2009 CVP/SWP Operations RPA Shasta Division Operations Adjustment Outline
September 23, 2016

DRAFT, FOR DISCUSSION PURPOSES ONLY

1. Background and rationale for adjustment

Conditions in the upper Sacramento River are variable and need to continue to be managed with variable hydrology in mind; the Shasta reasonable and prudent alternative actions (RPA) generally do this with different criteria and processes that are dependent on hydrology/storage. However, there are important lessons learned based on experience over last three years:

- High temperature-dependent mortality likely led to winter-run Chinook salmon year class failures in 2014 and 2015.
- Cold water pool volume is sensitive to Keswick releases in April, May and June – prior to the temperature management season on-set.
  - Keswick release schedules (especially for April and May) need to be decided by April 15 in order for Sacramento River Settlement (SRS) Contractors to make planting decisions and purchases for the growing season.
- Capping Keswick releases in June and July is an important and effective strategy to stretch the cold water temperature management season throughout September and October.
- There was a loss of water temperature control when the full Shasta side gates were accessed for water releases
  - Delay full side gate operations as long as possible
  - Explore engineering solutions to access cold water volume below side gates
- Water temperatures at upstream redd locations are not correlated with flow (*i.e.*, water quality, water quantity), but are strongly correlated with Keswick release temperatures.
- Keswick releases could be maintained throughout the summer at 7,250 cfs for temperature management. They do not need to be upwards of 15,000 cfs.
- Spring maximum storage that allows access to the upper gates is important to conserve cold water throughout the season. For this reason and to meet 55°F 7DADM at the CDEC station CCR, spring storage of 4.2 million acre-feet should the attained when possible.
- Wilkins Slough can go, and be maintained, as low as 3800 cfs.
- Stable flows are needed to prevent winter-run, spring-run, and fall-run redd de-watering and juvenile stranding.
- There are opportunities for fall transfers and fall flood up/pacific flyway created by these conditions
- The temperature model needs continued investment. The current Sacramento River Water Quality Model (SRWQM) has difficulty predicting water temperatures:
  - This difficulty is exacerbated with low Shasta storage

    - There is high uncertainty in the Shasta Reservoir lake stratification and temperature profile between February and May, making it difficult to plan for temperature management season prior to initial water contract allocations.
    - Inputs to the SRWQM are not conservative enough to reflect current warmer meteorological and climate conditions.
    - The SRWQM generally assumes that operations can achieve temperature targets, and often underperforms, as evidenced in the historical record. For example, it did a poor job of characterizing the Temperature Control Device (TCD) performance once the TCD side gate operation went into real-time effect and there was a loss of water temperature control in 2014 when the full Shasta side gates were accessed for water releases.
    - Outputs are sensitive to ambient air temperatures – Instead of using a 30-year historical average, we need to use warmer meteorological data to be conservative to more accurately reflect current warmer conditions
    - We need a reservoir model (stratification is difficult to predict)
    - We need a comprehensive reservoir/temperature model that addresses the complex operations of Trinity, Whiskeytown, and Shasta reservoirs.
    - There is a lack of stakeholder understanding behind the NMFS temperature dependent mortality model – we need to invest in collaborative science process with SRS contractors
- The Shasta temperature control device leaks. There may be engineering solutions that should be investigated to prevent the loss of cold water (tarps, *etc*.)
- Various operations and their effects on water temperature should be studied, for example, power peaking at Whiskeytown Reservoir.
- Low Sacramento River spring flows were correlated with low survival emigrating juvenile spring-run from Deer and Mill Creeks.
- Disease was documented to be more prevalent in the upper Sacramento River in 2015 than historically thought which may have impacted survival rates in 2013, 2014, and 2015. Further studies are needed.
- Further studies are needed to understand other stressors in the upper Sacramento River such as predation, lack of spawning/rearing habitat, food web supply, bioenergetics, *etc*.
- The performance criteria in the Shasta RPA have not been attained.
- California WaterFix modeling indicates worsening of temperature effects, but agencies also share an understanding that the Reclamation wouldn't necessarily operate the system that way due to seasonal planning and temperature requirements in the Shasta RPA. Adjusting the Shasta RPA now may provide for a more robust set of operational criteria that protect cold water with a dual Delta conveyance system.

Additional and emerging science: Water operations resulted in elevated water temperatures that had lethal and sub-lethal effects on egg and alevin incubation and juvenile rearing in upper Sacramento River. Evaluation of the scientific literature found:

- Water temperatures from 42.8°F to 50°F are optimal for salmon egg and fry survival and development [U.S. Environmental Protection Agency (EPA) 2003]

- 56°F daily average water temperature is a sub-optimal temperature that is not sensitive to extreme high or low water temperatures within a given day; and
- Critical temperature of 53.7°F, at which egg and fry mortality increases disproportionately with increasing water temperatures (Martin *et al*. 2016).

Past reviews and recommendations:

- Some recommendations from the CALFED Panel Report (Deas *et al*. 2008) include:
    - Adopt an analytical framework for modeling flow and temperature as a way to characterize more effectively the complex river and reservoir systems and their influences on fish life cycles.
    - Adopt the latest technology in flow and temperature modeling that will resolve some of the problems identified in previous reviews of the OCAP BO. This recommendation includes adopting models with smaller time-steps to better assess biological effects.
    - Identify specific biological impacts to salmonids of an altered thermal regime using a life cycle model that includes associated conceptual links to habitats and cumulative stressors.
- Annual reviews of the long-term operations biological opinions: For most of the annual reviews conducted to date, the independent review panel provided recommendations for Shasta operations and fisheries considerations. For example:
    - 2010:
        - The system needs to include bioenergetics models that characterize effects of temperature growth and survival across multiple life stages.
        - Compliance points should be re-evaluated and possibly moved to better match actual fish habitat usage.
    - 2011:
        - Given that WY2011 was a wet year (and high reservoir storage) and the Bend Bridge temperature compliance point was not met, it is highly unlikely that the RPA Action I.2.1 of meeting the TCP at Bend Bridge (15% of the time, or 1.5 years out of 10) will not be possible within 10 years
        - Utilize a more quantitative model-based program to analyze the biological response of temperature control operations and efficiently utilize the limited cold water resources in Shasta/Keswick Operations
    - 2013:
        - Evaluate effects of 7-Day Average Daily Maximum (7DADM) on changes in the location of the TCP and the survival of salmonid early life stages.
        - Evaluate the likelihood of critical depletions more than 30 days in advance so that water deliveries can be scheduled over a longer time period and avoid the operational criteria that have the effect of forcing inefficient use of cold water storage.
    - 2014:
        - HEC-5Q model based on 1-D reservoir stratification model is outdated and inadequate
        - Investigate reservoir de-stratification techniques to determine if they could be useful to bring colder, deeper water closer to the surface at the elevation of the lowest portion of the TCD.

- 2015:
  - There is a need for even greater interagency discussion and cooperation to describe a new set of storage and release scenarios into the future.
  - Both numerical models and field equipment used to manage temperature releases need to be supplemented and ultimately replaced.
  - Development of a model that can predict the timing and depth of stratification within Shasta Lake.

As a result of the above, the following are initial ideas for adjusting various aspects of the Shasta RPA in order for the specific actions to meet their respective objectives, as identified.

2. Ideas for adjustments

   a. Responsibilities and Procedures of Technical Teams (11.2.1.1) – This section needs to be updated to reflect the newly formed Shasta Water Interagency Management Team (SWIM Team) and its objectives, roles, and responsibilities. In addition, the objectives, roles, and responsibilities of the Sacramento River Temperature Task Group (SRTTG) need to be updated to reflect a need for year-round flow and temperature planning and management. The original objective of the SRTTG, to implement water rights orders 90-5 and 91-1, would stay intact within the modified SRTTG.

   b. Research and Adaptive Management (11.2.1.2):

      i. Investigate new ways to operate the Central Valley Project (CVP) based on current and future meteorological and hydrological conditions

         Rationale: Meteorological and hydrological conditions in the last four years of the drought are not indicative of historical conditions. Climate change is occurring and past conditions can no longer be used to operate the CVP. CVP operations must be updated to reflect current and future conditions (Anderson *et al.* 2014 and 2015, Deas *et al.* 2008).

      ii. Invest in new Shasta Reservoir and Sacramento River water temperature forecasting and modeling tools (Anderson *et al.* 2010, 2011, 2013, 2014 and 2015, Deas *et al.* 2008), including: (1) developing a collaborative science plan for model improvements; (2) the NMFS-SWFSC coupled reservoir and River Assessment Forecasting Tool (RAFT) modeled outputs into real-time operations and monthly forecasts; and (3) developing and implementing an integrated Shasta/Whiskeytown/Trinity/Lewiston operations and temperature model.

         Rationale: Currently there is no Shasta Reservoir stratification model and the SRQWM is an outdated and inadequate tool to provide sufficient precision to determine operations throughout the temperature management season and meet the regulatory requirements in the CVP/SWP operations Opinion. In addition, reservoir temperature models are needed to integrate the entire Shasta Division to better plan and manage operations.

iii. Research and implement engineering solutions to utilize inaccessible cold water pool in Shasta Reservoir and minimize warm water leaks through the Shasta Dam temperature control device to improve Sacramento River temperature management (Anderson *et al.* 2014).

iv. Fund further studies to understand other stressors associated with water temperatures and operations, such as disease, predation, lack of spawning and rearing habitat, food web supply, bioenergetics, *etc*. (Anderson *et al.* 2010, 2011, 2013, 2014 and 2015, Deas *et al.* 2008). This research is critical towards further understanding of the role that water operations plays on the current (and future) status of listed anadromous fish species in the Sacramento River (primarily winter-run Chinook salmon).

c. Monitoring and Reporting (11.2.1.3) – Updates to include long-term funding of: (1) redd-dewatering and juvenile stranding monitoring (that have been occurring since 2012 based on temporary funding); (2) additional temperature and dissolved oxygen monitoring in the Sacramento River; and (3) spawning gravel and juvenile rearing habitat monitoring. This monitoring is crucial towards understanding the biological effects of water operations (Anderson *et al.* 2010, 2011 and 2013, Deas *et al.* 2008).

d. Shasta Division RPA Actions (11.2.2):

i. Action I.2.1: Performance Measures

Objective: To establish and operate to a set of performance measures for temperature compliance points and End-of-September (EOS) carryover storage, enabling Reclamation and NMFS to assess the effectiveness of this suite of actions over time. Performance measures will help to ensure that the beneficial variability of the system from changes in hydrology will be measured and maintained.

Proposed Changes:

(1) Modify the 10-year running average for temperature compliance point (Anderson *et al.* 2011), as it provides very little utility because it does not account for deleterious effects to winter-run in dry and critically dry water years.

(2) Change the Shasta Reservoir storage performance measures to be based on water year type and include explicit end-of-April (or May) storage requirements in addition to EOS storage requirements.

Rationale: The Shasta RPA requires a temperature compliance point to be between Balls Ferry and Bend Bridge from May 15 through September 30. However, Anderson *et al*. (2010, 2011) and EPA (2003) have advised that appropriate compliance location should be the most downstream redd.

ii. Action I.2.2: November through February Keswick Release Schedule (Fall Actions)

Objective: Minimize impact to listed species and naturally spawning non-listed fall-run from high water temperatures by implementing standard procedures for release of cold water from Shasta Reservoir.

Proposed Changes:

(1) Update language to reflect potentially new EOS storage requirements [*e.g.*, EOS must be greater than 1.9 MAF and/or cold water volume (defined as water less than 49°F) must be greater than or equal to a certain volume] and potentially new minimum flows to minimize fall-run redd dewatering and juvenile winter-run stranding. EOS storage volumes for water years 2013, 2014, and 2015 were not adequate to reduce the adverse effects of high water temperature in the summer months for winter-run.

(2) Time a Keswick Reservoir fall pulse-flow(s) to occur immediately after the first significant fall rains to restore a more natural hydrograph to the Sacramento River, and aid emigrating spring-run juveniles by providing improved water quality conditions (*e.g*., flow, turbidity, temperature).

iii. Action I.2.3: February Forecast: March – May 14 Keswick Release Schedule (Spring Actions)

Objective: To conserve water in Shasta Reservoir in the spring in order to provide sufficient water to reduce adverse effects of high water temperature in the summer months for winter-run and spring-run, without sacrificing carryover storage in the fall.

Proposed Changes:

(1) Change the February forecast requirement to a March forecast prior to initial water allocation decisions. A March forecast would provide better accuracy for the water year and allocations than a February forecast;

(2) Update language to require initial minimum and maximum monthly Keswick release schedules for the water year and to delay full side gate operations as long as possible in low storage years to ensure the Shasta Reservoir cold water pool lasts throughout the temperature management season;

(3) Change temperature compliance point language to 61°F 7DADM during winter-run adult holding period (EPA 2003);

(4) Require pulse flows for spring-run juveniles from Deer and Mill creeks to aid in their emigration down the Sacramento River (Johnson 2016); and

(5) Implement a bed load moving pulse flow, if needed, to flush out accumulated vegetation and sediments in order to provide suitable spawning habitat in the upper Sacramento River (Stillwater Sciences 2007).

iv. Action I.2.4 May 15 – October 31 Keswick Release Schedule (Summer Action)

Objective: To manage the cold water storage within Shasta Reservoir and make cold water releases from Shasta Reservoir to provide suitable habitat temperatures for winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon in the

Sacramento River between Keswick Dam and Bend Bridge, while retaining sufficient carryover storage to manage for next year's cohorts. To the extent feasible, manage for suitable temperatures for naturally spawning fall-run.

Proposed Changes:
(1) Change the temperature compliance point language to manage operations not in excess of 55.0°F 7DADM to downstream most Sacramento River winter-run Chinook redd throughout spawning and egg incubation season (EPA 2003);
(2) Add language to stabilize Keswick releases to minimize the potential for winter-run redd dewatering and juvenile stranding;
(3) Establish Keswick release flow schedules by water year type, as necessary, to meet the above criteria; and
(4) Add language to incorporate conservative meteorological forecasting and exceedance triggers into temperature management planning until hydrological and forecasting model updates are completed.

v. Action I.4 Wilkins Slough Operations

Objective: Enhance the ability to manage temperatures for anadromous fish below Shasta Dam by operating Wilkins Slough in the manner that best conserves the dam's cold water pool for summer releases.

Proposed Change:
(1) Change the currently outdated 5,000 cfs navigation criterion to 3,800 cfs based on water users' minimum pumping requirements.
(2) Keep current requirement, but consider it as an alternative, for Reclamation to convene a subteam to determine a minimum fish flow.

vi. Update Appendix 2-A, Decision Criteria and Processes for Sacramento River Water Temperature Management, to reflect current information and processes and resolve inconsistencies with Shasta Division RPA actions regarding acceptable criteria exceedances.

3. The updated RPA will include (1) track changes of pages in the RPA that have changes (not limited to the Shasta RPA, as there are other clarifications, *etc*., needed since the 2011 adjustment) and (2) clean version of entire RPA, including revised section 11.3 Analysis of RPA

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