Clear Creek Spring Pulse Flows and Summer Temperature Management 2019

Proposal from the Clear Creek Technical Team
April 1, 2019

Summary of Proposed Actions

- Manage Whiskeytown Dam release to approach but not exceed a 60°F average daily water temperature at Igo (RPA target), following spring reservoir turnover and start of thermal stratification.
- Produce two spring pulse flow from Whiskeytown Dam releases, one to peak May with 700 cfs from Whiskeytown Dam, and the second to peak June 22 with 500 cfs from Whiskeytown Dam. Attempt to maximize the difference in water temperatures between pulse releases and general base flows.
- Attempt to maintain relatively similar flows one week prior, and one week post each pulse flow for consistency of conditions for snorkel survey monitoring.
- Following pulse flows, manage Whiskeytown Dam releases to approach but not exceed a 60°F mean daily average water temperature at Igo through September 14.
- Manage flows to approach but not exceed a 56°F mean daily average water temperature from September 15 through October 31 (end of RPA criteria period).
- Continue monitoring efforts to inform effectiveness (spring-run Chinook Salmon entry into Clear Creek, spring-run Chinook Salmon distribution in Clear Creek, temperature monitoring).

Background and Justification

California Central Valley spring-run Chinook Salmon (*Oncorhynchus tshawytscha;* spring-run) and Central Valley steelhead (*O. mykiss; steelhead*) are listed as Threatened under the Endangered Species Act. Populations of both occur in Clear Creek, and are addressed by the National Marine Fisheries Service Biological and Conference Opinion on the Long-Term Operation of the Central Valley Project and State Water Project (Long-term BO; NMFS 2009, 2011), and by the Recovery Plan for both (NMFS 2014). Among the Reasonable and Prudent Alternatives (RPA) Actions specified for Clear Creek water operations, are *Action I.1.1*: provision for spring pulse flows for spring-run, and *Action I.1.5:* temperature management for spring-run and steelhead.

Spring pulse flows

The spring pulse flow portion of this proposal is designed to implement RPA Action I.1.1 "Spring attraction flows" of the BO, where NMFS expresses the objective, action, and rationale for the action as follows:

Action I.1.1. Spring Attraction Flows

> ***Objective:*** *To encourage spring-run movement to upstream Clear Creek habitat for spawning.*
>
> ***Action:*** *Reclamation shall annually conduct at least two pulse flows in Clear Creek in May and June of at least 600 cfs for at least three days for each pulse, to attract adult spring-run holding in the Sacramento River main stem. This may be done in conjunction with channel-maintenance flows (Action I.1.2).*

Rationale: *In order to prevent spring-run from hybridizing with fall-run in the Sacramento River, it is important to attract early spring-run adults as far upstream in Clear Creek as possible, where cooler water temperatures can be maintained over the summer holding period through releases from Whiskeytown Dam. This action will also prevent spring-run adults from spawning in the lower reaches of Clear Creek, where water temperatures are inadequate to support eggs and pre-emergent fry during September and October.*

The primary goals of the pulse flows are to encourage adult spring-run to enter Clear Creek from the Sacramento River, and attract them to the furthest upstream habitats for holding and spawning. In these upstream habitats, spring-run can capitalize on the cool water temperatures of the Whiskeytown Dam tailwater, over-summer in the large and remote holding pools characteristic Clear Creek upstream of the Clear Creek Road Bridge, spawn in gravel provided to the upper reaches by the Clear Creek Program, and avoid hybridization and competition with fall-run Chinook Salmon which are excluded from upstream reaches by a segregation weir installed each August near the Clear Creek Road Bridge. Pulse flows also provide secondary geomorphic benefit by some dispersal of injected gravel and mobilization fine sediment Clear Creek.

Temperature management

The summer temperature portion of this proposal is designed to implement RPA Action I.1.5 "Thermal Stress Reduction" of the BO, where NMFS expresses the objective, action, and rationale for the action as follows:

Action I.1.5. Thermal Stress Reduction

Objective*: To reduce thermal stress to over-summering CCV steelhead and CV spring-run Chinook Salmon during holding, spawning, and embryo incubation.*

Action: *Reclamation shall manage Whiskeytown releases to meet a daily water temperature of:*

1) 60°F at the Igo gage from June 1 through September 15; and

2) 56°F at the Igo gage from September 15 to October 31.

Reclamation, in coordination with NMFS, will assess improvements to modeling water temperatures in Clear Creek and identify a schedule for making improvements."

Suitable temperatures for holding, spawning, and embryo development are critical for Clear Creek salmon and steelhead. We believe ambient river temperatures and the thermal gradient expressed from Whiskeytown Dam to the mouth may also play a role in the over-summering distribution of adult spring-run within Clear Creek.

In undammed native spring-run watersheds, adults emigrate into freshwater in the spring and ascend to habitats that provide cold water throughout the summer months. Those high elevation spring-run habitats are also generally out of reach of fall-run Chinook Salmon and the spatial separation contributes to the genetic differentiation of spring and fall runs. Whiskeytown Dam blocks access to higher elevation habitats where pre-dam over-summering may have occurred, but its tailwater release is a source of water that usually provides cold temperatures throughout the summer and into early fall. In Clear Creek sometimes, significant portions of the adult spring-run population have been observed holding through the summer period in deep pools of the lower reaches of Clear Creek several miles downstream of Whiskeytown Dam. These lower Creek pools are downstream of the Igo temperature compliance point where temperatures often exceed 60°F mean daily average in summer, and they are in high-use areas where poaching or other disturbances may play a role in survival though the summer. Lower Clear Creek also experiences high use by fall-run Chinook Salmon that start coming in in September. Between spring and late summer, the RBFWO has observed sharp declines in the numbers of spring-run Chinook counted in snorkel surveys of deep pools in lower Clear Creek (unpublished data). These declines were not accompanied by observation of sharp increases in the distribution of fish upstream. The lowermost holding pools are also downstream of where the segregation weir is annually installed, and these fish are not afforded the protection of the segregation weir from fall-run Chinook Salmon introgression and redd superimposition.

Considerations

To develop the timing, magnitude, and duration of pulse flows each year, the Clear Creek Technical Team (CCTT) has considered results from fisheries, geomorphic, and avian monitoring, and outcomes of pulse flow dam operations. Since initiation of Clear Creek spring pulse flows in 2010, the CCTT with concurrence from NMFS have varied in timing and magnitude of proposed pulses ranging from as low as 400 to as high as 800 cfs. Spring-run entry into Clear Creek, spring-run distribution within Clear Creek, water temperature, and turbidity data, continue to be collected to inform the effectiveness of spring pulse flows and improve our understanding of the mechanisms that influence adult spring-run migratory behavior.

Fishery monitoring

Entry timing

A video monitoring station was installed in 2013 in Clear Creek near its confluence with the Sacramento River. This provides a means to monitor spring-run entry to Clear Creek through pulse flows. Video and sonar footage capture passage-timing data throughout the entire spring-run migration period and reveal entry rates. The majority of entry observed in in Clear Creek occurs from late-April through late June periods (Figure 1). Few spring-run have been observed to enter during the April pulse flows of previous years (Figure 2). Entry typically begins to decline in June, but has appeared to increase in response to June pulse flows at rates higher than other times during the immigration period. In many years, low populations of returning spring-run precludes drawing strong inferences regarding the influence of spring pulses on spring-run entry (e.g. 2017; Figure 2). Contributing to this, estimates of the numbers of spring-run holding in the Sacramento River are unavailable. Unavailability of these data add to the challenge of drawing conclusions regarding the effectiveness of pulse flows for drawing Sacramento River populations into Clear Creek.

Video monitoring results have suggested that spring-run passage into Clear Creek during pulse flows is greatest in the early portion of pulse flows. The value of prolonged pulse events declines rapidly after day one or two. The shape of recent pulse flows has been shortened to capitalize on the quick response of spring-run Chinook Salmon, and to conserve cold water resources.

The timing of flow increases have been designed to arrive at the confluence at night. Video station data results that suggest spring-run primarily migrate between 8:00 pm and 6:00 am.

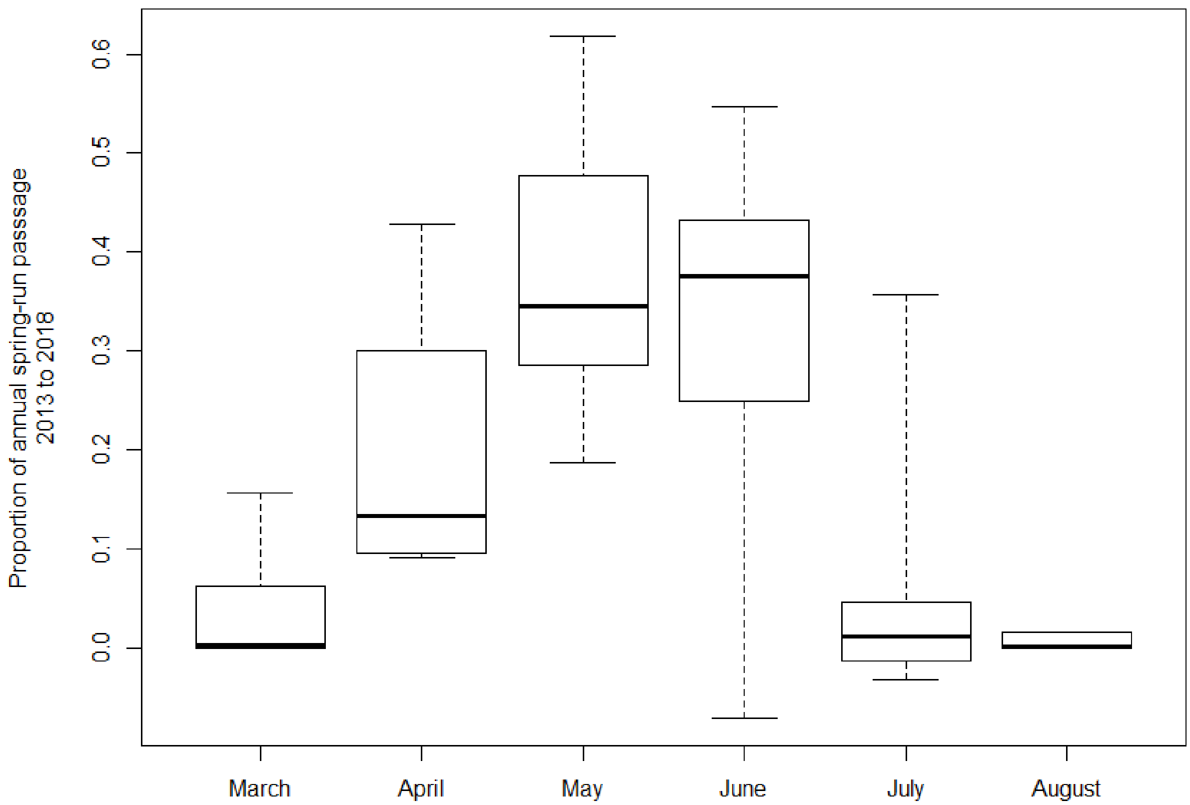

Figure 1. Proportion of annual spring-run Chinook Salmon passage by month at the Clear Creek Video Station (CCVS) from 2013 to 2018.

Distribution

Mask-and-snorkel (snorkel) surveys of the entire Clear Creek mainstem are utilized to characterize spring-run distribution throughout Clear Creek. Conducted prior and post each pulse, snorkel surveys provide a coarse indication of response to pulse flows. Distribution is again characterized in August just prior to installation of the segregation weir. The detectability of adult salmon to snorkelers varies with water depth and clarity, pool complexity, and fish behavior. Total counts are treated as indices rather than censuses, but the spatial distribution of the fish observed is informative when numbers are sufficient. The inferences that can be drawn from these data regarding effectiveness of the action are however limited when spring run returns are low (e.g. only 4 spring-run were observed during August index counts in 2017; Figure 3 and Figure 4).

Interpretation of changes in the distribution of Clear Creek spring-run between snorkel surveys is at least partially confounded by new fish entering Clear Creek from the Sacramento River between surveys. For instance: fish documented by river mile prior to a pulse flow may indeed move well upstream on a pulse, but the overall expression of fish distribution after the pulse might not be significantly different, or even shift downstream if numerous new fish enter from the Sacramento River and occupy downstream habitats (see example from June surveys in 2012, Figure 5).

Careful interpretation is likewise required for apparent changes in the spatial distribution of spring-run between the last post-pulse snorkel survey and the annual August index survey. Factors contributing to an upstream shift in distribution could be as widely varied as: fish responding to a thermal gradient in temperature and “seeking” cooler upstream water (as this proposal aims to implement), natural inclination of spring-run to migrate upstream independent of management actions, or even differential mortality where higher fish mortality in the lower Creek would be expressed as a shift in the overall distribution upstream.

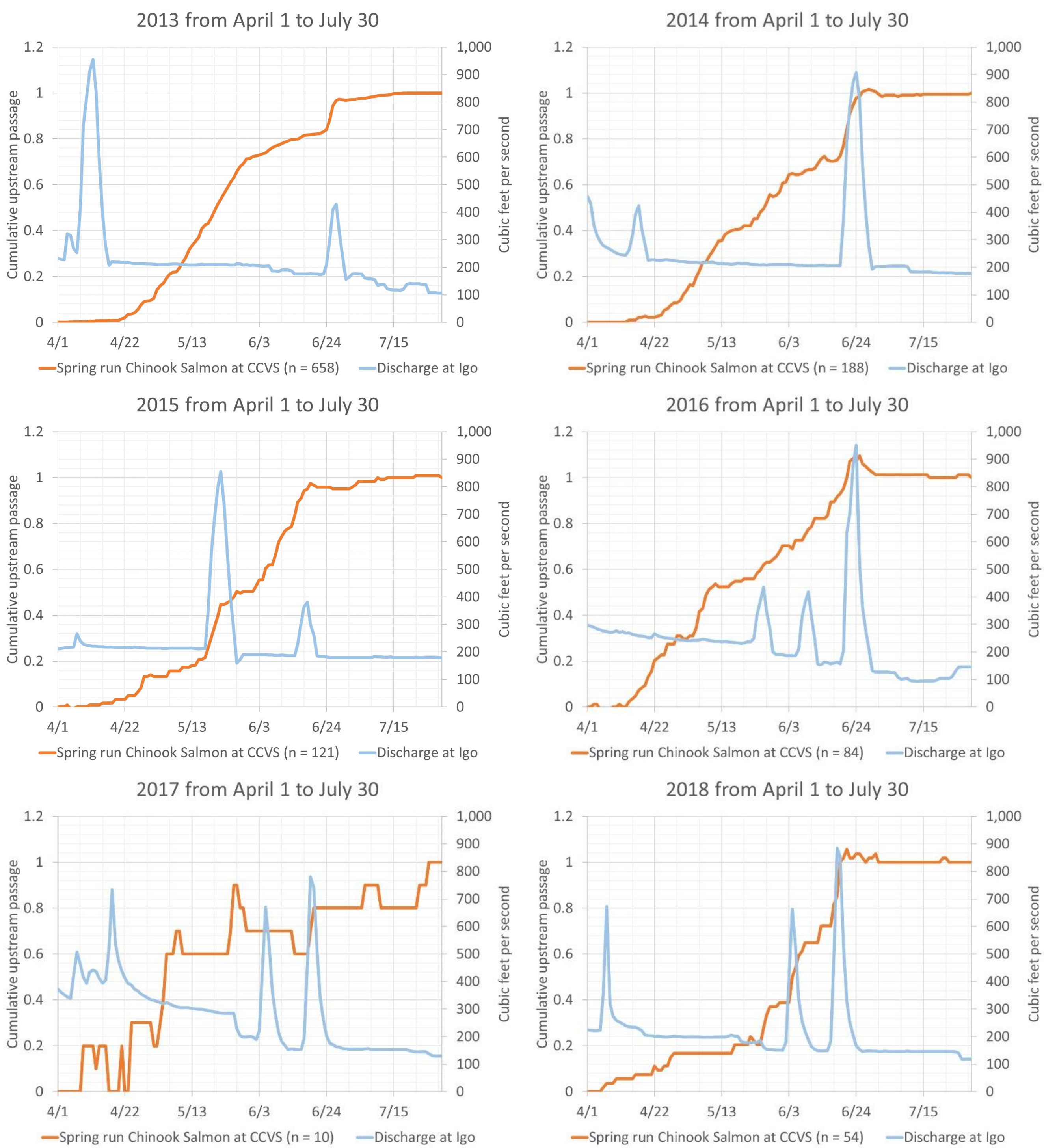

Figure 2. Igo flows and cumulative annual proportion of spring-run Chinook Salmon entry at the Clear Creek Video Station near the mouth, years 2013 to 2018.

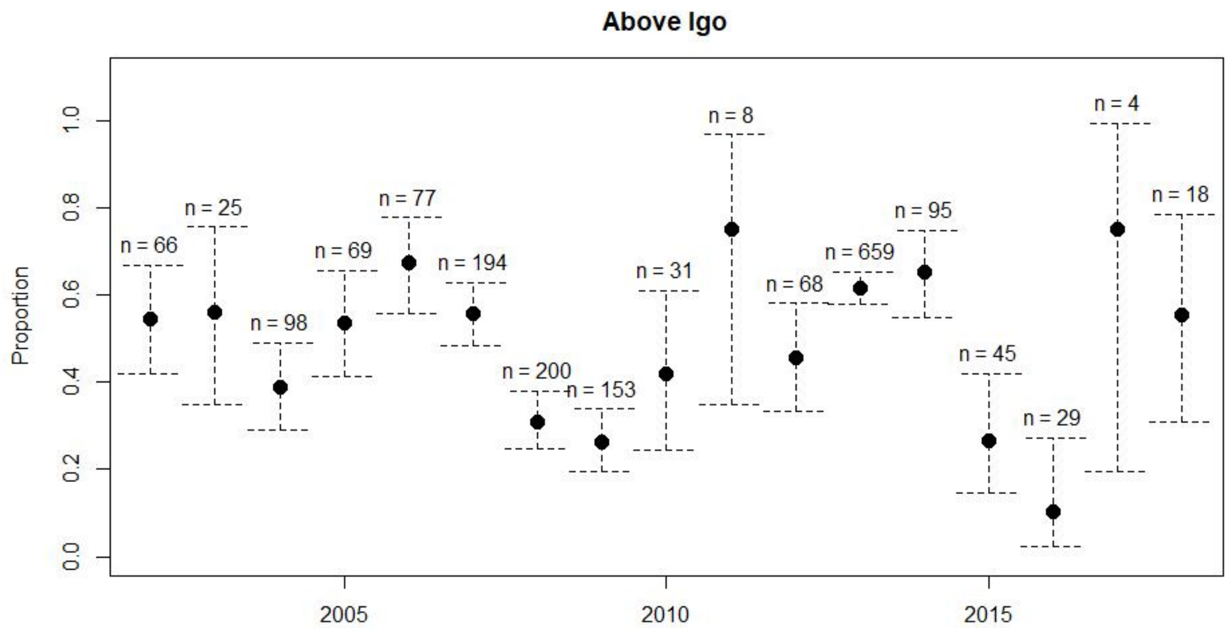

Figure 3. Proportion of adult Chinook Salmon observed upstream of the Igo temperature compliance point during the August survey. Solid dot = estimated proportion; dashed lines = 95% confidence interval; number = total adult salmon observed during the August snorkel survey. Spring pulse flows started in 2010.

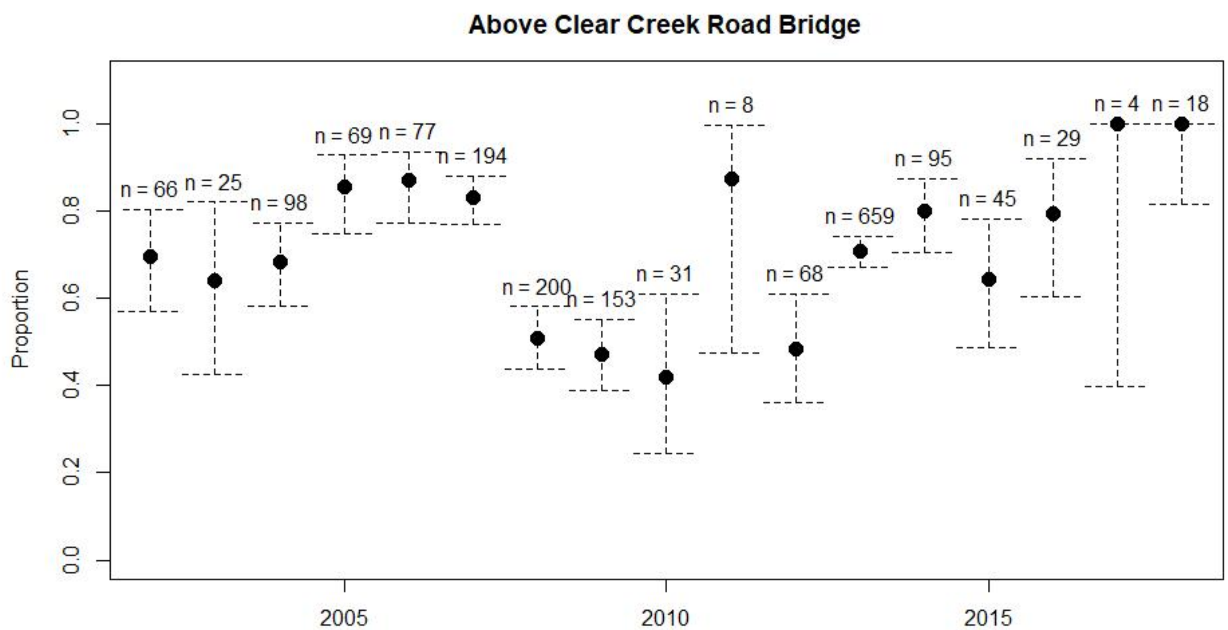

Figure 4. Proportion of adult Chinook Salmon observed upstream of the Clear Creek Road Bridge (near the segregation weir site) during the August survey. Solid dots = estimated proportion; dashed lines = 95% confidence interval; numbers = total adult salmon observed during the August snorkel survey. Spring pulse flows started in 2010.

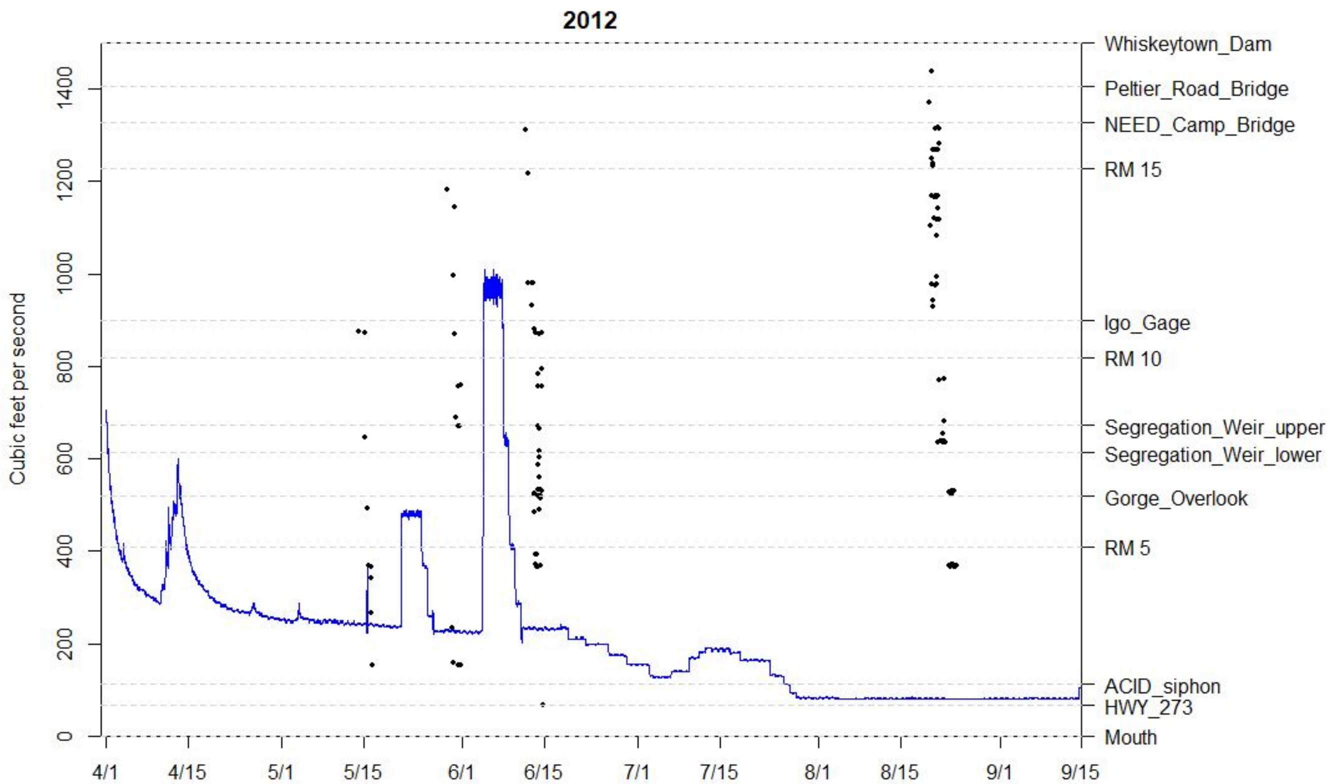

Figure 5. Example fish distribution as characterized by snorkel surveys in 2012. Flow as measured at the Igo Gage indicated by the blue line. Distribution of spring-run Chinook Salmon observed during snorkel surveys are indicated by the black dots. Dots are "jittered" to reveal locations where multiple fish may otherwise be obscured by a single dot.

Avian nesting

The period of peak avian nesting productivity has been considered each year when determining the timing and magnitude of pulse flows. Low lying riparian habitat within and along the channel margin are used by a number of bird species during the breeding period of approximately mid-April through the end of July. Point Blue Conservation Science historical monitoring data shows one of the two peaks of Song Sparrow (*Melospiza melodia*) nesting activity occurs during mid to late May. Song Sparrows are particularly vulnerable to increases in creek flows given the relatively low height of their nests and their preferred nesting locations along the margins of creek and backwater areas. It was acknowledged by the CCTT that higher magnitude flows in May and June could increase the risk for nest failure. Pulse flows in 2019 are proposed to occur in May and June when peak spring-run migration occurs to maximize benefit to spring-run - the focus of the RPA. Earlier pulse flow timing was considered, but early pulses in prior years rarely produced any measurable response, and snorkel surveys revealed few if any spring-run Chinook Salmon present to benefit from the flows.

Ramping rate

The up-ramping shape for each pulse is designed to prolong the minor increase in turbidity, which is thought to be desirable for attracting adult spring-run, and benefit juvenile salmonid outmigration. Out-migrating juvenile Chinook Salmon are less susceptible to predation when there was turbidity (Gregory and Levings 1998).

The potential susceptibility of juvenile salmonids to stranding during the down-ramp period of the pulses has been considered. The timing of the maximum rate of flow decrease has been chosen to occur primarily during dark hours through much of the Creek, particularly in the lower portions where juvenile densities can be expected to be higher than those upstream. While the down-ramp initiates in the latter part of daylight hours at Whiskeytown Dam, because of travel time the decrease occurs in the dark in the lower watershed where juvenile fish densities are higher. In the upper watershed, the few remaining juvenile Chinook Salmon rearing there will be relatively large and therefore less vulnerable to stranding. Studies have documented that fewer juvenile fish are stranded when flow decreases occur at night (Bradford et al. 1995; Halleraker et al. 2003; Irvine et al. 2014). Based on observations from the 24-hr sampling trials conducted on the Clear Creek USFWS rotary screw traps in 2013, juvenile Chinook Salmon passage primarily occurred during the night (personal communication, James Earley, USFWS). Since juveniles are not out-migrating during the day, they may be located closer to shore in locations more susceptible to stranding.

Reclamation has requested the CCTT accommodate limitations of the Whiskeytown Dam that control the flow to Clear Creek. The consideration includes the operational limitations of the facility/outlet works and its precision; flow schedules are requested to the nearest 5 cfs and the change in flow is requested to be greater than or equal to 15 cfs.

Down ramping rates have been specified over particular ranges of flow by NMFS (2009; see Table 1). From page 782 to 784 of that document:

13.4 Terms and Conditions

Reclamation and DWR must comply or ensure compliance by their contractor(s) with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

....

3. Reclamation shall minimize the adverse effects of flow fluctuations associated with CVP controlled stream operations on listed anadromous fish species spawning, egg incubation, and fry and juvenile rearing.

a. Reclamation shall schedule maximum ramping down rates of non-Glory Hole (i.e., nonflood control) releases from Whiskeytown Reservoir according to the table, below (estimated at RM 3.03). Ramping rates for releases greater than 300 cfs shall be made after consultation with the Clear Creek Technical Team, considering: time of year, time of day, timing the change to occur with natural changes in-flow and/or turbidity, size of fish present in the creek, species and protected status of vulnerable fish, the amount of water required, and relative costs or benefits of proposed flow. Reclamation shall time flow decreases so that the most juvenile Chinook salmon and steelhead experience the stage decrease during darkness. Maximum ramping rate of flow releases from Whiskeytown Dam into Clear Creek shall be accomplished based on the following targets within the precision of the outlet works or the City of Redding powerplant equipment.

Table 1. Maximum down ramping rates for Whiskeytown Dam non-spillway releases to Clear Creek per the National Marine Fisheries Service Biological and Conference Opinion on the Long-Term Operation of the Central Valley Project and State Water Project (NMFS 2009).

Discharge	Ramping Rate
600-330 cfs	16 cfs / hour
330-105 cfs	15 cfs / hour
105-50 cfs	14 cfs / hour

Proposed actions

Pulse flows

The CCTT proposes two spring pulses this year, one at 700 cfs and the other at 500 cfs, set to reach their peaks on May 11 and June 22 respectively (Table 2, Figure 6, Appendix A). The timing is designed to co-occur with typical spring-run migration, replicate spring-run attraction success observed during past June pulse flows, and to evaluate the effectiveness of an early-to-mid May pulse which has not yet been attempted in Clear Creek. The pulses are proposed for June to provide colder water temperatures at the confluence during a period when Clear Creek is otherwise warming. The timing of each pulse has been designed to arrive at the Clear Creek mouth at night. Down ramp rates are reflective of the Long-term BO (NMFS 2009).

Table 2. 2019 Clear Creek pulse flow proposal for discharge from Whiskeytown Dam Volume relative to base flow may vary depending on possible alterations to meet temperature criteria.

Dates including ramp up and ramp down	Peak	Estimated volume used over base flow (acre feet)
May 10-18 (peak May 11)	700 cfs	1,895
June 21-28 (peak June 22)	500 cfs	1,247
	Total	3,142

Temperature management

To encourage spring-run to migrate further upstream in Clear Creek to isolated reaches upstream of the Igo temperature compliance point, we propose releases from Whiskeytown Dam be managed such that mean daily average temperature at Igo closely meets the maximum 60°F mean daily average as specified in the RPA (Figure 7). In meeting the criteria by a close (rather than large) margin we hope to encourage spring-run to migrate further upstream in Clear Creek where temperatures will be consistently suitable throughout the summer months, where human interactions will be fewer, and where the segregation weir will protect them from fall-run Chinook Salmon.

An ancillary benefit to managing close to the 60°F mean daily average is conservation of cold water resources in Whiskeytown Lake. Frequently, especially in dry years, cold water resources are depleted in Whiskeytown Lake toward late summer or early fall when the RPA criteria for temperature at Igo changes to 56°F mean daily average (see example from 2016, Figure 8).

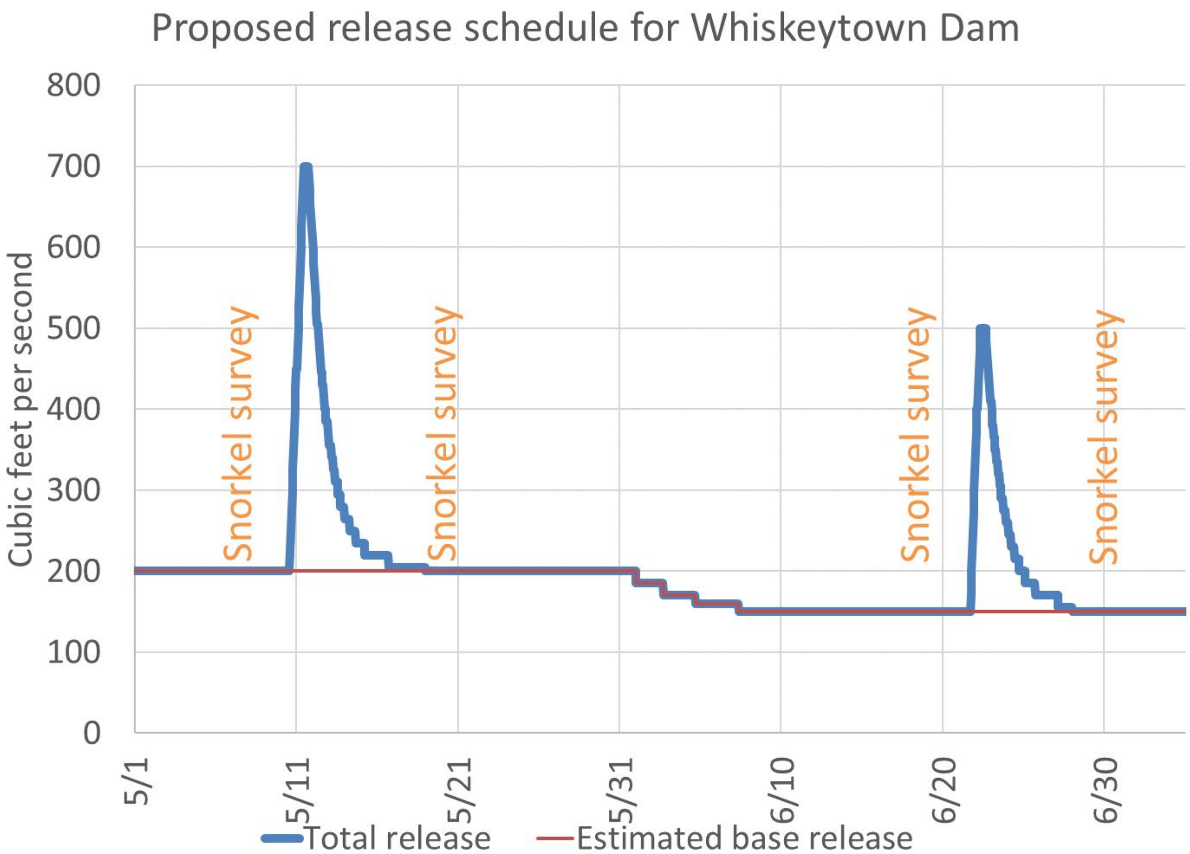

Figure 6. Hydrograph for the 2019 Clear Creek proposed pulse flow releases from Whiskeytown Dam. Summer base flow estimated. Actual summer base release may vary for temperature management, though similar flow conditions between pulses will be targeted to maximize consistency for snorkel survey purposes.

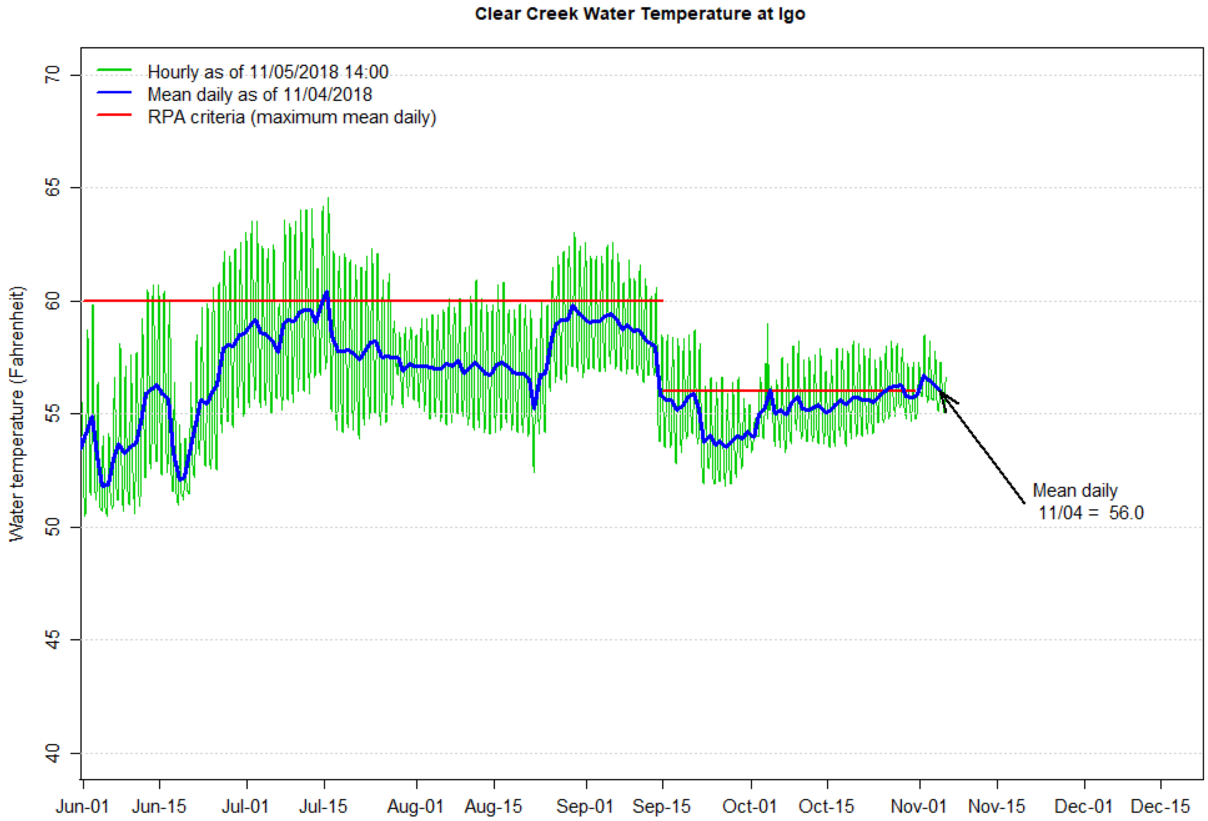

Figure 7. Water temperature at Igo in 2018 compared to the daily average RPA criteria for spring-run Chinook Salmon holding (60°F June 1 to September 15) and spawning and incubation (56°F September 15 to October 31). Except for the periods of each pulse flow event, we propose to manage temperature close to the RPA criteria without exceeding it.

Thermal stratification of Whiskeytown Lake annually begins to occur around April (Figure 9). We think it would be beneficial to begin at that time to manage the gate configurations at Whiskeytown Dam for releases to Clear Creek so at to conserve cold water resources, and increase the likelihood of meeting RPA temperatures through the summer and fall.

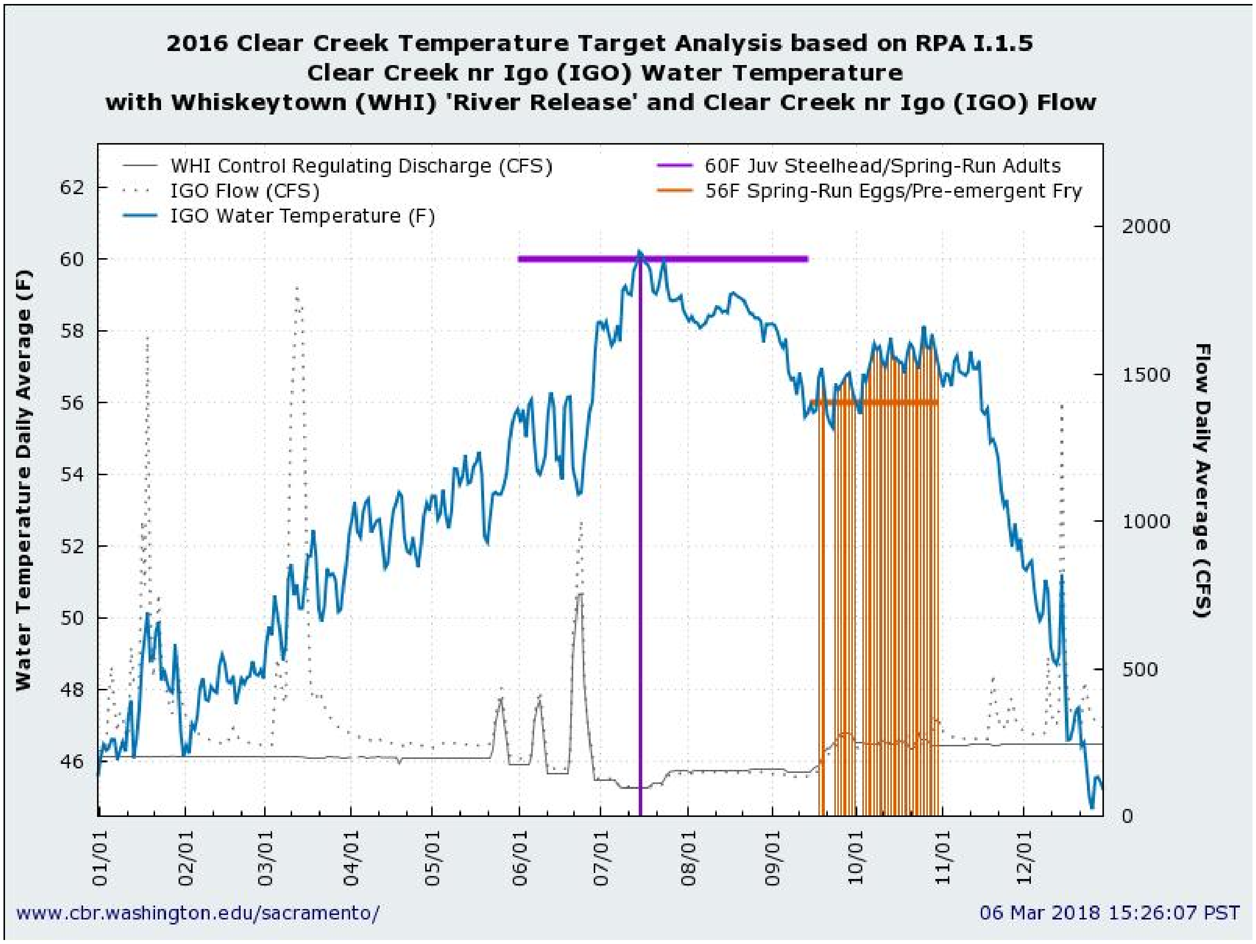

Figure 8. Example year when cold water resources in Whiskeytown Lake were depleted in September, leaving inadequate cold water to meet 56°F mean daily average RPA criteria for spawning and egg incubation of spring-run Chinook Salmon.

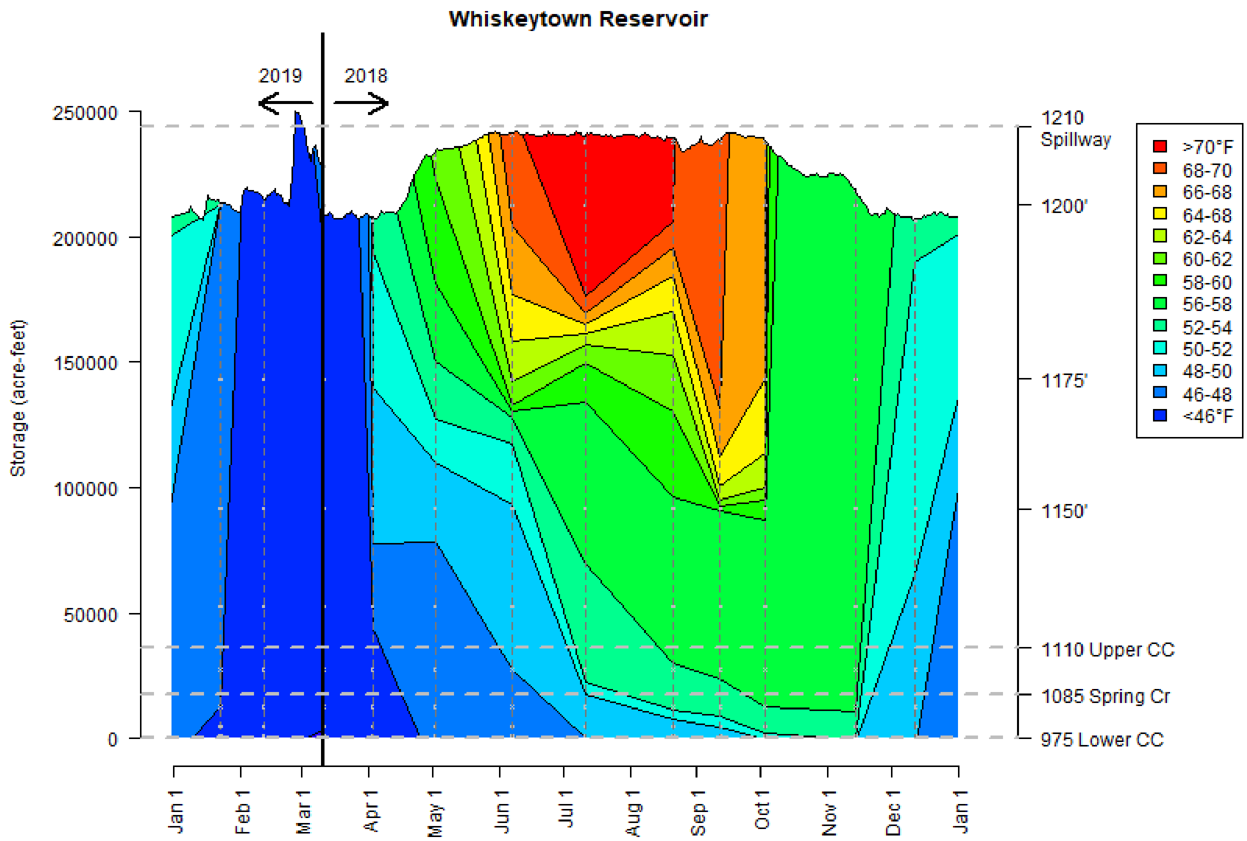

Figure 9. Thermal profile of Whiskeytown Lake in 2018 and the beginning of 2019.

Monitoring

To determine if pulse flows are successful at attracting spring-run in to Clear Creek, and moving them further upstream, the Red Bluff Fish and Wildlife Office will use results from snorkel surveys and video monitoring. The present video monitoring station near the mouth of Clear Creek detects adult spring-run entering Clear Creek through the migration period. In addition to capturing video footage, the monitoring station is equipped with a sonar device capable of detecting salmon during periods of high flow and turbidity. Snorkel surveys for adult spring-run will be conducted before and after each pulse flow to detect changes in counts and holding distribution. Water temperature and turbidity data will also be collected throughout the migration period and analyzed with video monitoring data to help determine if they serve as migratory cues.

Though rare, winter-run Chinook Salmon are also occasionally observed in Clear Creek upstream of the Clear Creek Video Station (CCVS) near the mouth. In 2017 a salmon redd in July (characteristic of winter run spawn timing) was observed in Clear Creek, and three hatchery-tagged winter-run carcasses were recovered through the summer months as well. Hatchery fish dominated the winter run in the Sacramento River in 2017 and may have contributed to the number of observations. Hatchery fish are known to stray at sometimes high rates. We plan to initiate targeted spawning and carcass surveys in the summer months to characterize winter run in Clear Creek. We will continue to monitor winter-run passage at the CCVS and attempt to determine if pulse flow actions contribute to winter run straying in Clear Creek.

Objectives and Monitoring Metrics:

1) **Spring run immigration to Clear Creek**. Increase the rate of adult spring-run immigration into Clear Creek during pulse flows as compared to non-pulse flow period. Video and sonar monitoring data will be used to determine passage rates of Chinook through the spring-run migration period (March 1 through August 15), and investigated for response to pulse flows. Low spring-run Chinook Salmon run sizes can inhibit evaluation of effectiveness of this approach as the sample size is very low. We look forward to continuing this approach and evaluating its effectiveness with larger future run sizes.
2) **Distribution of spring-run adult Chinook Salmon before and after a pulse flows**. One of the primary purposes of the pulse flows is to shift the distribution of spring-run upstream. Snorkel surveys conducted before and after each pulse will give us an index of fish distribution up and downstream of the temperature criteria point at Igo, and up and downstream of the spring- and fall-run Chinook Salmon segregation weir.
3) **Response to changes in turbidity and water temperature**. We will collect continuous water temperature data at the video station throughout the spring-run migration period, and compare temperatures at passage during pulse and non-pulse periods. We will also use flow and turbidity data from the Graham Mathews & Associates P4 gaging station and compare it to spring-run passage.
4) **Characterize winter run distribution above CCVS**. Winter run occasionally stray into Clear Creek (NMFS 2009). RBFWO will coordinate a spawning survey in July/August to detect and map winter-run Chinook Salmon redds and recover carcasses.
5) **Segregation of spring from fall Chinook Salmon**. August snorkel surveys of spring Chinook Salmon will give us an index of fish distribution up and downstream of the temperature criteria point at Igo, and up and downstream of the spring- and fall-run Chinook Salmon segregation weir. This index occurs immediately prior to weir installation and gives an overall picture of how the population may have responded to Creek conditions including temperature and flow actions.

Clear Creek Technical Team Review

A draft of this proposal was circulated March 15, 2019 to the Clear Creek Technical Team and presented to the team for discussion at the quarterly CCTT meeting March 21, 2019. This proposal captures CCTT input.

References

Bradford, M.J., G.C. Taylor, J.A. Allan, and P.S. Higgins. 1995. An experimental study of the stranding of juvenile Coho Salmon and rainbow trout during rapid flow decreases under winter conditions. North American Journal of Fisheries Management 15, 473–479.

Gregory, R.S., and C.D. Levings, 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. Transactions of the American Fisheries Society 127, 275–285.

Halleraker, J. H., Saltveit, S. J., Harby, A., Arnekleiv, J. V., Fjeldstad HP, and Kohler B. 2003. Factors influencing stranding of wild juvenile brown trout (*Salmo trutta*) during rapid and frequent flow decreases in an artificial stream. River Res. Applic., 19: 589–603.

Irvine R. L., Thorley J. L., Westcott R., Schmidt D., and DeRosa D. 2014. Why do fish strand? An analysis of ten years of flow reduction monitoring data from the Columbia and Kootenay Rivers, Canada. River Res. Applic., DOI: 10.1002/rra.2823.

National Marine Fisheries Service (NMFS). 2009. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. June 4, 2009.

National Marine Fisheries Service (NMFS). 2011. 2009 Reasonable and prudent alternative revised to include the 2011 amendments. April 7, 2011.

National Marine Fisheries Service (NMFS). 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.

Appendix A

Proposed flow schedule for spring pulse flows 2019.

Date time	Release	Change
Estimated base prior to pulse	200	0
5/10/2019 15:00	225	25
5/10/2019 16:00	250	25
5/10/2019 17:00	275	25
5/10/2019 18:00	300	25
5/10/2019 19:00	325	25
5/10/2019 20:00	350	25
5/10/2019 21:00	375	25
5/10/2019 22:00	400	25
5/10/2019 23:00	425	25
5/11/2019 0:00	450	25
5/11/2019 2:00	475	25
5/11/2019 3:00	500	25
5/11/2019 4:00	525	25
5/11/2019 5:00	550	25
5/11/2019 6:00	575	25
5/11/2019 7:00	600	25
5/11/2019 8:00	625	25
5/11/2019 9:00	650	25
5/11/2019 10:00	675	25
5/11/2019 11:00	700	25
5/11/2019 19:00	685	-15
5/11/2019 20:00	670	-15
5/11/2019 21:00	655	-15
5/11/2019 22:00	640	-15
5/11/2019 23:00	625	-15
5/12/2019 0:00	610	-15
5/12/2019 1:00	595	-15
5/12/2019 2:00	580	-15
5/12/2019 3:00	565	-15
5/12/2019 4:00	550	-15
5/12/2019 5:00	535	-15
5/12/2019 6:00	520	-15
5/12/2019 7:00	505	-15
5/12/2019 9:00	490	-15
5/12/2019 10:00	475	-15
5/12/2019 12:00	460	-15
5/12/2019 13:00	445	-15
5/12/2019 15:00	430	-15
5/12/2019 17:00	415	-15

Date time	Release	Change
5/12/2019 18:00	400	-15
5/12/2019 20:00	385	-15
5/12/2019 23:00	370	-15
5/13/2019 1:00	355	-15
5/13/2019 4:00	340	-15
5/13/2019 7:00	325	-15
5/13/2019 10:00	310	-15
5/13/2019 14:00	295	-15
5/13/2019 18:00	280	-15
5/14/2019 0:00	265	-15
5/14/2019 7:00	250	-15
5/14/2019 16:00	235	-15
5/15/2019 6:00	220	-15
5/16/2019 17:00	205	-15
5/19/2019 0:00	200	-5
6/1/2019 1:00	185	-15
6/2/2019 17:00	170	-15
6/4/2019 17:00	160	-10
6/7/2019 9:00	150	-10
6/21/2019 18:00	175	25
6/21/2019 19:00	200	25
6/21/2019 20:00	225	25
6/21/2019 21:00	250	25
6/21/2019 22:00	275	25
6/21/2019 23:00	300	25
6/22/2019 0:00	325	25
6/22/2019 1:00	350	25
6/22/2019 2:00	375	25
6/22/2019 3:00	400	25
6/22/2019 5:00	425	25
6/22/2019 6:00	450	25
6/22/2019 7:00	475	25
6/22/2019 8:00	500	25
6/22/2019 17:00	485	-15
6/22/2019 18:00	470	-15
6/22/2019 19:00	455	-15
6/22/2019 20:00	440	-15
6/22/2019 22:00	425	-15
6/22/2019 23:00	410	-15
6/23/2019 1:00	395	-15

Appendix A (continued)

Date time	Release	Change
6/23/2019 2:00	380	-15
6/23/2019 4:00	365	-15
6/23/2019 6:00	350	-15
6/23/2019 8:00	335	-15
6/23/2019 10:00	320	-15
6/23/2019 13:00	305	-15
6/23/2019 15:00	290	-15
6/23/2019 18:00	275	-15
6/23/2019 22:00	260	-15
6/24/2019 2:00	245	-15
6/24/2019 6:00	230	-15
6/24/2019 11:00	215	-15
6/24/2019 18:00	200	-15
6/25/2019 3:00	185	-15
6/25/2019 18:00	170	-15
6/27/2019 4:00	155	-15
6/28/2019 1:00	150	-5
Estimate base after pulse	150	0