APPENDIX E-1

SUPPORTING DOCUMENTATION FOR DEVELOPMENTAL ANALYSIS, PREFERRED PLAN AND ALTERNATIVES PROPOSED BY OTHERS

ATTACHMENT F

ADAPTIVE MANAGEMENT OF PULSE FLOW TIMING FOR THE BENEFIT OF FALL-RUN CHINOOK SALMON IN THE LOWER TUOLUMNE RIVER

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Adaptive management of pulse flow timing for the benefit of fall-run Chinook salmon in the lower Tuolumne River

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1 BACKGROUND AND PURPOSE

The October 2017 amendment of application of the Don Pedro Project (Project) includes the Districts' Preferred Plan for the future operations of the Project. The Preferred Plan provides a substantial increase in spring pulse flows intended to benefit fall-run Chinook salmon emigration from the Tuolumne River. Maximizing the benefit of these functional flows for Tuolumne River juveniles and smolts requires a greater understanding of the emigration behavior of Tuolumne River fall-run Chinook. The purpose of this adaptive management plan (AMP) is to develop this improved understanding so as to optimize the use of the WY-driven pulse flow volumes in the Preferred Plan. Optimization strategies within the scope of the AMP include timing and duration of pulse flows within the fixed volumes contained in the Preferred Plan.

Although a range of environmental, developmental and demographic factors may affect smolt emigration timing (Bjornn 1971, Høgåsen 1998, Myrick and Cech 2001, Sykes et al 2009), seasonally timed outmigration pulse flows have been implemented on the Tuolumne River under the current FERC (1996) license to improve conditions for emigrating smolts. Short-term increases in rotary screw trap (RST) smolt passage during and following pulse flow reductions have been observed on the Tuolumne River as well as the neighboring Stanislaus River (Sonke 2016, Demko and Cramer 1996). However, because of the limited sample size used in evaluating flow as a stimulatory cue for smolt emigration from the Tuolumne River, as well as the high variability in daily RST passage outside of the pulse flow periods, flow magnitude or flow change currently have limited ability to predict the initiation of smolt outmigration (Robichaud and English 2013). As a result, recent modeling of smolt outmigration timing on the Tuolumne River was based upon a probability function representing the historical RST observations of fish size at emigration (TID/MID 2017).

Pulse flow magnitudes influence smolt survival and smolt productivity (TID/MID 2017). Beginning in 1986, the California Department of Fish and Game (CDFG) conducted paired release experiments of coded wire tagged (CWT) Chinook salmon smolts to estimate survival rates and to quantify the relationship between smolt survival and flow in the Tuolumne River. Because season wide estimates of outmigration survival in recent rotary screw trap (RST) monitoring reports (2008–2012) are on the order of 4–21 percent, well below that suggested by the CWT based smolt survival relationship, additional examination of RST passage at Waterford (RM 29.8) and Grayson (RM 5.2) was conducted to further evaluate apparent smolt survival relationships with flow (TID/MID 2017). More recent analyses of event-specific smolt survival indices have allowed development of a refined smolt survival relationship based upon longer term (2006-2014) records of discharge at La Grange as an explanatory variable of relative passage between the Waterford and Grayson RSTs (Robichaud and English 2017).

In addition to the direct effects of increasing discharge on smolt survival, observations of larger fish size at emigration during wet water years with extended periods of high flows suggests a linkage between flows and development rates, as found in monitoring of other river systems (e.g., Rombough 1985, Roper and Scarnecchia 1999). These and other factors affecting smolt emigration timing (e.g., spawning timing, run sizes) were shown to produce simulated emigration patterns with variable overlap with the scheduled pulse flow period (generally April 15th though May 15th) (TID/MID 2017). Because of the potential for higher smolt survival using appropriately timed pulse flows, both direct monitoring as well as model simulations of spring pulse flow timing have been shown to affect smolt productivity. This suggests that variable pulse flow timing or duration by water year type or other means (e.g., real-time monitoring of fish sizes) could be used to optimize water use and smolt productivity. With the goal of increasing smolt production from the lower Tuolumne River, an adaptively managed program for spring pulse flow implementation is proposed under the new license for the Don Pedro Project.

2 ADAPTIVE MANAGEMENT OF SPRING PULSE FLOW TIMING

Under current operations of the Don Pedro Project, the Districts develop an annual FERC pulse flow volume based upon the water year type from the March 1st runoff forecast of the San Joaquin River basin index. In general, the current procedure is for the Districts to identify the WY type and associated pulse flow volume[1], suggest a preliminary pulse flow schedule, then provide this to resource agencies for comment. In some years, resource agencies provide a pulse flow schedule directly to the Districts. In either process, a consultation period follows which results in a final pulse flow schedule. The final pulse flow timing is determined by April 10th and filed with FERC. Pulse flows can begin any time after April 15 under current procedures.

Whether the pulse flow schedule is proposed by the resource agencies or the Districts, the pulse flow schedules that have been implemented in the past were only weakly informed by conditions affecting juvenile fall-run Chinook on the Tuolumne River, and no empirical evidence of how to maximize the benefit of the pulse flows has been collected or evaluated. To develop a science-based, better-informed, design of pulse flow schedules under the new FERC license, an experimental pulse flow management program including real time monitoring and salmon population modeling is proposed for a period of seven (7) years. A Tuolumne science team (TST) will be formed to guide the efforts of the seven-year program. The following annual tasks will be performed by the Districts in conjunction with the TST:

1. **Develop Spawning Timing Estimates**. Beginning with fall upmigrant passage estimates of spawners past the RM 25.5 counting weir and in conjunction with available redd count information with date, estimates of run size and the seasonal spawning distribution will be developed by January 31 of each outmigration year. This information will be shared with the TST through a dedicated web-based information-sharing site.
2. **Modeling of Juvenile Development Timing**. Using the estimates of spawner arrival timing (Step 1) in conjunction with monitoring of discharge and water temperature at

[1] The Districts' Preferred Plan continues the current process for WY selection.

the USGS La Grange gage, the Districts will apply the most recent updated Tuolumne River Chinook (TRCh) model (TID/MID 2017) calibration to simulate egg incubation and juvenile development of Chinook salmon and predict the date at which Chinook will smolt during spring. Although there is evidence that a portion of annual smolt emigration occurs at sizes as low as 70 mm in all years, average smolt size is initially estimated to be 80 mm in Critical, Dry, and Below Normal water years, and 90 mm in Above Normal and Wet water years (TID/MID 2017). Use available seine and/or snorkel data on observed rearing fish sizes in conjunction with up-to-date water temperature data to refine model predictions periodically during winter and spring. Post the updated results to the information-sharing site every two weeks for TST review.

3. **Pulse Flow Timing**. Using the estimated fish size thresholds for smoltification and dates predicted above, pulse flows will be timed to center one or more pulse flow periods upon modeled peak(s) of emigration timing determined above (Step 2). Examination of modeled smolt emigration dates has also shown a pattern of earlier and later emigration in dry and wet WY types, respectively, with considerable year-to-year variability demonstrated between the wetter and drier years.

4. **Pulse Flow Implementation.** During the first two to three years of the AMP, a draft proposed pulse flow(s) duration, timing, and hydrograph will be posted to the information sharing site, supplemented by the preliminary March 1 forecasted WY designation, by March 10. On or before March 20, the TST will meet to discuss, potentially adjust, and decide on the design of the pulse flow(s). During the first two to three years, the draft pulse flow will be informed by TRCh modeling. After this period, the TST will discuss and decide if changes to the method of pulse flow design are warranted.

   Data on fish size and hydrology will continue to be updated and posted through April 5. Based on these updated data, adjustments to the pulse flow(s) may occur based on updated field data and modeling. A draft final pulse flow design would be posted by April 10. A conference call or web-based meeting of the TST will finalize any remaining pulse flow(s). If a final pulse flow is not agreed upon by April 13, the Districts will implement the most recent draft pulse flow(s).

5. **Monitoring and Assessment**. Fish response to the spring pulse flow(s) will be assessed based upon analysis of RST passage as well as fish sizes of smolts captured at Waterford (RM 29.8) and Grayson (RM 5.2) sampling locations. Some fish will be marked to assess RST trap efficiency and smolt survival. Future year adjustments to the estimated fish size thresholds as well as pulse flow implementation will be done through “hindcasting” of TRCh model performance in order to continue to improve predictive thresholds as well as more optimal pulse flow duration, flow rates, and timing that maximize smolt production.

An annual report that tracks the timing of spawning, juvenile development (i.e., fish size in routine seine and RST monitoring data), pulse flow design, pulse flow implementation, and preliminary monitoring results will be posted to the TST for comment by October 31 and filed with FERC by December 15 of each year. After a period of seven years, the results of the pulse

flow management program will be assessed to determine adjustments in pulse flow triggers and duration as well as whether other pulse flow management options should be considered. No changes to pulse flow volumes contained in the Preferred Plan would occur without the consent of the Districts.

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