BUREAU OF RECLAMATION

2026 Sacramento River Pulse Flows Operations Plan

3/31/2026

Executive Summary

- Reclamation's Shasta Division has been marked by low snow runoff, warmer air temperatures, and above average Shasta reservoir storage during water year 2026. However, forecasted runoff is anticipated to be low and affect End of September storage.
- Reclamation has discussed many spring pulse flow scenarios for April 2026 and identified considerations through the Sacramento Rive Group (SRG) and evaluated a range of scenarios in this operations plan. Based on available tools, SRG feedback from interest holders, agencies, and tribes Reclamation plans the following operation:
    - A 4-day pulse flow starting on April 8, 2026, with an estimated 25% increase in outmigration survival (compared to no pulse) and an estimated water cost of 35 TAF (estimated resulting Keswick release would be 10,000 cfs targeting a flow at Wilkins Slough flow of 11,000 cfs).
- This pulse flow is anticipated to increase outmigration survival for spring-run Chinook in the lower Sacramento River and fall-run chinook salmon released in the Upper Sacramento River from Coleman Fish Hatchery. In addition, Delta water temperatures are approaching unsuitable levels for outmigrating juvenile salmonids; therefore, an earlier season pulse is likely to have better outmigration survival than later season pulse implementation.
- This pulse flow is anticipated to increase temperature dependent mortality, although there remains a high degree of uncertainty about the differences between these values. This pulse flow reduces end of September Shasta storage, although the Shasta Operations Framework year type should remain a Bin 2B. This pulse flow is likely to reduce fall operational flexibility to reduce fall-run Chinook salmon redd dewatering.
- Reclamation will continue to coordinate and evaluate additional Central Valley Project Pulse Flows through the SRG once an April operations forecast and Draft Temperature Management Plan is available.

Background

As part of Action 5 for the Long term Operation of the Central Valley Project and State Water Project (2.11 Central Valley Project Pulse Flows), pulse flows address the outmigration cue stressor on steelhead juveniles and spring-run Chinook salmon juveniles

by providing flow cues for outmigration and increasing the outmigration travel rate. Reclamation would release up to 150 thousand acre-feet (TAF) in pulse flow(s) each water year, typically in the spring when the pulse does not interfere with the ability to meet water temperature objectives or other anticipated operations of the reservoir. Reclamation through governance, may discuss the plan and make any appropriate and/or necessary refinements prior to implementation.

Forums are established for the purpose of sharing operational plans via notifications, gathering scientific and commercial data to inform the operation of the CVP and SWP, and for reporting the outcomes of operations. Reclamation would schedule this pulse after coordination through the (SRG) and may include coordinating timing with natural flow events, potential storage management operations and/or pulse flows in tributaries. The timing, magnitude, duration, and frequency of the pulse flows will be refined through the SRG assessment process. The SRG ad hoc pulse flow group convened to discuss pulse flows on 3/17 and 3/24. The SRG convened on 3/26 to discuss, among other items, spring pulse flow. The SRG provided feedback about these conditions and requests included pulse flows in late March. At the March 26 SRG meeting, early observations of coldwater pool stratification were presented and showed very low volumes of coldwater. At the March 31 SRG meeting, a draft of this Operation Plan was shared, and the start date was moved back a day further.

The temperature and flow plans are developed using the best available science including current hydrologic forecasts, CVP operational outlooks, fishery information, and modeling information. Reclamation coordinates through SRG to develop a protocol for agency collaboration regarding temperature and flow models and will strive to create shared understanding of model constraints, uncertainties, limitations, applied assumptions and interpretations; develop management questions and scenarios that may benefit from modeling support; develop and review early season operational scenarios to support temperature management and flow planning. Reclamation, through the Fish and Water Operations Group (FAWOG), will discuss the weekly fish and water outlook operations plan assessment and make any appropriate and/or necessary refinements prior to implementation. SRG meeting notes are posted to Reclamation's webpage.

Forecasted and Current Conditions

Shasta storage is 4.065 MAF as of March 23, 2026, which is 121% of the 15-year average. Total May 1 Shasta Reservoir storage is predicted to be 3.916 MAF based on the

preliminary March 90% exceedance forecast and 3.940 MAF based on the preliminary March 50% exceedance forecast. Snowpack levels are 8 percent of average (Figure 1). March Shasta Reservoir temperature profiles as of March 23, consist of low cold-water pool similar to a drought year (Northern CVP Water Temperature Report).Water temperatures at Wilkins Slough are approaching 68F (Figure 2).

CVP actual operations do not follow any forecasted operation or outlook; actual operations are based on real-time conditions. CVP operational forecasts or outlooks represent general system-wide dynamics and do not necessarily address specific watershed/tributary details. CVP releases or export values represent monthly averages. CVP Operations are updated monthly as new hydrology information is made available December through May.

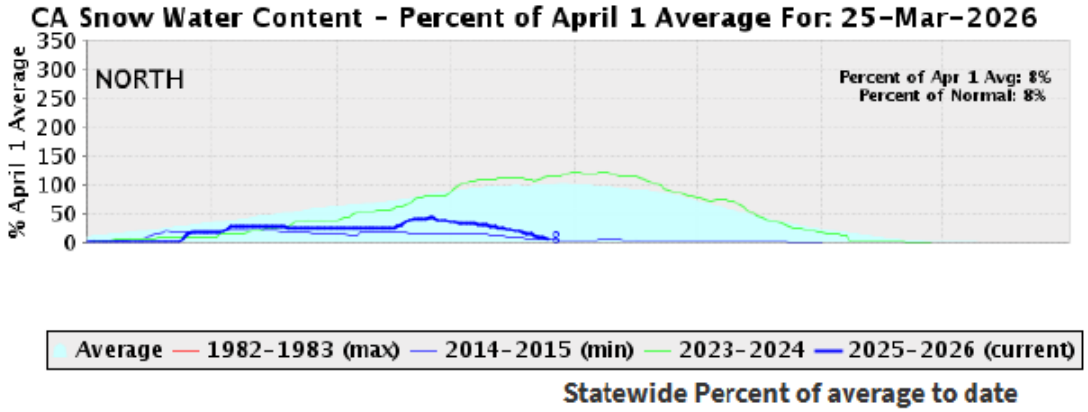


Figure 1. Snowpack Conditions - Snow Water Content Graph

Figure 1 shows statewide California snow water content as a percent of the April 1 average as of March 25, 2026. Current statewide snowpack conditions are approximately 8 percent of the April 1 average, which is substantially below the historical average and recent representative water years shown in the figure. These conditions indicate limited snowpack accumulation heading into the late-season runoff period.

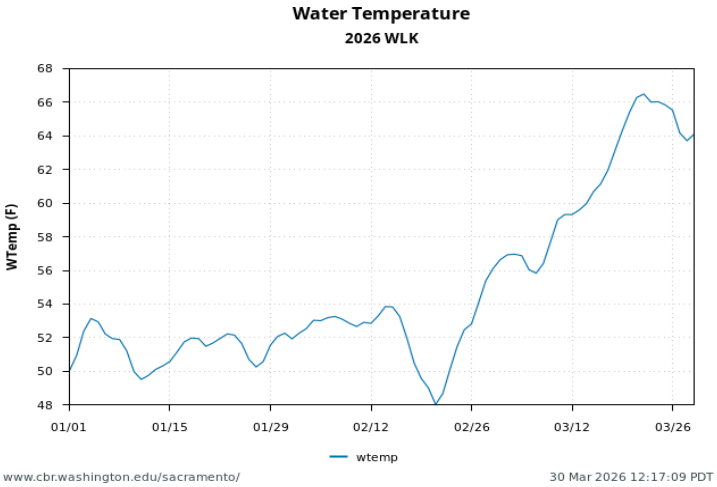


Figure 2. Water temperatures at Wilkins Slough.

Figure 2 shows daily water temperature at Wilkins Slough during early 2026. Water temperatures generally ranged from approximately 49°F to 54°F through January and early February, briefly declined to near 48°F in mid-February, and then increased steadily through March to approximately 66°F by late March. These conditions reflect seasonal warming trends typical of late winter transitioning into early spring.

Scenario Modeling

655 scenarios were modeled to assess outmigration survival benefits (Attachment 1; 2026 Sacramento River Spring Pulse Flow Scenario Evaluation). Note the tool used to develop these scenarios is not peer reviewed and for discussion purposes only. Many of these scenarios are anticipated to interfere with temperature management objectives and even exceed 150 TAF, which are not being considered. There are also concerns with elevated water temperatures impact to outmigration survival and interest in implementing pulse flow action/s earlier in the early than in previous years.

Temperature Dependent Mortality (TDM) modeling compared the NAA, and pulses of 10, 20,30,40, 50 TAF occurring in the month of April based on the March 90% forecast exceedance (Table 1). Water temperature forecasts were contrary to expectations in which pulse scenarios of lower volumes of 50 TAF were warmer and consequently had higher TDM estimates than the 50 TAF scenario. Also unexpected was the 50 TAF pulse in May scenario was forecasted to be warmer than the 50 TAF in April and 50 TAF in May scenario and therefore was estimated to have higher TDM than that scenario. Overall, the scenarios are fairly similar results, and our tools are likely not precise enough for evaluating 10 TAF volume differences. For more information, refer to Attachment 2.

TDM values described in the tradeoff table do not correspond perfectly with the flow scenarios as more precise estimates for water cost are available for the flow scheduling than is practical for temperature modeling. Water costs for scenarios were rounded to the nearest 10 TAF for assigning TDM values.

Table 1. Water and fish management predicted performance measures for considered scenarios. Survival was estimated with the Burford et al (2025) model.

Metric	Scenario description	EOA (MAF)	EOS (MAF)	Bin	TDM% (stage-dependent)	TDM% (stage-independent)	Predicted Estimated Survival (%)	% Change in Survival	Water Cost (TAF)
No Pulse	No pulse flow	3.916	2.105	2B	3	6	3.9	0	0
3.1	1-day pulse 4/7	3.903	2.092	2B	8	13	4.2	7.1	13
3.2	2-day pulse 4/7	3.896	2.085	2B	4	9	4.4	11.1	20.1
3.3	3-day pulse 4/7	3.888	2.077	2B	4	9	4.6	17.5	27.9
3.4	4-day pulse 4/7	3.881	2.07	2B	4	9	4.7	24.5	35.3
4.1	1-day pulse 4/14	3.902	2.091	2B	8	13	4.4	16	14
4.2	2-day pulse 4/14	3.894	2.083	2B	4	9	4.8	27.5	22.4
4.3	3-day pulse 4/14	3.885	2.074	2B	4	9	5.5	41.3	30.8

Anticipated Salmonid Effects

Spring-run young-of-year outmigrate from the upper Sacramento River through the winter and spring. Between 2010-2024, the mean date of passage by these fish at Red Bluff Diversion Dam is March 15, with 95% passing by April 26. Spring-run Chinook salmon from Mill and Deer Creek and other tributaries demonstrate a shorter outmigration period, typically peaking in late April and May. Between 2010-2024, the mean date of passage entering the Delta (e.g. Sacramento Trawl) for spring-run Chinook salmon was April 8, with 95% entering the Delta by April 27. This periodicity suggests spring-run Chinook salmon rearing in the lower Sacramento River through April and May. Fish monitoring is detecting these fish in the lower Sacramento River and Delta, where spring-run Chinook salmon (Feather River lineage) are being salvaged at the CVP and SWP fish collection facilities.

Those outmigrating in April and May experience worse outmigration conditions during this later period of their outmigration. In 2023-2025, pulse flows during late April and early May were predicted to have the greatest improvement in riverine outmigration survival.

Steelhead juveniles migrate past Red Bluff Diversion as early as April and throughout the summer, which likely reflects redistribution of these fish into rearing habitat rather than outmigration through the Sacramento River. Between 2011-2025, the median date for steelhead outmigration passing Knights Landing was March 12 and the median last day of May 3 suggesting many steelhead smolts outmigrate prior to May.

Fall-run Chinook salmon are being released from Coleman National Fish Hatchery in March and April 2026. During water year 2025, fall-run Chinook salmon passage by Red Bluff Diversion Dam was greatest in January and early February when high flows occurred in the upper Sacramento River, and currently very few fall-run Chinook salmon are being sampled at Red Bluff Diversion Dam (Figure 3; Michel 2026 Attachment 1). This year, water temperatures are already approaching unsuitable levels (i.e., above 68°F; Marine and Cech 2004) for outmigrating salmonids. For example, water temperatures were 67.6°F on March 22 at Wilkins Slough. Historically, temperatures at critical migration points in the river and Delta do not exceed 68°F until late April (Figure 4-5).

Increased reservoir releases can improve outmigration conditions resulting in better survival than under lower releases (Notch et al 2020, Michel et al 2021, Burford et al 2025). Due to warm March water temperatures (Figure 4-5), the SRG has shared feedback to pair WY2026 pulse flow releases with water temperature conditions in early April before it is expected to be too hot downstream. There remains uncertainty as to the mechanism resulting in improved outmigration survival and is likely increased flows resulting in some combination of reduced travel times by juvenile salmon, reduced predation effects, and improvement in other environmental conditions favoring successful outmigration (e.g. cooler temperatures, higher turbidity, greater habitat access).

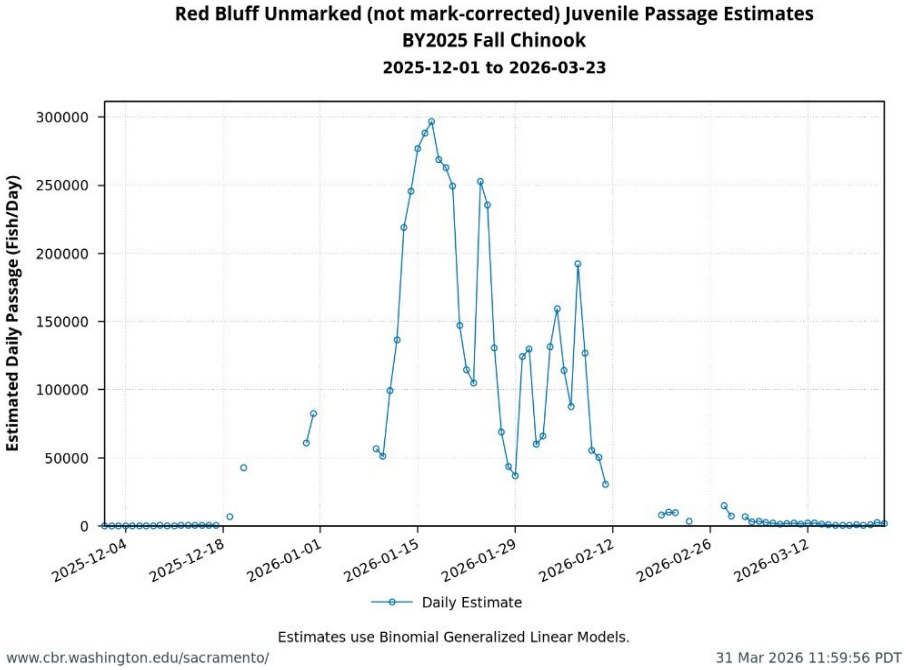


Figure 3. Historic median daily passage (with 20-day moving average smoothing) at Red Bluff Diversion Dam screw traps for all years of data (2006-2019), for spring-run chinook salmon.

Figure 3 illustrates the seasonal timing pattern of juvenile spring-run Chinook salmon passage past Red Bluff Diversion Dam based on long-term observations from 2006 through 2019. Passage generally increases through winter, peaks in late winter to early spring, and declines through the remainder of the spring migration period, reflecting the typical outmigration window for this run.

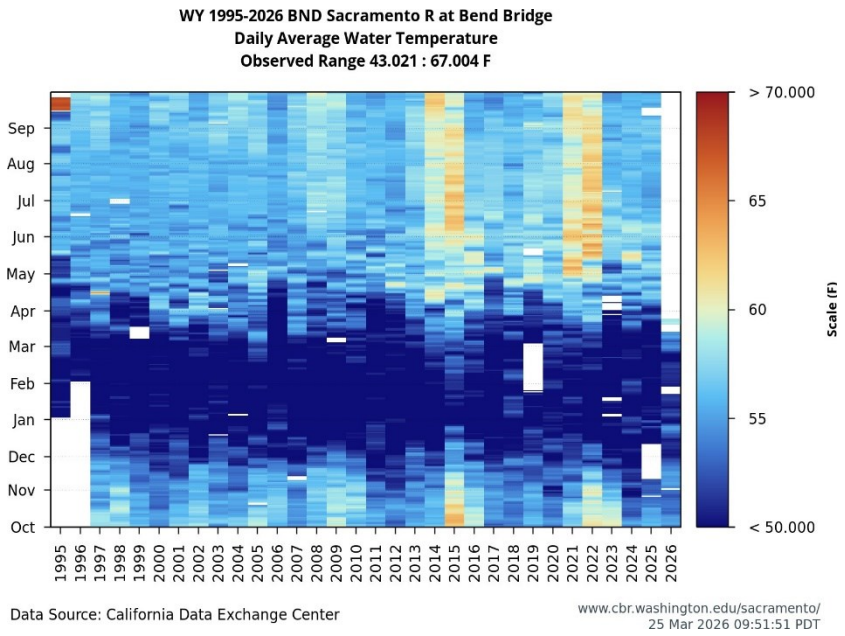


Figure 4. Historical water temperature (degree F) in the Sacramento River at Bend Bridge. Historical water temperatures in degrees F from 2008 to 2026 at Freeport.

Figure 4 shows historical daily average water temperature patterns in the Sacramento River at Bend Bridge across water years 1995 through 2026. The figure illustrates substantial interannual variability in spring water temperatures, with cooler conditions generally observed in wetter years and warmer conditions more common in drier years. In particular, May temperatures in some dry years exceed levels typically considered suitable for juvenile salmonid outmigration, while wetter years more often maintain cooler temperature conditions during this period.

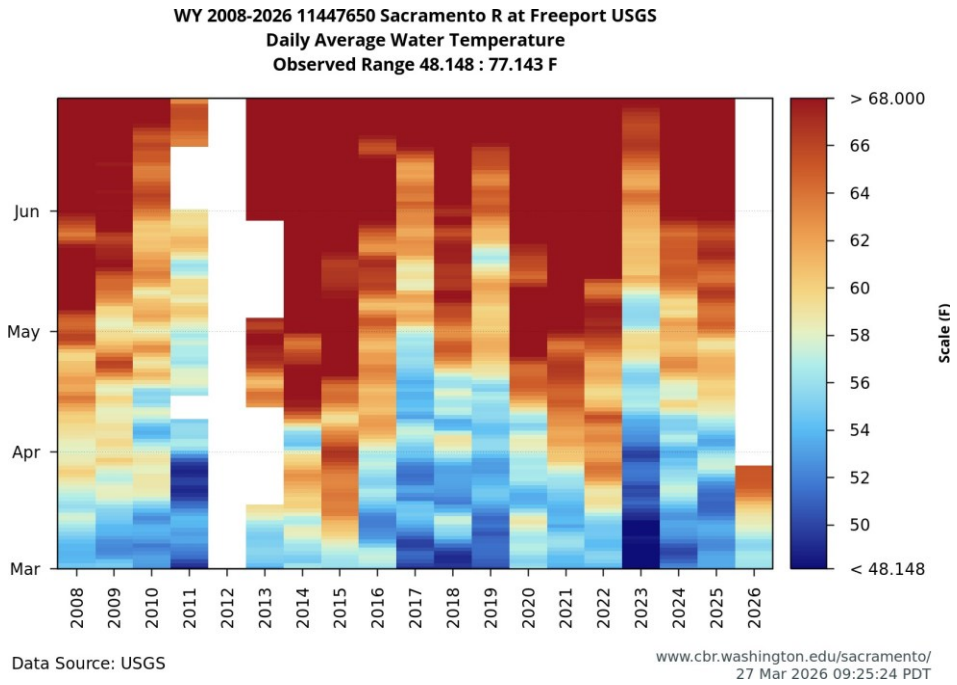


Figure 5. Historical water temperatures in degrees F from 2008 to 2026 at Freeport.

Figure 5 shows historical daily average water temperature patterns in the Sacramento River at Freeport from 2008 through 2026. The figure illustrates seasonal warming trends from March through June each year, with substantial interannual variability in spring temperatures. In some years, temperatures increase rapidly during late spring and exceed levels typically considered suitable for juvenile salmonid outmigration, while other years maintain cooler conditions for a longer portion of the migration period.

Initial real-time results for this year's Pulse Flow Study as well as previous years are posted to: CalFishTrack. Results will be posted to: Central Valley Enhanced Acoustic Tagging Project (noaa.gov) and will also be reported in the Shasta Winter Storage Rebuilding and Spring Pulse Flow Seasonal Report. In addition, wild O. mykiss have been acoustically tagged and released in the Sacramento River to evaluate survival and outmigration rates; however, many of these transmitters may expire before the end of the season CalFishTrack.

Considerations

ACID dam facility

This requires low flow (4,000 to 6,000 cfs) during its installation and cannot sustain high flows greater than 14,000 cfs while fully installed; although flashboards can be removed to adjust flow capacity ACID Dam was installed during the last two weeks of March.

Diversion Schedule

Water Diversions on the Sacramento River are expected to increase mid-April as agricultural water demands begin to ramp up. As these depletions increase, releases from Shasta would increase to meet demands.

Ecological effects

Interested parties have provided observations and described concerns related to reduced insect abundance, juvenile stranding, redd scouring, and other disruptions to spawning events that they believe are associated with pulse/storm flows releases. In 2024, trout guides observed impacts to invertebrate communities following large flood control release that were around 36,000 cfs, which may be three orders of magnitude greater than the spring pulse flows.

Fish Monitoring

Flow fluctuations are anticipated to affect monitoring efforts. For example, efforts for juvenile stranding surveys increase, and effectiveness monitoring for habitat restoration projects is hindered during flow fluctuations. Flows exceeding 20,000 cfs can hinder continuous sampling at Red Bluff rotary screw trap.

GCID Hamilton City Intake Channel Dredging Project

GCID is preparing to start work on Dredging of the Hamilton City Intake Channel pursuant to our permit with CDFW. This is a critical activity to provide sufficient flow through the fish screen and pumping plant to service GCID landowners and the three wildlife refuges served by GCID. Currently, pursuant to the permit, GCID must put in a fish guidance structure 7 days prior to starting dredging activities. Currently, GCID anticipates that occurring on April 2nd and possibly April 3rd to complete. GCID anticipates initiating dredge efforts on April 9th or 10th. There are concerns that the higher river levels associated with a pulse flow could affect dredging work due to high river levels during the pulse flow. GCID prefers if such an action could be complete on or before April 9th.

Reclamation updated GCID regarding potential pulse flows on March 30. Continued close coordination with GCID may be able to minimize impacts and ensure their permit condition compliance and complete this important maintenance.

Habitat restoration project implementation

Salmonid rearing habitat project in which 25 to 30 rockwads are being installed upstream of Sundial Bridge during the first week in May. Variable flows could affect barge and stability of craning the rockwads into the river. Higher flows are likely beneficial for building the barge due to deposition at the access site.

Hatchery releases

Coleman National Fish Hatchery fall-run smolts are ready for release early this year. Most of these fish were or are planned to be released in March and early April. Juvenile fall-run Chinook that outmigrate during higher flows and cooler conditions are expected to have better survival.

Hydropower Generation

In terms of power cost impacts, it is generally preferrable to schedule the peak of a pulse flow to occur during the week rather than the weekend, and during warmer periods.

Lunar phase

Outmigration survival is anticipated to increase during a new moon and predation is hypothesized to decrease due to reduced illumination. The new moon is Friday April 17 and May 16.

Recreational and Commercial Fishing

Fishing guides have expressed concerns with variable flows impacting trout behavior and fly hatches, which affect their business.

Redd Dewatering and Juvenile Stranding

WY2026 Spring pulse flows are likely to manage End of September Storage close to the Shasta Framework Bin 2b/3 threshold of 2.0MAF. This may potentially reduce flexibility for higher releases as part of the Wilkins Slough October Maximum Flows and Fall Release Ramp Down (November) actions. Through Governance, Reclamation may determine releases and ramping rates are necessary, that potentially result in higher Chinook salmon stranding and redd dewatering than without pulse flows to maximize the available coldwater pool for water year 2027.

Seepage

Flows exceeding 18,000 cfs at Wilkins Slough have been reported to create seepage problems. Also, weir spills limit the ability for ground preparation and farming within the bypasses, so those thresholds should be considered.

Storage and temperature-dependent mortality

Temperature modeling is unreliable before thermoclines establish in Shasta, typically in late April. In previous years, pulse flow planning occurred simultaneously to temperature management planning during April when temperature stratification allowed for modeling temperature-dependent mortality. Another method is to consider general relationships between Shasta storage and TDM, as shown in Figure 6. In this positional analysis, TDM was estimated using a 53° F, 54°F, and 55° F temperature target at Sacramento at Clear Creek, combining different starting storage levels, hydrology, and meteorology in CalSim2. This produced 100 TDM estimates at individual end-of-April storage values across a range of these storage levels, summarized in boxplots in Figure 4 below. The assumptions for this relationship reflect a deprecated No Action Alternative operations logic, meaning the operational nuances of Action 5 are not reflected. Nonetheless, with few exceptions, TDM remains low when end-of-April Shasta storage is above 3.8 MAF, and end of September

Shasta storage exceeds 2.0 MAF. Current forecasts project end-of-April Shasta storage may or may not exceed 3.8 MAF with implementation of full potential pulse flow volume (150,000 acre feet). Pulse flow action implementation could also result in EOS Shasta storage volume below 2.0 MAF.

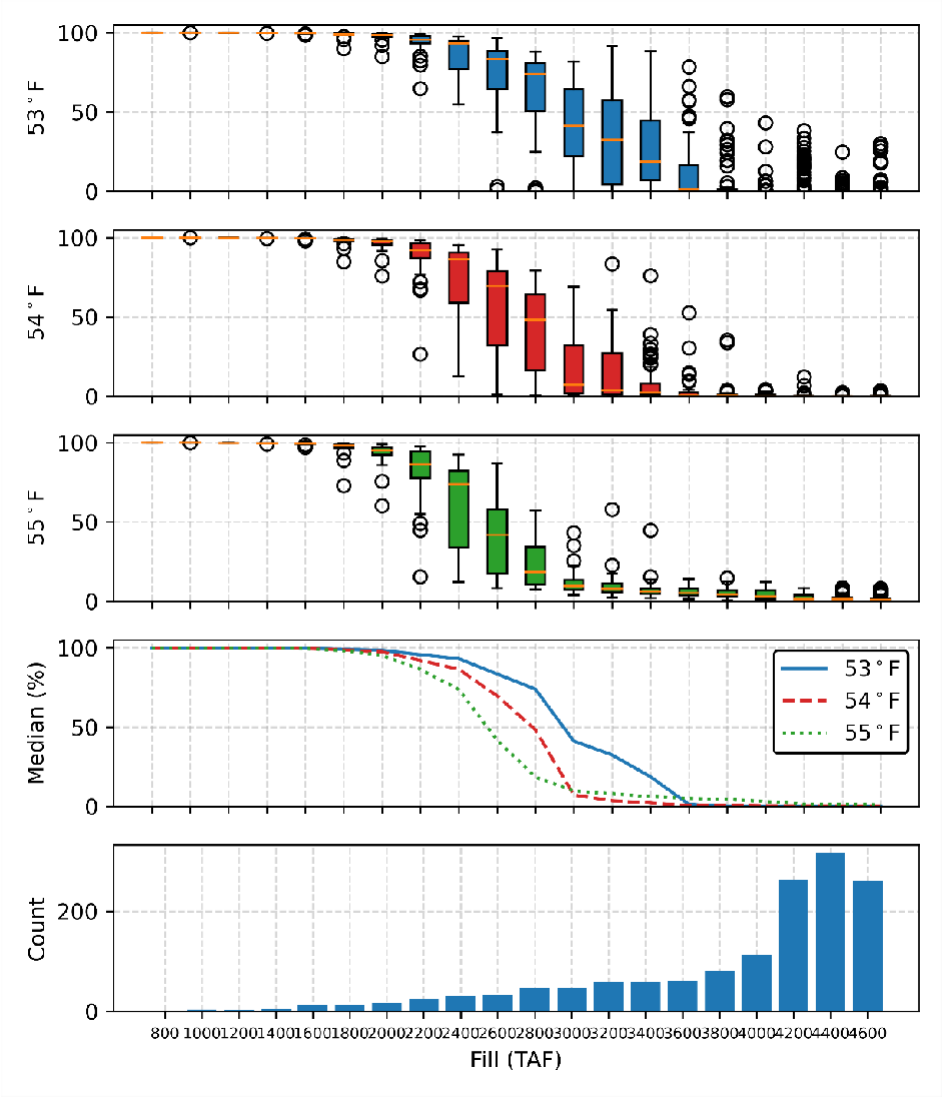


Figure 6. Winter-run Chinook salmon percent temperature dependent mortality (TDM) estimates associated with Shasta fill (e.g., end of April storage; thousand of acre feet (TAF). This figure utilizes the Calsim II model with deprecated No Action Alternative operations logic.

Figure 6 shows the relationship between end-of-April Shasta Reservoir storage and estimated temperature-dependent mortality for winter-run Chinook salmon under multiple temperature thresholds. Results indicate that higher reservoir storage levels are generally associated with lower mortality risk, while lower storage levels correspond to substantially higher projected mortality. The figure also illustrates that mortality increases more rapidly under warmer temperature thresholds, highlighting the sensitivity of winter-run Chinook survival to both storage conditions and downstream temperature management.

Systemwide releases

The American River Group is discussing a spring pulse flow and the possibility of synching with Sacramento River releases. Stanislaus pulse flows are planned April 11-May 9.

Tuolumne River pulse flows are planned to start on April 17.

References

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Marine, KR and JJ Cech. 2004. Effects of high water temperature growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. Fisheries Management 24:198-210.

Michel, CJ, JJ Notch, F Cordoleani, AJ Ammann, EM Danner. 2021. Nonlinear survival of imperiled fish informs managed flows in a highly modified river. Ecosphere. 12:1-20.

Notch, J.J. A.S. McHuron, C.J. Michel, F. Cordoleani, M. Johnson, M.J. Henderson, A.J. Ammann. 2020 Outmigration survival of wild Chinook salmon smolts through the Sacramento River during historic drought and high water conditions. Environmental Biology of Fishes 103: 561-576.

Attachment 1: Pulse flow scenario evaluation

Pulse flow scenario evaluation

2026 Spring Pulse Flow Survival Simulations for Flow Scenarios

Prepared by Cyril Michel, UC Santa Cruz, cyril.michel@noaa.gov

Using operational forecasts from file: Spring Pulse Flow Mar23 2026.xlsx

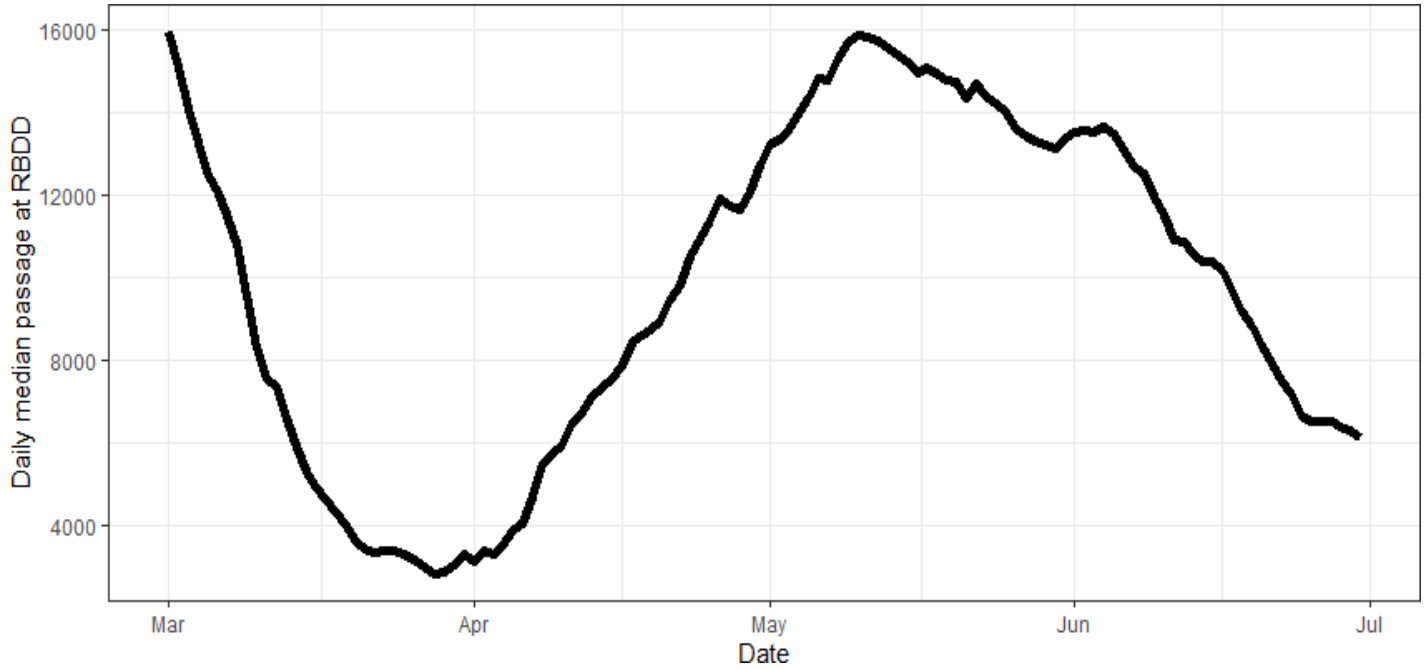


Figure 1. Historic median daily passage (with 20-day moving average smoothing) at Red Bluff Diversion Dam USFWS Screw traps for all years of data (2006-2019)

Figure 1 illustrates the typical seasonal timing of juvenile salmonid passage at Red Bluff Diversion Dam based on median daily estimates from 2006 through 2019. Passage generally declines through March, increases through April, and reaches peak levels in May before gradually decreasing through June. This pattern reflects the characteristic spring outmigration period observed at this monitoring location.

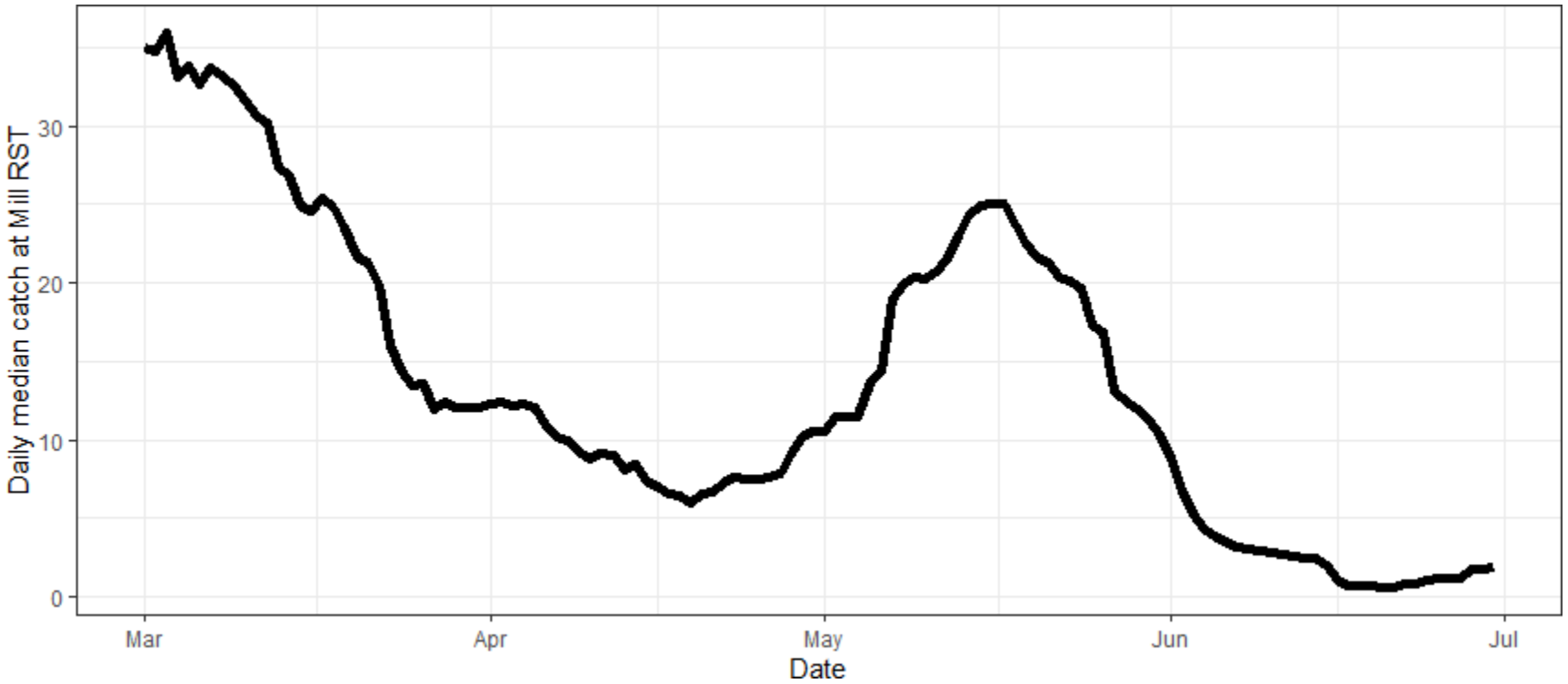


Figure 2. Historic median daily catch (with 20-day moving average smoothing) at Mill Creek CDFW Screw trap for all years of data (1996, 2000, 2001, 2002, 2003, 2007, 2008, 2009, and 2010)

Figure 2 illustrates the typical seasonal timing of juvenile salmonid catch at the Mill Creek screw trap based on median daily estimates across available monitoring years. Catch is generally highest in early March, declines through April, increases again to a secondary peak in mid-May, and then decreases to low levels by June. This pattern reflects the seasonal progression of juvenile outmigration observed in Mill Creek.

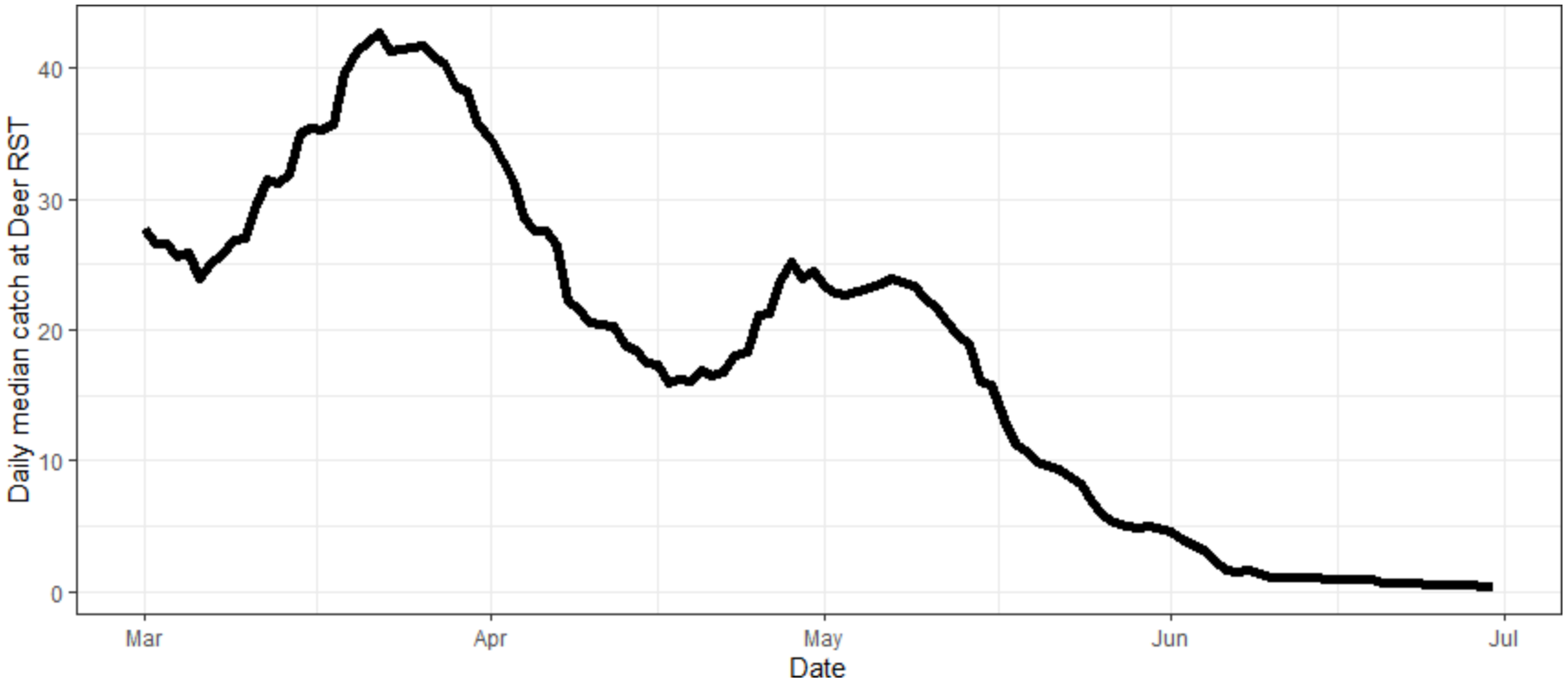


Figure 3. Historic median daily catch (with 20-day moving average smoothing) at Deer Creek CDFW Screw trap for all years of data (1995, 1996, 2000, 2001, 2002, 2003, 2004, 2005, 2007, 2009, and 2010).

Figure 3 illustrates the typical seasonal timing of juvenile salmonid catch at the Deer Creek screw trap based on median daily estimates across available monitoring years. Catch generally increases through March to a peak in late March, followed by a gradual decline through April, a smaller secondary increase in early May, and continued decreases to low levels by June. This pattern reflects the seasonal progression of juvenile outmigration observed in Deer Creek.

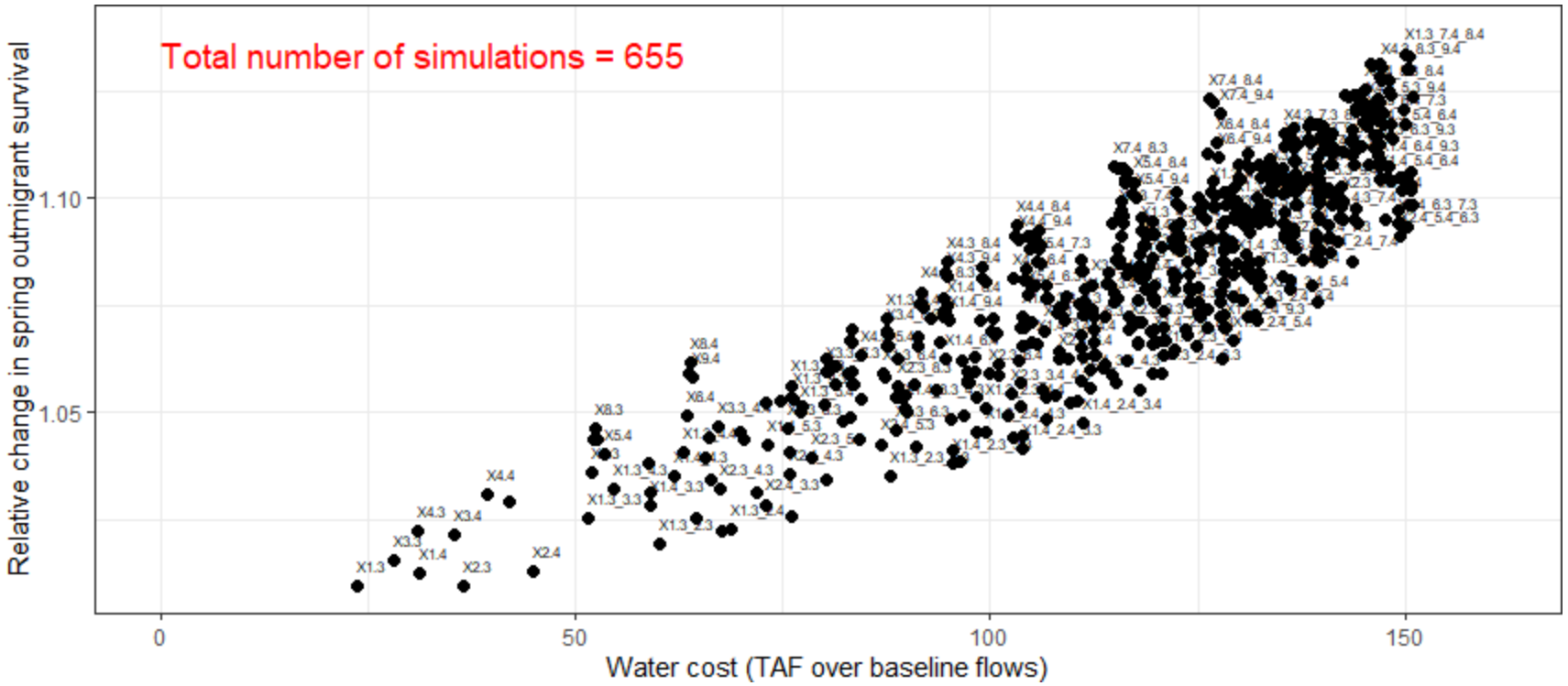


Figure 4. Relative change in spring outmigration survival (over status quo) as a function of water cost (TAF) for all pulse flow scenarios using all years of fish passage data at RBDD (2006-2019), and using the Michel et al. (2021) nonlinear flow:survival relationship

Figure 4 illustrates modeled changes in spring outmigration survival relative to baseline conditions across a range of pulse flow scenarios with varying water costs. Results indicate a generally positive relationship between increased water allocation above baseline flows and improved estimated survival, with higher water costs associated with progressively greater relative survival benefits. The distribution of simulations reflects variability across pulse flow timing and magnitude scenarios evaluated using historical fish passage data and a nonlinear flow–survival relationship.

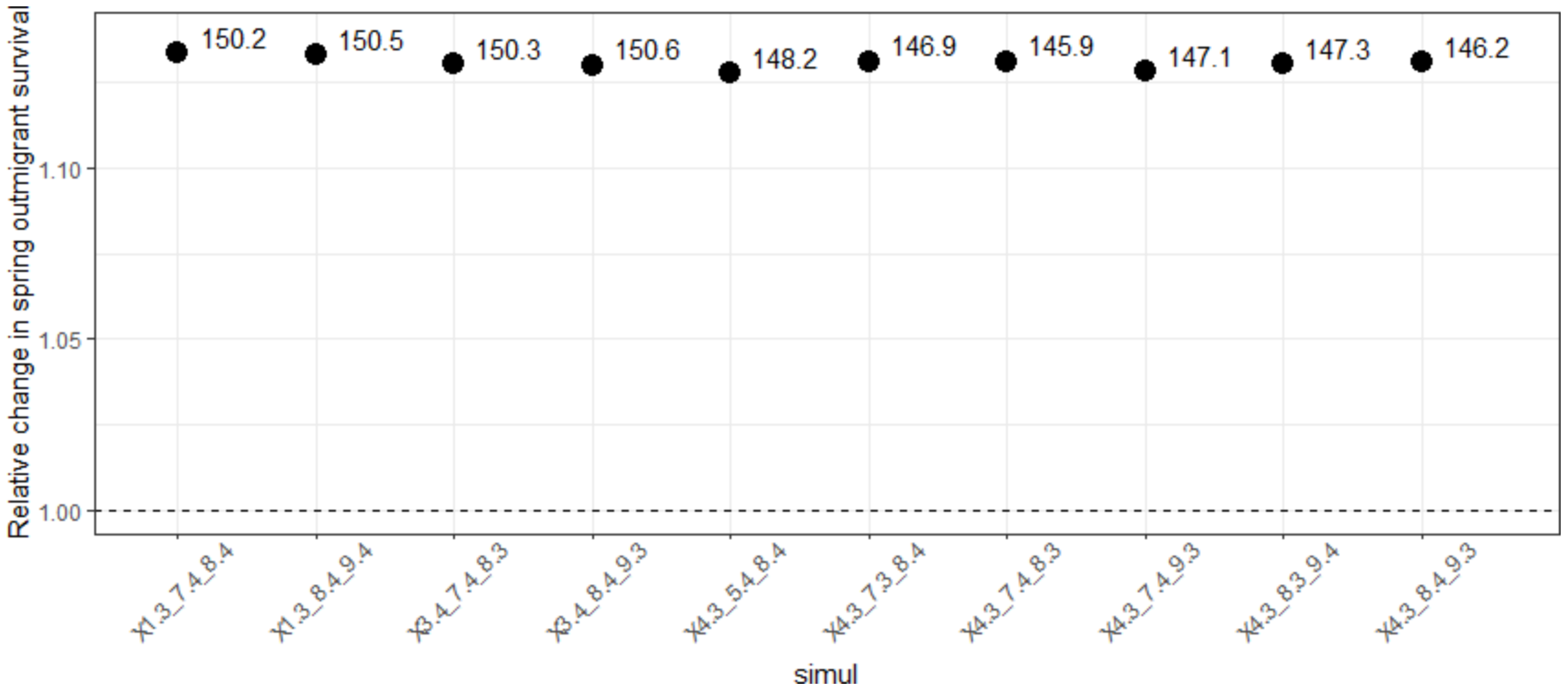


Figure 5. Top 10 pulse flow scenarios as ranked by best spring season survival relative improvement (over status quo), using all years of fish passage data at RBDD (2006-2019), and using the Michel et al. (2021) nonlinear flow:survival relationship. Water cost is shown as point labels (TAF)

Figure 5 shows the ten pulse flow scenarios associated with the greatest modeled increases in spring outmigration survival relative to baseline conditions. All scenarios result in similar relative survival improvements, with modest variation among scenarios and corresponding water costs generally near 145 to 150 TAF. These results highlight a group of scenarios that provide comparable estimated survival benefits under the nonlinear flow–survival relationship applied to historical fish passage data.

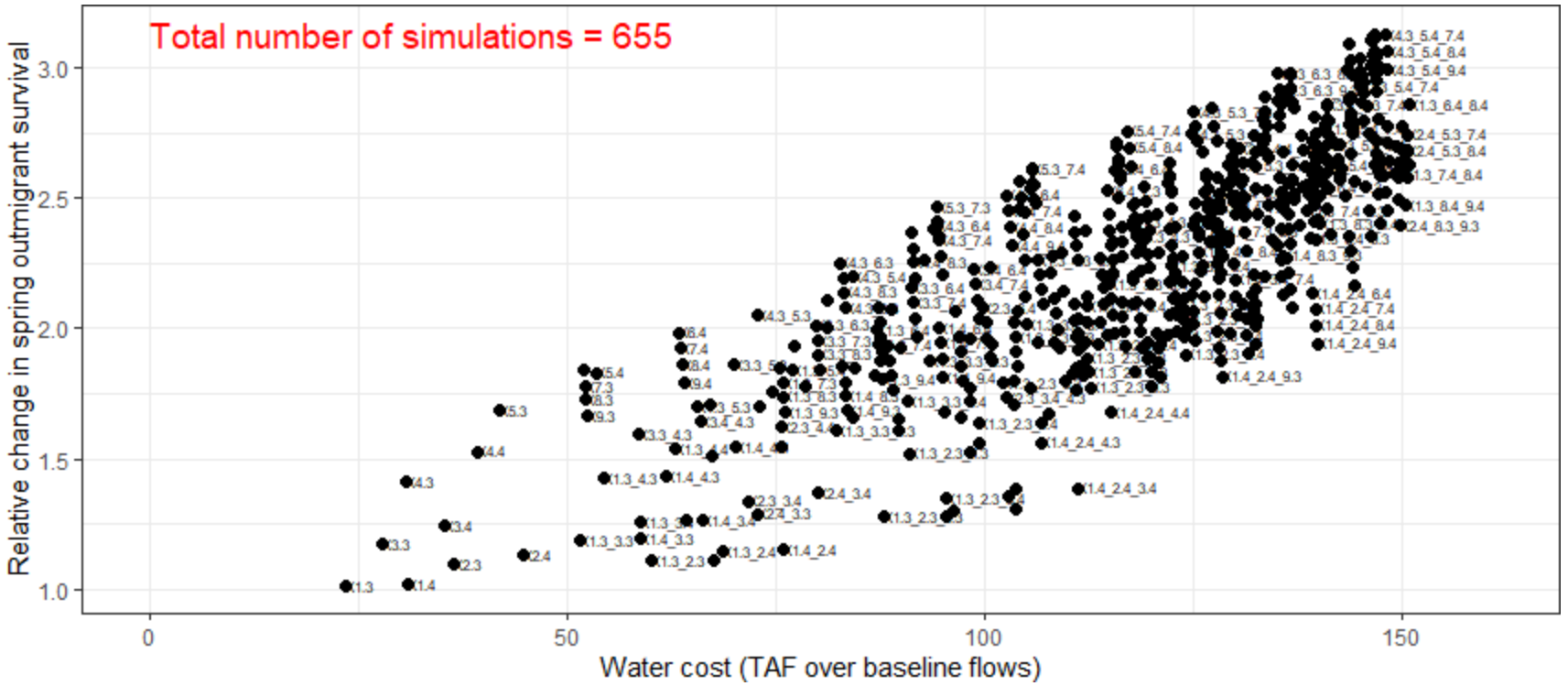


Figure 6. Relative change in spring outmigration survival (over status quo) as a function of water cost (TAF) for all pulse flow scenarios using the Burford et al. (2025) model. This model is different from the Michel et al. (2021) model in 4 ways: 1. it uses a continuous, non-linear relationship between flow and survival (i.e., not a threshold), 2. it incorporates a seasonal component in the flow survival relationship (e.g., survival is worse in June vs April for the same flow), 3. it incorporates responses in the number of fish initiating migration as a function of flow changes, and 4. it estimates survival to Benicia Bridge rather than the confluence of the Sacramento and Feather Rivers (as in Michel et al. 2021).

Figure 6 illustrates the range and distribution of modeled survival responses across pulse flow scenarios evaluated with the Burford et al. (2025) framework. Results show substantially larger estimated survival gains compared to baseline conditions across many scenarios, with survival responses increasing progressively across higher water-cost scenarios and exhibiting greater spread than shown under alternative modeling approaches. The pattern reflects sensitivity to both flow magnitude and timing, as well as migration dynamics incorporated in the modeling framework.

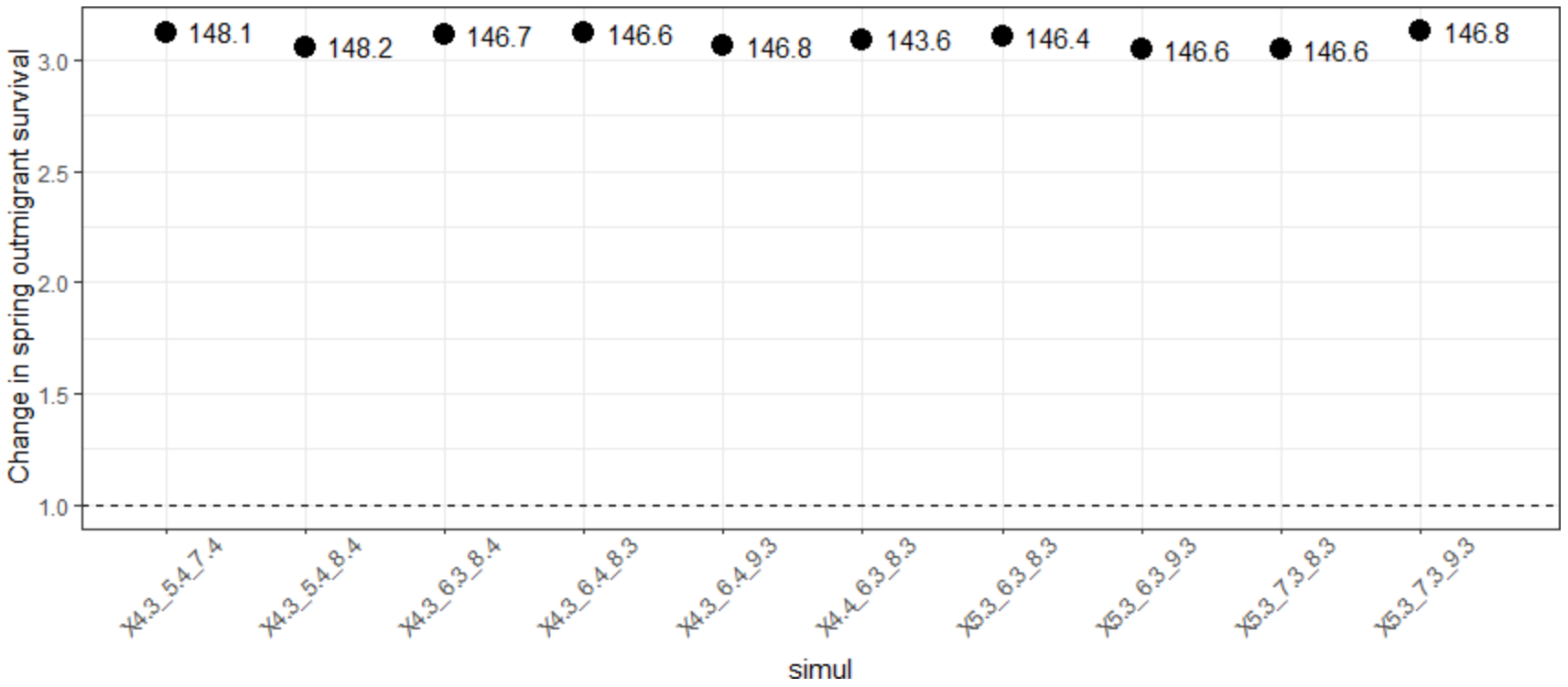


Figure 7. Top 10 pulse flow scenarios as ranked by best spring season survival relative improvement (over status quo) using an adaptation of the Burford et al. (2025) model. This model is different from the Michel et al. (2021) model in 4 ways: 1. it uses a continuous, non-linear relationship between flow and survival (i.e., not a threshold), 2. it incorporates a seasonal component in the flow survival relationship (e.g., survival is worse in June vs April for the same flow), and 3. it incorporates responses in the number of fish initiating migration as a function of flow changes, and 4. it estimates survival to Benicia Bridge rather than the confluence of the Sacramento and Feather Rivers (as in Michel et al. 2021). Water cost is shown as point labels (TAF)

Figure 7 illustrates the magnitude and consistency of modeled survival gains across the highest-performing pulse flow scenarios evaluated with the adapted Burford et al. (2025) framework. Results indicate similarly high estimated survival responses among the leading scenarios, with only modest variation in relative improvement despite differences in scenario configuration and associated water costs. This clustering suggests that multiple pulse flow timing combinations produce comparable modeled benefits under the migration and seasonal survival dynamics represented in the analysis.

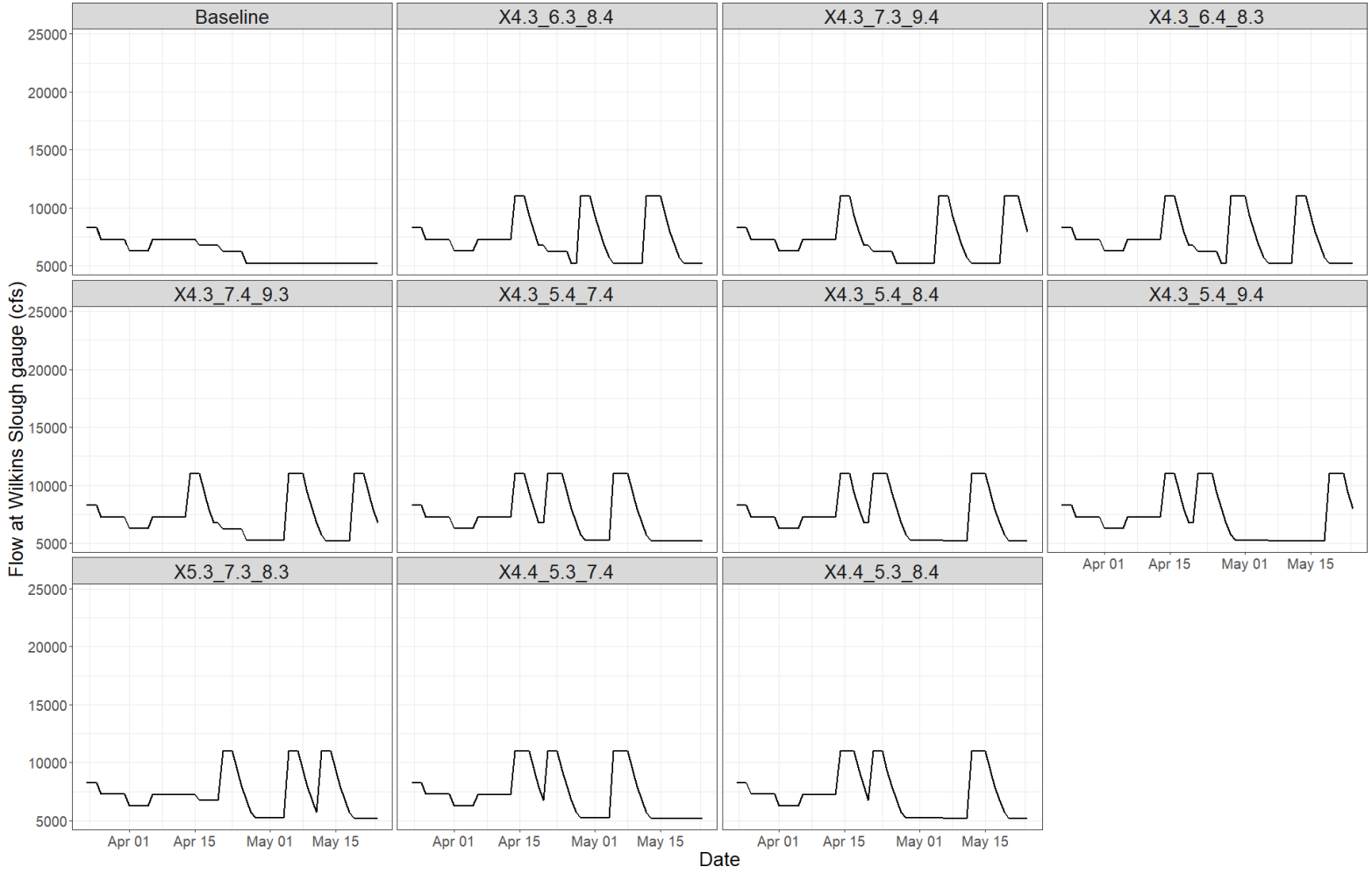


Figure 8. Spring pulse flow hydrographs for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models, and including baseline flows (dashed black line)

Figure 8 illustrates the timing and magnitude of spring pulse flow releases at Wilkins Slough associated with the highest-performing scenarios identified across both modeling approaches, compared to baseline conditions. The scenarios generally include one or more short-duration flow increases during April and May, with similar peak magnitudes but varying timing and sequencing of pulses. These hydrographs highlight the range of alternative pulse flow configurations evaluated to support improved spring outmigration conditions relative to baseline operations.

Table 1. Spring season survival estimates, survival improvement over baseline, and rank for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models and including baseline flows. Please note survival estimates are informed by historical fish abundances and passage timing and should only be used for scenario evaluation and not used at face value.

Scenarios	TAF	Spring Survival Michel	Relative Survival Improvement over Baseline Michel	Spring Survival Burford	Relative Survival Improvement over Baseline Burford	Rank Michel	Rank Burford
X4.3_5.4_7.4	148.1	0.247	1.125	0.123	3.125	13	2
X4.3_5.4_8.4	148.2	0.248	1.128	0.121	3.061	10	8
X4.3_6.3_8.4	146.7	0.247	1.123	0.123	3.115	21	4
X4.3_7.4_9.3	147.1	0.248	1.128	0.118	3.007	9	16
X4.3_6.4_8.3	146.6	0.246	1.121	0.123	3.123	29	3
X4.3_5.4_9.4	148.4	0.247	1.124	0.118	2.991	14	18
X4.3_7.3_9.4	147.2	0.248	1.128	0.117	2.985	11	21
X5.3_7.3_8.3	146.6	0.246	1.122	0.120	3.048	24	9
X4.4_5.3_7.4	145.1	0.246	1.122	0.119	3.034	26	13
X4.4_5.3_8.4	145.2	0.247	1.125	0.117	2.971	12	27
Baseline	0.0	0.220	1.000	0.039	1.000	655	655

Table 2. Hydrograph at Wilkins Slough for baseflow, as well as for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models

Date	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4	Baseline
2026-03-23	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275
2026-03-24	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275
2026-03-25	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275
2026-03-26	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-27	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-28	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-29	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-30	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-03-31	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275	7,275
2026-04-01	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-02	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-03	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-04	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-05	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275	6,275
2026-04-06	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-07	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-08	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-09	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-10	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-11	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-12	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-13	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250	7,250
2026-04-14	11,000	11,000	11,000	11,000	11,000	11,000	11,000	7,250	11,000	11,000	7,250
2026-04-15	11,000	11,000	11,000	11,000	11,000	11,000	11,000	7,250	11,000	11,000	7,250
2026-04-16	11,000	11,000	11,000	11,000	11,000	11,000	11,000	6,750	11,000	11,000	6,750
2026-04-17	9,350	9,350	9,350	9,350	9,350	9,350	9,350	6,750	11,000	11,000	6,750
2026-04-18	7,948	7,948	7,948	7,948	7,948	7,948	7,948	6,750	9,350	9,350	6,750

Date	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4	Baseline
2026-04-19	6,756	6,756	6,756	6,756	6,756	6,756	6,756	6,750	7,948	7,948	6,750
2026-04-20	6,750	6,750	6,750	6,750	6,750	6,750	6,750	6,750	6,756	6,756	6,750
2026-04-21	11,000	11,000	6,250	6,250	6,250	11,000	6,250	11,000	11,000	11,000	6,250
2026-04-22	11,000	11,000	6,225	6,225	6,225	11,000	6,225	11,000	11,000	11,000	6,225
2026-04-23	11,000	11,000	6,225	6,225	6,225	11,000	6,225	11,000	11,000	11,000	6,225
2026-04-24	11,000	11,000	6,225	6,225	6,225	11,000	6,225	9,350	9,350	9,350	6,225
2026-04-25	9,350	9,350	6,225	6,225	6,225	9,350	6,225	7,948	7,948	7,948	6,225
2026-04-26	7,948	7,948	5,225	5,225	5,225	7,948	5,225	6,756	6,756	6,756	5,225
2026-04-27	6,756	6,756	5,225	5,225	5,225	6,756	5,225	5,743	5,743	5,743	5,225
2026-04-28	5,743	5,743	11,000	5,225	11,000	5,743	5,225	5,225	5,225	5,225	5,225
2026-04-29	5,225	5,225	11,000	5,225	11,000	5,225	5,225	5,225	5,225	5,225	5,225
2026-04-30	5,225	5,225	11,000	5,225	11,000	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-01	5,225	5,225	9,350	5,225	11,000	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-02	5,225	5,225	7,948	5,225	9,350	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-03	5,225	5,225	6,756	5,225	7,948	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-04	5,225	5,225	5,743	5,225	6,756	5,225	5,225	5,225	5,225	5,225	5,225
2026-05-05	11,000	5,225	5,225	11,000	5,743	5,225	11,000	11,000	11,000	5,225	5,225
2026-05-06	11,000	5,225	5,225	11,000	5,225	5,225	11,000	11,000	11,000	5,225	5,225
2026-05-07	11,000	5,200	5,200	11,000	5,200	5,200	11,000	11,000	11,000	5,200	5,200
2026-05-08	11,000	5,200	5,200	11,000	5,200	5,200	9,350	9,350	11,000	5,200	5,200
2026-05-09	9,350	5,200	5,200	9,350	5,200	5,200	7,948	7,948	9,350	5,200	5,200
2026-05-10	7,948	5,200	5,200	7,948	5,200	5,200	6,756	6,756	7,948	5,200	5,200
2026-05-11	6,756	5,200	5,200	6,756	5,200	5,200	5,743	5,743	6,756	5,200	5,200
2026-05-12	5,743	11,000	11,000	5,743	11,000	5,200	5,200	11,000	5,743	11,000	5,200
2026-05-13	5,200	11,000	11,000	5,200	11,000	5,200	5,200	11,000	5,200	11,000	5,200
2026-05-14	5,200	11,000	11,000	5,200	11,000	5,200	5,200	11,000	5,200	11,000	5,200
2026-05-15	5,200	11,000	11,000	5,200	9,350	5,200	5,200	9,350	5,200	11,000	5,200
2026-05-16	5,200	9,350	9,350	5,200	7,948	5,200	5,200	7,948	5,200	9,350	5,200
2026-05-17	5,200	7,948	7,948	5,200	6,756	5,200	5,200	6,756	5,200	7,948	5,200
2026-05-18	5,200	6,756	6,756	5,200	5,743	5,200	5,200	5,743	5,200	6,756	5,200

Date	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4	Baseline
2026-05-19	5,200	5,743	5,743	11,000	5,200	11,000	11,000	5,200	5,200	5,743	5,200
2026-05-20	5,200	5,200	5,200	11,000	5,200	11,000	11,000	5,200	5,200	5,200	5,200
2026-05-21	5,200	5,200	5,200	11,000	5,200	11,000	11,000	5,200	5,200	5,200	5,200
2026-05-22	5,175	5,175	5,175	9,350	5,175	11,000	11,000	5,175	5,175	5,175	5,175
2026-05-23	5,175	5,175	5,175	7,948	5,175	9,350	9,350	5,175	5,175	5,175	5,175
2026-05-24	5,175	5,175	5,175	6,756	5,175	7,948	7,948	5,175	5,175	5,175	5,175

Table 3. Hydrograph at Keswick for baseflow, as well as for the top 10 scenarios as ranked by both Michel et al. and Burford et al. models

Date	KES	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4
2026-03-23	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-24	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-25	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-26	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-27	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-28	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-29	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-30	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-03-31	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-01	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-02	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-03	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-04	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-05	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2026-04-06	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-07	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-08	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-09	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-10	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2026-04-11	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
2026-04-12	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
2026-04-13	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
2026-04-14	8,000	11,750	11,750	11,750	11,750	11,750	11,750	11,750	8,000	11,750	11,750
2026-04-15	8,000	11,750	11,750	11,750	11,750	11,750	11,750	11,750	8,000	11,750	11,750
2026-04-16	8,500	12,750	12,750	12,750	12,750	12,750	12,750	12,750	8,500	12,750	12,750
2026-04-17	8,500	11,100	11,100	11,100	11,100	11,100	11,100	11,100	8,500	12,750	12,750

Date	KES	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4
2026-04-18	8,500	9,698	9,698	9,698	9,698	9,698	9,698	9,698	8,500	11,100	11,100
2026-04-19	8,500	8,506	8,506	8,506	8,506	8,506	8,506	8,506	8,500	9,698	9,698
2026-04-20	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,506	8,506
2026-04-21	9,000	13,750	13,750	9,000	9,000	9,000	13,750	9,000	13,750	13,750	13,750
2026-04-22	9,000	13,775	13,775	9,000	9,000	9,000	13,775	9,000	13,775	13,775	13,775
2026-04-23	9,000	13,775	13,775	9,000	9,000	9,000	13,775	9,000	13,775	13,775	13,775
2026-04-24	9,000	13,775	13,775	9,000	9,000	9,000	13,775	9,000	12,125	12,125	12,125
2026-04-25	9,000	12,125	12,125	9,000	9,000	9,000	12,125	9,000	10,723	10,723	10,723
2026-04-26	9,000	11,723	11,723	9,000	9,000	9,000	11,723	9,000	10,531	10,531	10,531
2026-04-27	9,000	10,531	10,531	9,000	9,000	9,000	10,531	9,000	9,518	9,518	9,518
2026-04-28	9,000	9,518	9,518	14,775	9,000	14,775	9,518	9,000	9,000	9,000	9,000
2026-04-29	9,000	9,000	9,000	14,775	9,000	14,775	9,000	9,000	9,000	9,000	9,000
2026-04-30	9,000	9,000	9,000	14,775	9,000	14,775	9,000	9,000	9,000	9,000	9,000
2026-05-01	9,000	9,000	9,000	13,125	9,000	14,775	9,000	9,000	9,000	9,000	9,000
2026-05-02	9,000	9,000	9,000	11,723	9,000	13,125	9,000	9,000	9,000	9,000	9,000
2026-05-03	9,000	9,000	9,000	10,531	9,000	11,723	9,000	9,000	9,000	9,000	9,000
2026-05-04	9,000	9,000	9,000	9,518	9,000	10,531	9,000	9,000	9,000	9,000	9,000
2026-05-05	9,000	14,775	9,000	9,000	14,775	9,518	9,000	14,775	14,775	14,775	9,000
2026-05-06	9,000	14,775	9,000	9,000	14,775	9,000	9,000	14,775	14,775	14,775	9,000
2026-05-07	9,000	14,800	9,000	9,000	14,800	9,000	9,000	14,800	14,800	14,800	9,000
2026-05-08	9,000	14,800	9,000	9,000	14,800	9,000	9,000	13,150	13,150	14,800	9,000
2026-05-09	9,000	13,150	9,000	9,000	13,150	9,000	9,000	11,748	11,748	13,150	9,000
2026-05-10	9,000	11,748	9,000	9,000	11,748	9,000	9,000	10,556	10,556	11,748	9,000
2026-05-11	9,000	10,556	9,000	9,000	10,556	9,000	9,000	9,543	9,543	10,556	9,000
2026-05-12	9,000	9,543	14,800	14,800	9,543	14,800	9,000	9,000	14,800	9,543	14,800
2026-05-13	9,000	9,000	14,800	14,800	9,000	14,800	9,000	9,000	14,800	9,000	14,800
2026-05-14	9,000	9,000	14,800	14,800	9,000	14,800	9,000	9,000	14,800	9,000	14,800
2026-05-15	9,000	9,000	14,800	14,800	9,000	13,150	9,000	9,000	13,150	9,000	14,800
2026-05-16	9,000	9,000	13,150	13,150	9,000	11,748	9,000	9,000	11,748	9,000	13,150
2026-05-17	9,000	9,000	11,748	11,748	9,000	10,556	9,000	9,000	10,556	9,000	11,748

Date	KES	X4.3_5.4_7.4	X4.3_5.4_8.4	X4.3_6.3_8.4	X4.3_7.4_9.3	X4.3_6.4_8.3	X4.3_5.4_9.4	X4.3_7.3_9.4	X5.3_7.3_8.3	X4.4_5.3_7.4	X4.4_5.3_8.4
2026-05-18	9,000	9,000	10,556	10,556	9,000	9,543	9,000	9,000	9,543	9,000	10,556
2026-05-19	9,000	9,000	9,543	9,543	14,800	9,000	14,800	14,800	9,000	9,000	9,543
2026-05-20	9,000	9,000	9,000	9,000	14,800	9,000	14,800	14,800	9,000	9,000	9,000
2026-05-21	9,000	9,000	9,000	9,000	14,800	9,000	14,800	14,800	9,000	9,000	9,000
2026-05-22	9,000	9,000	9,000	9,000	13,175	9,000	14,825	14,825	9,000	9,000	9,000
2026-05-23	9,000	9,000	9,000	9,000	11,773	9,000	13,175	13,175	9,000	9,000	9,000
2026-05-24	9,000	9,000	9,000	9,000	10,581	9,000	11,773	11,773	9,000	9,000	9,000

Table 4. Starting dates for each potential study week of the Spring period, for reference

week	Start date
1	2026-03-23
2	2026-03-30
3	2026-04-06
4	2026-04-13
5	2026-04-20
6	2026-04-27
7	2026-05-04
8	2026-05-11
9	2026-05-18

Attachment 2 - Winter-run Chinook Salmon Temperature Dependent Mortality Estimates

Executive Summary

Water temperature forecasts were contrary to expectations in which pulse scenarios of lower volumes of 50 TAF were warmer and consequently had higher TDM estimates than the 50 TAF scenario. Also unexpected was the 50 TAF pulse in May scenario was forecasted to be warmer than the 50 TAF in April and 50 TAF in May scenario and therefore was estimated to have higher TDM than that scenario. Overall, the scenarios are fairly similar results, and our tools are likely not precise enough for evaluating 10 TAF volume differences.

Temperature modeling described in the tradeoff table do not match up perfectly with the pulse flow scenarios as more precise estimates of water cost are available for the flow scheduling than is practical for temperature modeling. Additionally, information for spring flow forecasts and summer/fall temperature forecasts for informing their associated models are available on different timelines. Water costs for scenarios were rounded to the nearest 10 TAF for assigning TDM values.

Background

To forecast temperature dependent mortality (TDM) of winter-run chinook salmon for the 2026 Sacramento River Spring Pulse Operations Plan, nine scenarios were evaluated. All scenarios targeted 53.5F at Clear Creek (CCR) but consisted of pulse flows in April and/or May of different water volumes described in Table 1.

The modeling framework used spatially explicit, daily average water temperature forecasts from the WTMP model. These forecasts were applied at multiple locations along the Sacramento River, including Keswick Dam and Clear Creek. Observed temperature data were used through March 26, 2026, and modeled forecasts were used thereafter. For locations between these gauges, daily temperatures were estimated by interpolating between nearby model output points. These temperature estimates were then matched to the river mile locations of simulated winter-run Chinook redds constructed based on observed spawning distributions from 2013 to 2022.

TDM was estimated by simulating the thermal history of each redd throughout its incubation period. Mortality was calculated based on cumulative thermal exposure using a degree-day threshold to represent development time, as well as on daily temperature exceedance past critical thresholds known to induce mortality. Two mortality models were applied. The first, based on Martin et al. (2017), assumes stage-independent mortality, using a single temperature threshold (12.14°C) applied consistently from spawning through emergence. The second model, based on Anderson et al. (2022), incorporates stage-dependent mortality, assigning a temperature threshold (11.82°C) and mortality

sensitivities across distinct developmental stages. This approach was also applied to all scenarios. Results from the temperature-dependent mortality simulations did not reveal biologically meaningful results among some scenarios and between modeling approaches.

Table 1. Summary of winter-run chinook salmon TDM results for all scenarios developed during the week of March 23, 2026, based on the March 90% exceedance forecast.

Scenario	Stage Dependent (%)	Stage Independent (%)
Baseline/no pulse	3	5.9
50TAFin April	3.5	7.7
50TAF in May	8.2	14.2
50TAFin April and 50TAF in May	4.3	9.2
50TAFin April and 100TAF in May	7.4	13.8
10TAF in April	7.9	12.9
20TAF in April	4.2	8.6
30 TAF in April	4.4	9
40 TAF in April	7.3	12.3

Table 2. Modeling assumptions for TDM estimates for pulse flow scenarios developed during the week of March 23, 2026.

Parameter	Associated Information
Meteorology Source	HIST-2015
Time Period	1/1/2026 – 3/26/2026: Observed temperatures 3/27/2026: Simulated temperatures
Reservoir Model Used	WTMP
River Model Used	WTMP
Shasta Profile Date	3/2/2026
TCD Gate Operations	WTMP
Sacramento Water Temperature Used	WTMP output at Keswick and Clear Creek
Biological Model Used	SacPAS Fish model (Temperature effect only)
Temperature Mortality Models	Stage-independent mortality Stage-dependent mortality
Egg Emergence Timing Models	Linear. 958 ATUs (degrees C), as indicated for Zeug et al. on SacPAS under Egg to emergence timing model.
TDM Redd Time Distribution	Winter-run chinook salmon carcass surveys 2013-2022
TDM Redd Space Distribution	Winter-run chinook salmon carcass surveys 2013-2022
TDM TCRIT (50th Percentile)	Stage-independent mortality: 12.14°C Stage-dependent mortality: 11.82°C
TDM BT (50th Percentile)	Stage-independent mortality: 0.026°C-1d-1 Stage-dependent mortality: 0.436°C-1d-1
Critical Days	Stage-independent mortality: all Stage-dependent mortality: 4 days

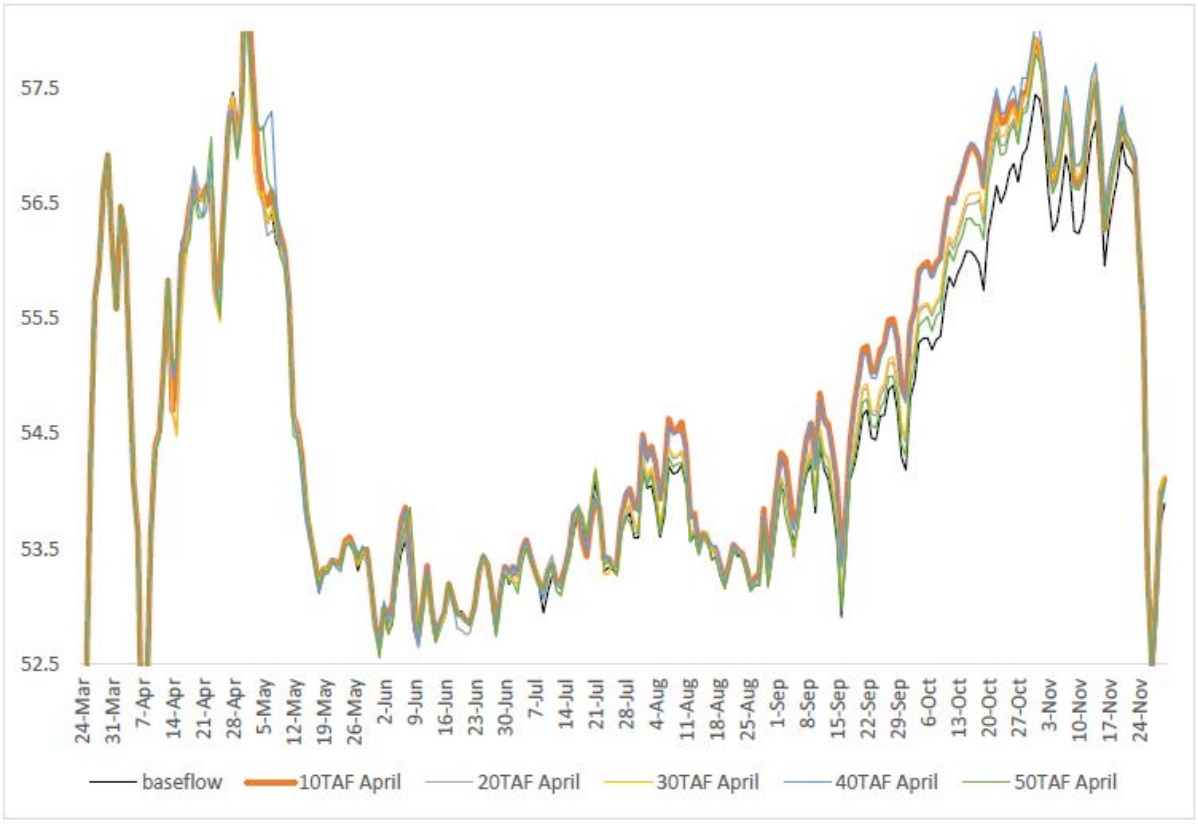


Figure 1. Forecasted daily water temperatures in degrees F at Clear Creek for pulses only occurring in April.

Figure 1 illustrates modeled daily water temperature patterns at Clear Creek under a range of April-only pulse flow scenarios compared to baseline conditions. Results indicate generally small differences among scenarios, with slightly cooler temperatures occurring under larger April pulse volumes during portions of the late spring and fall period. Overall seasonal temperature trends remain similar across scenarios, reflecting limited sensitivity of downstream temperature conditions to the range of April pulse magnitudes evaluated.

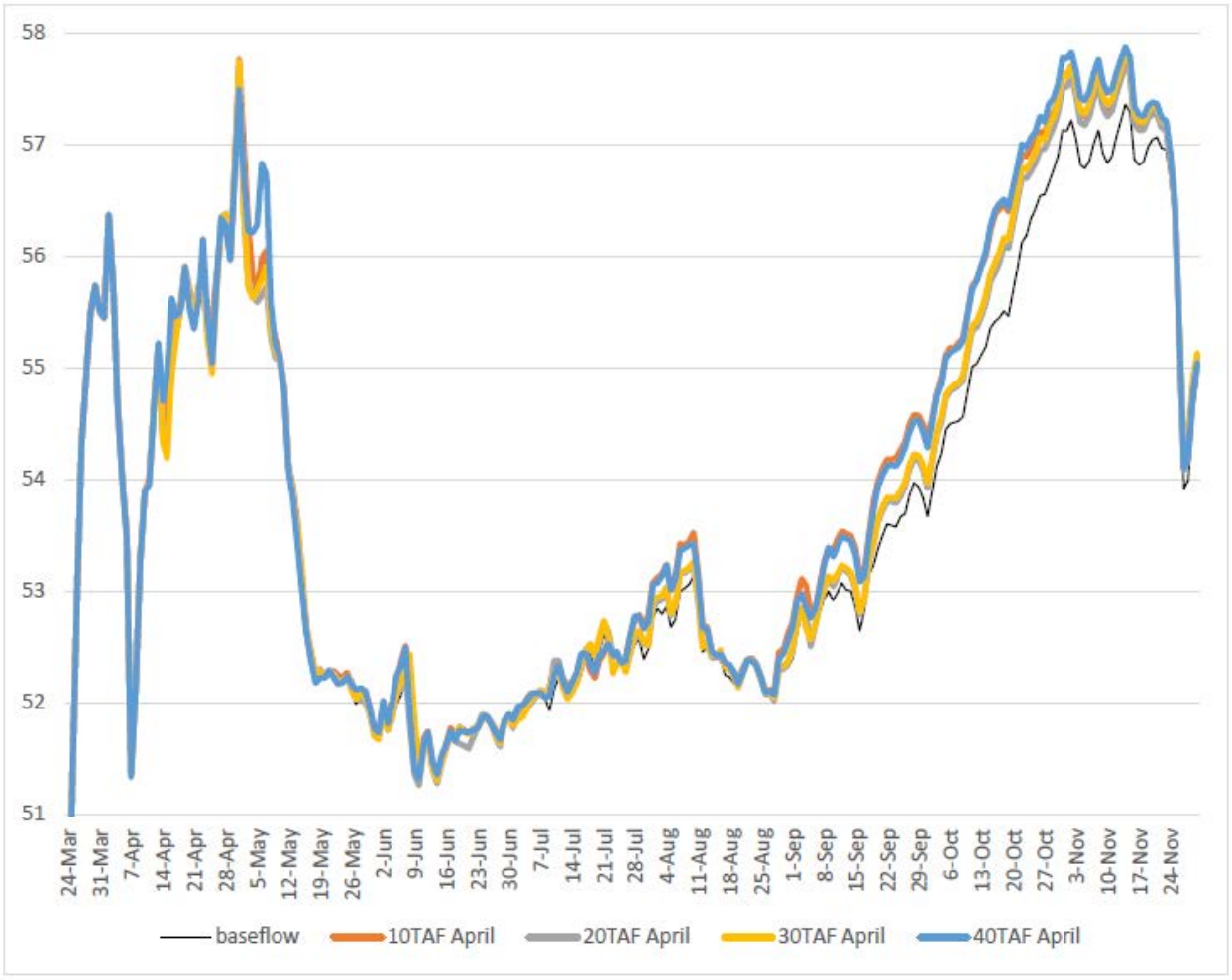


Figure 2. Forecasted daily water temperatures in degrees Fahrenheit at Keswick for pulses only occurring in April.

Figure 2 illustrates modeled daily water temperature patterns at Keswick under a range of April-only pulse flow scenarios compared to baseline conditions. Results show minor differences among scenarios, with slightly cooler temperatures generally associated with larger April pulse volumes during portions of the late spring and fall period. Overall seasonal temperature patterns remain similar across scenarios, indicating limited sensitivity of Keswick water temperatures to the range of April pulse magnitudes evaluated.