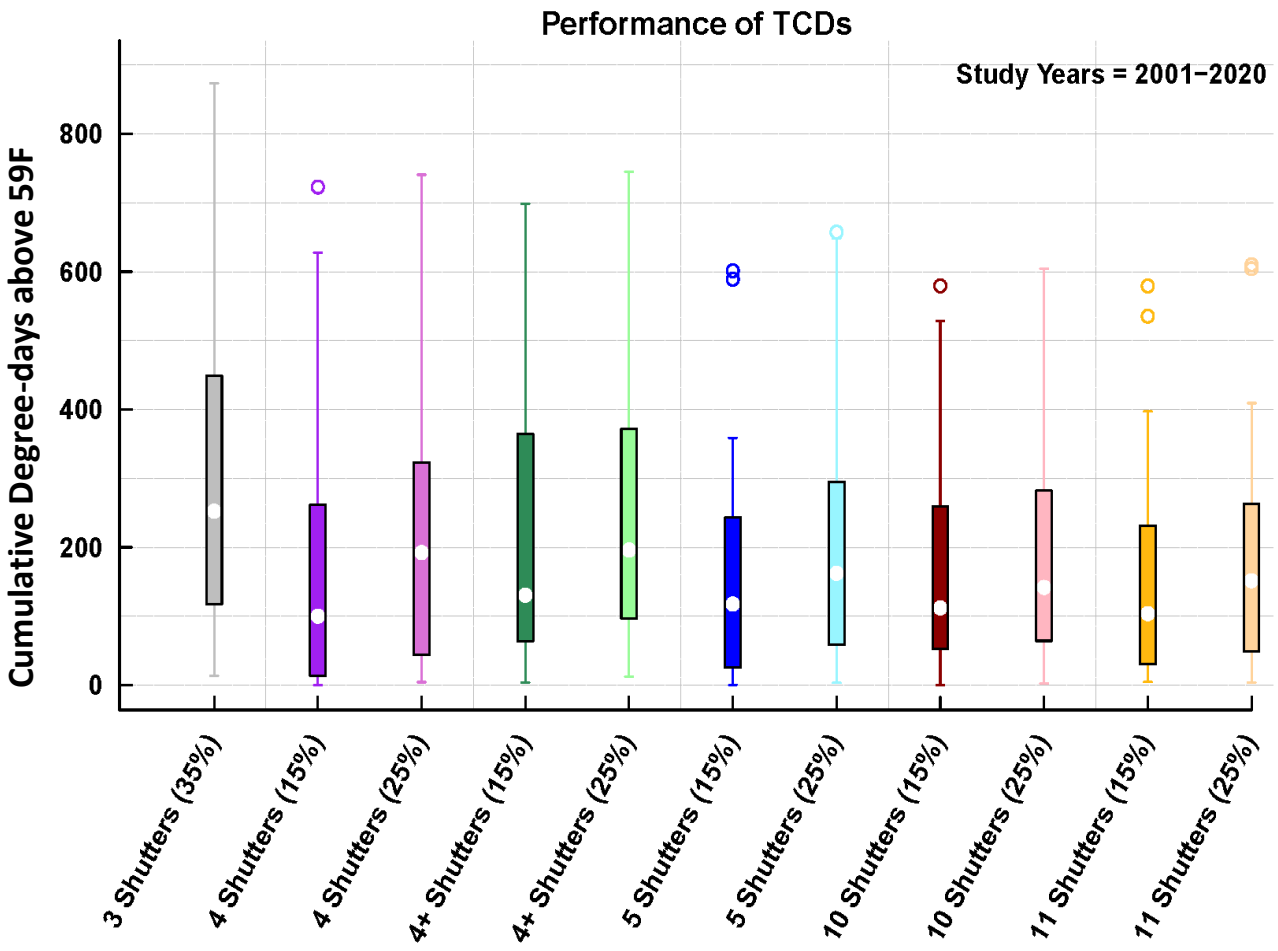
- 13’ increments to match the trash rack scaffold
- Converges to the limit of “continuous” selection flexibility
- Assumption across all new designs that the leakage is less than the current 35%

Comparing Observed and Modeled Water Temperatures during Validation Period



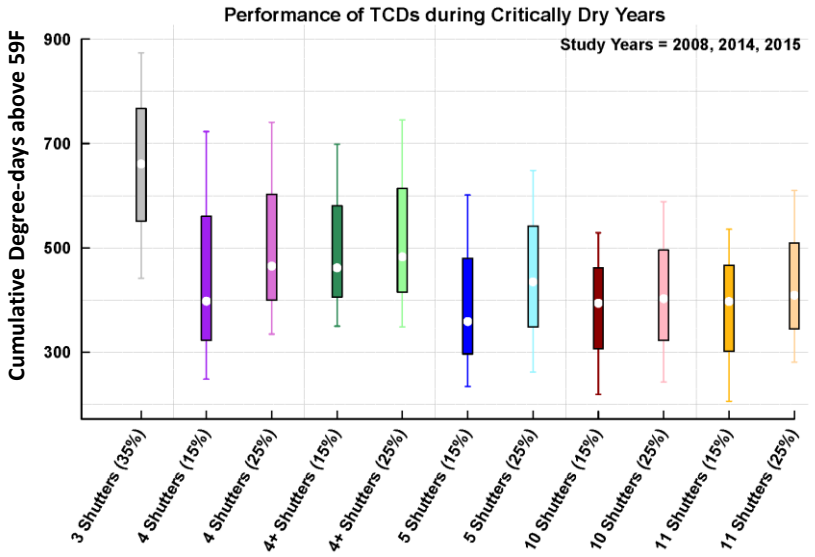
- Overall Performance:
- R^2 = 0.92
- MAE = 0.92 C (1.6 F)
- RMSE = 1.19 C (2.1 F)

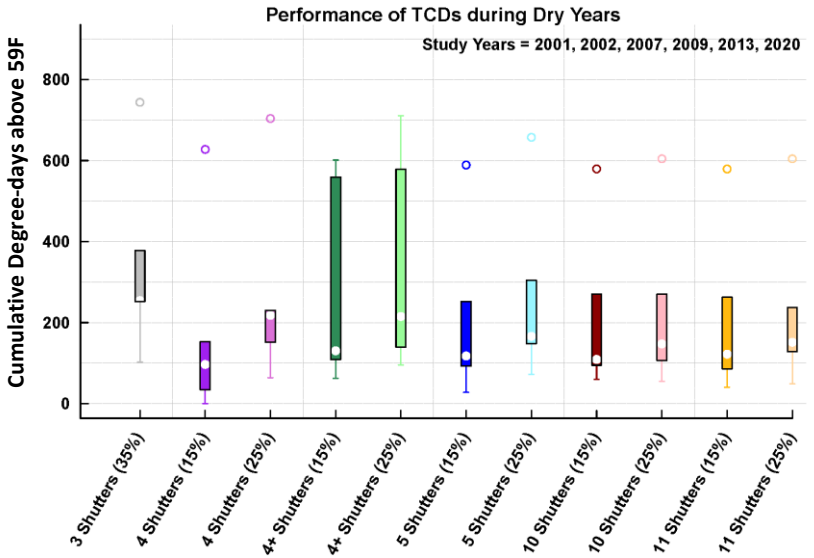
Performance of TCSs during All Years

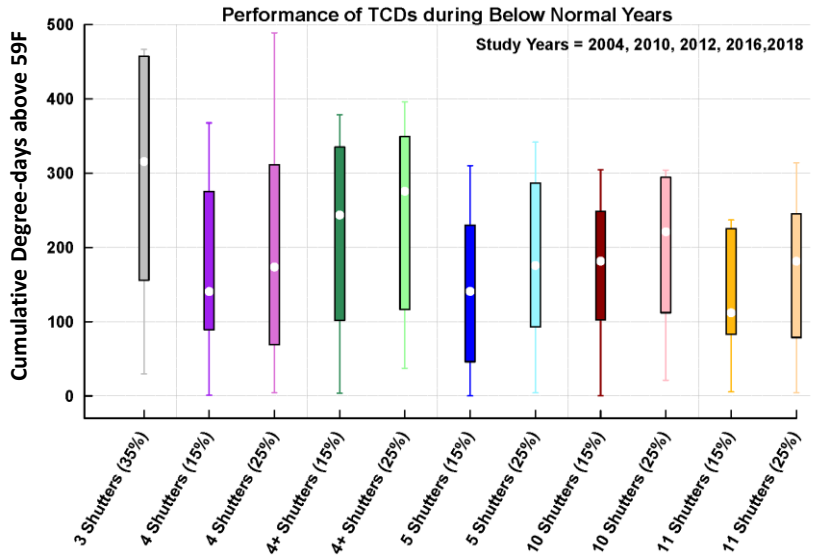


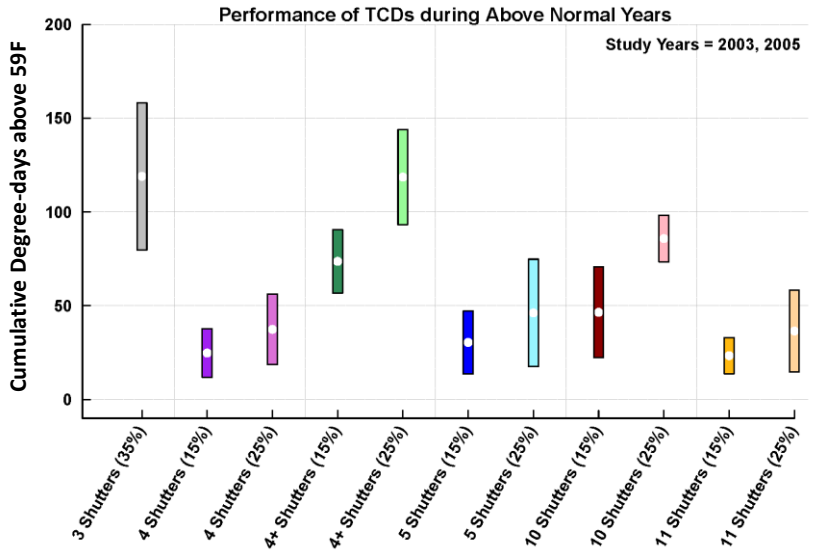
- New TCS designs have lower cumulative degree-days above 59F compared to existing structure.
- TCS designs with higher #of release elevations and leakage efficiency have lower magnitude and variability in the CDD above 59F relative to those with lower #of release elevations and leakage efficiency.

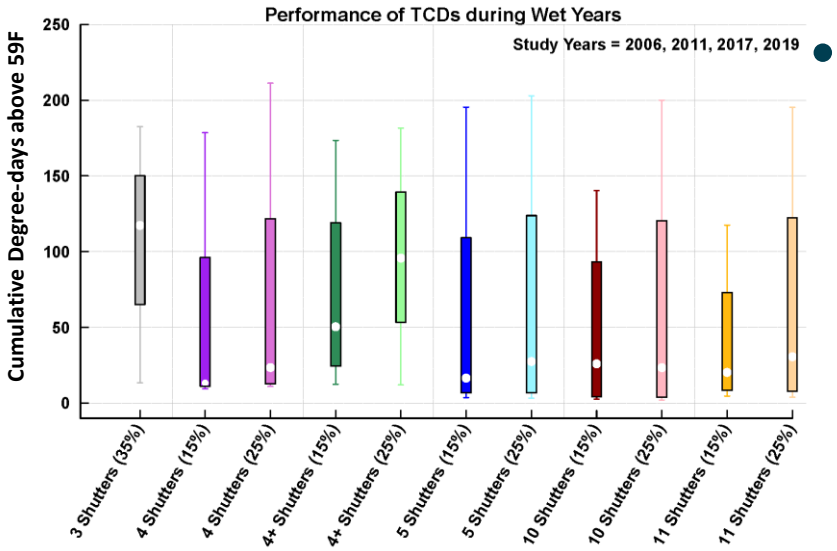
Performance of TCSs Among the Years





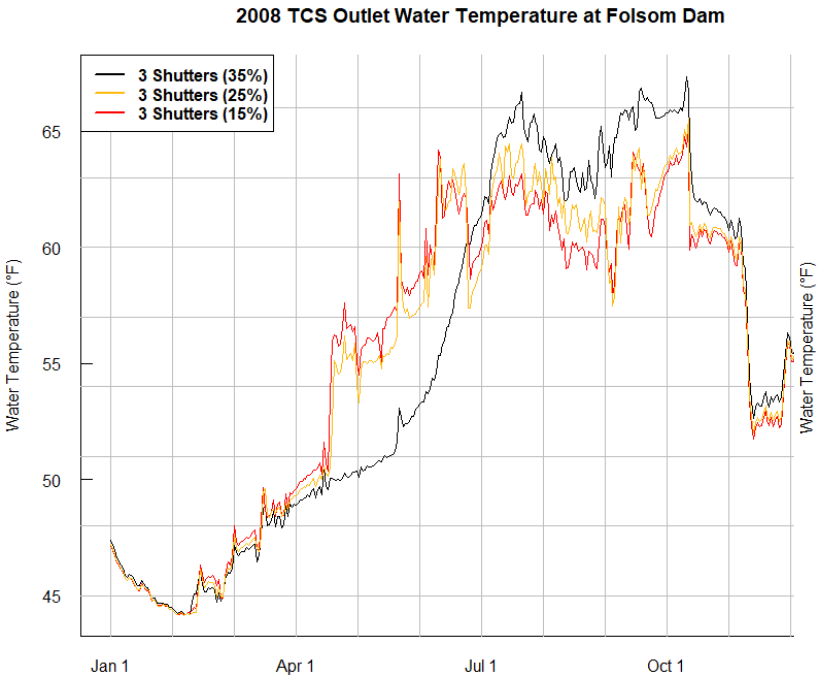


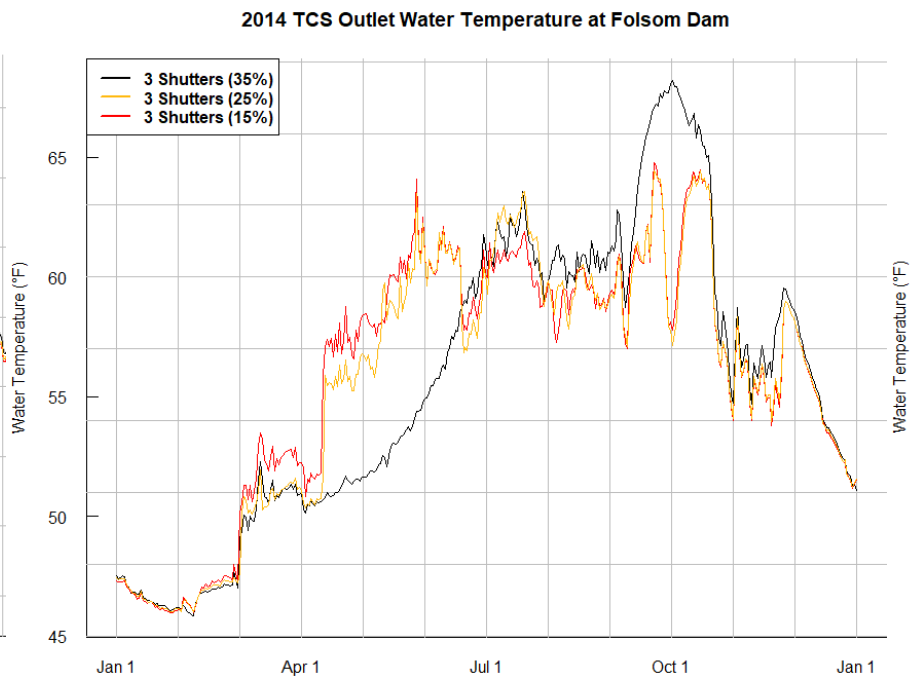


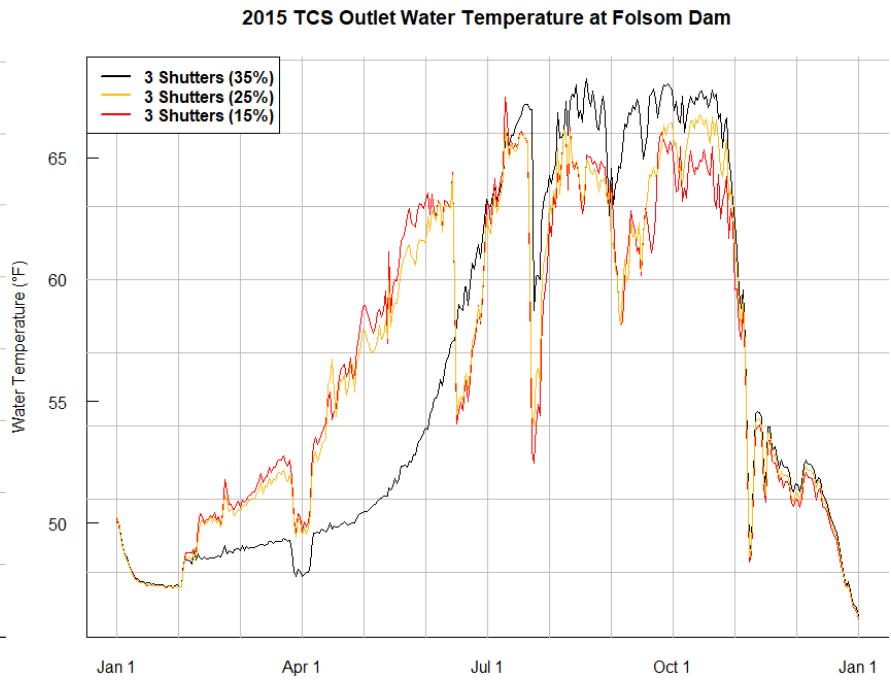


- Relative improvements in the performance of new TCS designs are the greatest during critically dry years.

Effect of Improved Leakage Efficiency on TCS Performance during Critically Dry Years

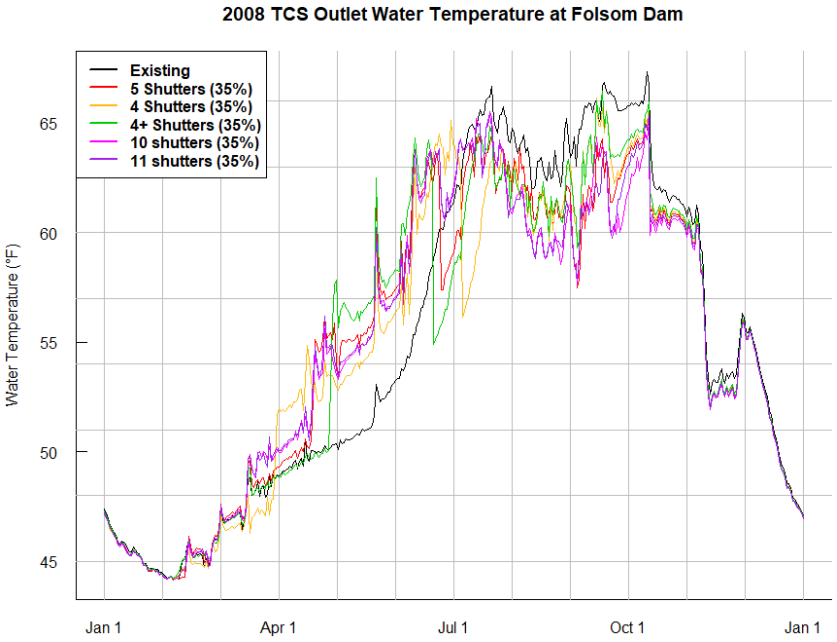


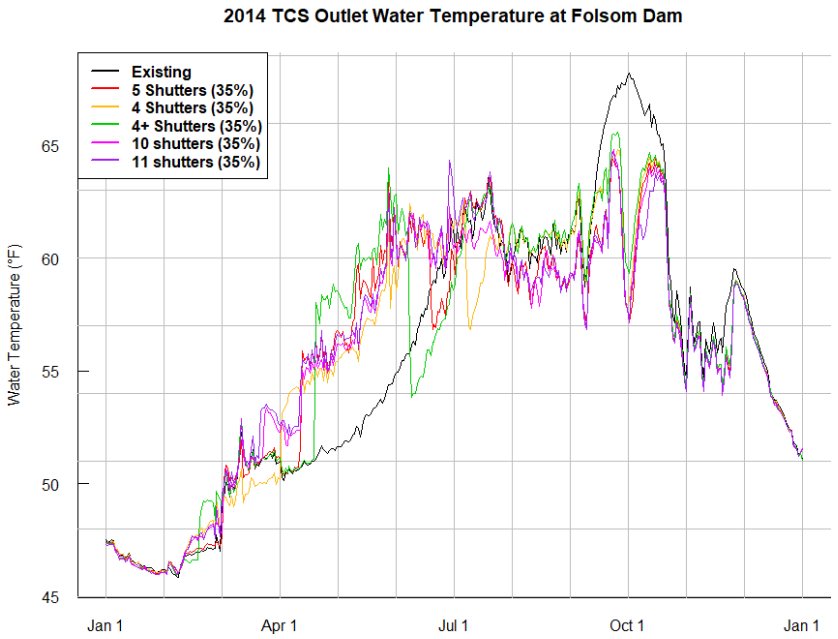


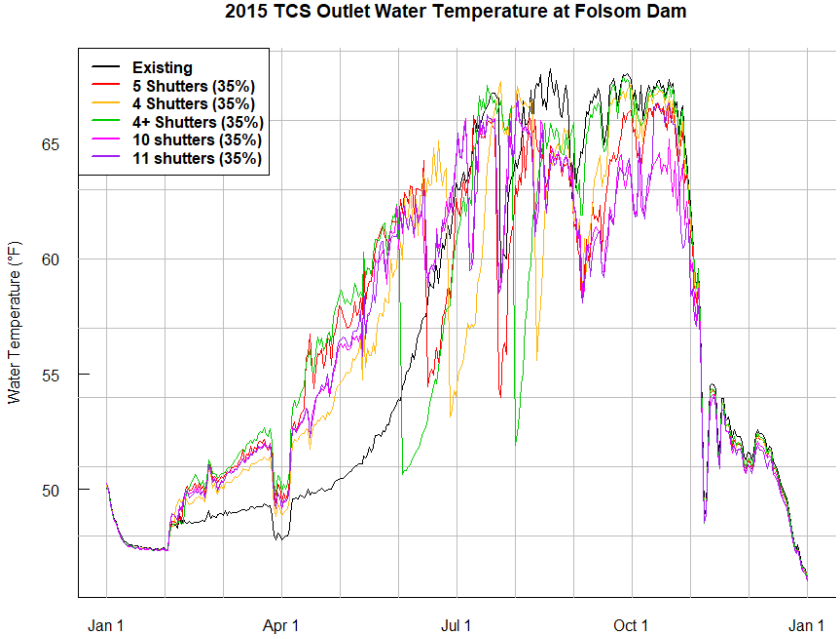


- TCS unit with best leakage efficiency provided the coolest summer and fall release temperatures irrespective of shutter elevations.

Effect of Release Elevations on TCS Performance during Critically Dry Years



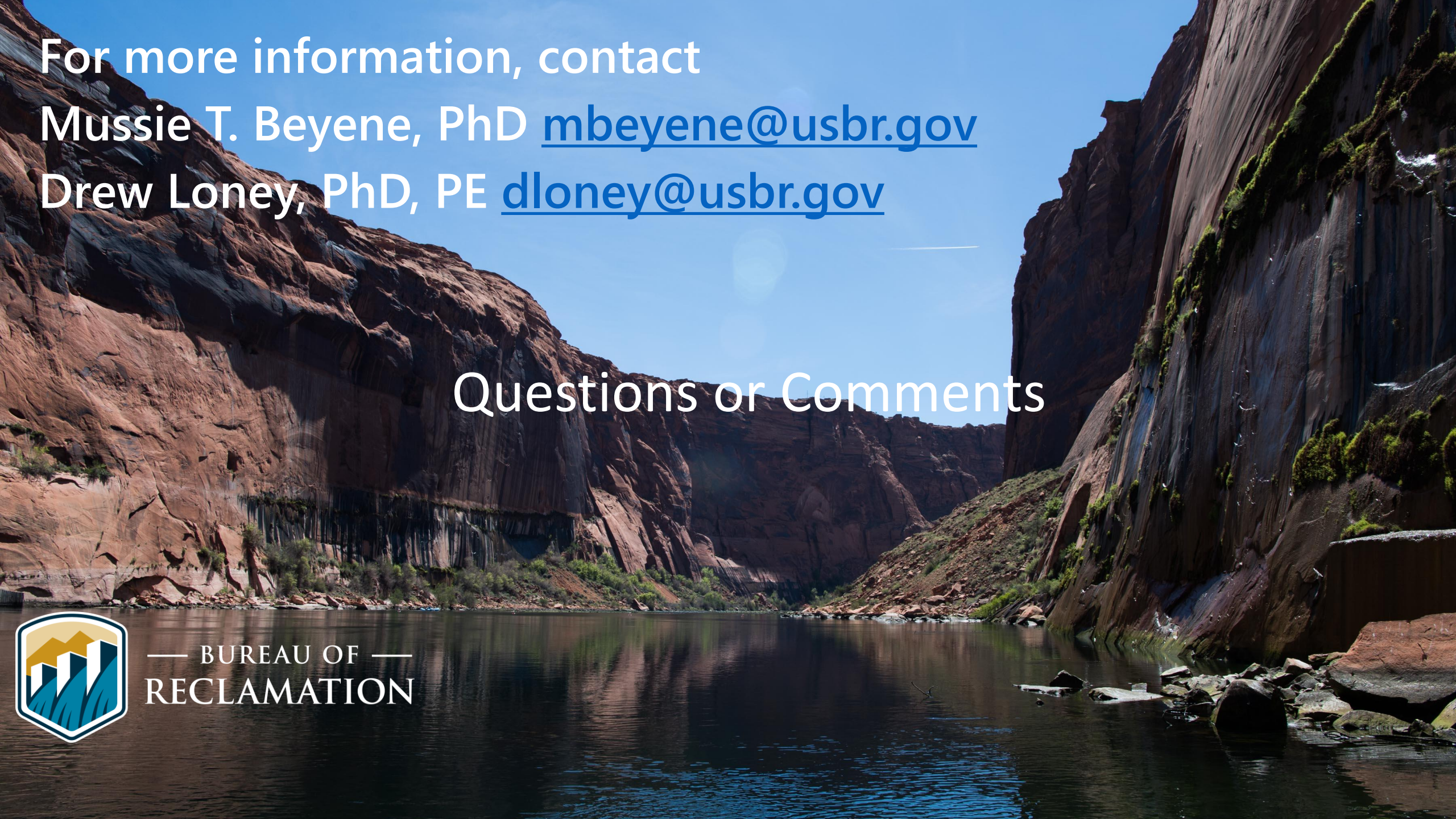




- TCS unit with higher number of release elevations (i.e., 5, 10 & 11 shutters) generally provided the coolest d/s summer and fall release temperatures irrespective of the leakage efficiency.

Summary

- TSC designs with higher number of release elevations and leakage efficiency performed better than TSC designs with lower number of release elevations and leakage efficiency
- The greatest improvements in new TSC designs occurred during critically dry years.



For more information, contact

Mussie T. Beyene, PhD mbeyene@usbr.gov
Drew Loney, PhD, PE dloney@usbr.gov

Questions or Comments

BUREAU OF RECLAMATION