Shasta Temperature Management Plan – Key Components

The Bureau of Reclamation, in coordination with NOAA's National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), the California Department of Water Resources (DWR), the California Department of Fish and Wildlife (CDFW), and the State Water Resources Control Board (State Water Board), has developed a new Shasta Temperature Management Plan. This document summarizes key components of that plan. Additional details of the final plan are being prepared, and the plan will be submitted to NMFS, USFWS, CDFW, and the State Water Board for review and concurrence within the next week.

Current circumstances:

1. **Cold water storage in Shasta Reservoir is critically low**. The lack of snowpack translated into a much smaller volume of cold water in Shasta Reservoir (called the "cold water pool") than occurred last year. The cold water pool is both about 30% smaller than what was anticipated in early May 2015, and is not as cold as it was at this time last year. The size of the projected cold water pool is a key variable in any seasonal temperature management plan, hence the need to revise the 2015 plan to reflect these new and significantly lower projections (see Supplemental Graphics document, Figure 1).
2. **Summer is likely to bring record-breaking high temperatures**. Scientists have been tracking a 'warm blob' of Pacific Ocean surface water since fall of 2013. The warmest ocean temperatures in the blob now are around 5°F above average. Researchers have linked these ocean temperatures to record high temperatures on land, which are likely to continue. Air temperatures in Redding over the last 3 months have tracked an average of almost 7°F (3.82°C) higher than normal (Supplemental Graphics, Figure 2).
3. **Most streams and rivers are already running warm**. For example, water temperatures coming from Whiskeytown Dam into Clear Creek have been about 2°F warmer than last year and 3°F warmer than average (Supplemental graphics, Figure 3). Further, temperature profiles in Shasta Reservoir showed significantly warmer water than expected, making it very unlikely to meet the NMFS Biological Opinion and Water Rights Order 90-5 requirements of 56°F maximum temperature at any compliance point in the river throughout the temperature-control season (through October).
4. **Models used to predict Shasta cold water pool temperatures are uncertain.** A hindcast report issued in March 2015[1] found that the Sacramento River temperature model represented well the pre-side gate performance progression of the Shasta Temperature Control Device (TCD), but did a poor job at characterizing the TCD performance once the TCD side gate operation went into real-time effect 2014. These

[1] http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/sac_river_hindcast_usbr_2014.pdf

model errors led to an excess expenditure of Shasta cold water pool last summer, resulting in early depletion of cold water reserves and loss of temperature control in the river in September 2014.

5. **The population of winter run Chinook salmon is at extreme risk**. NMFS recently named Sacramento River winter-run Chinook as one of the eight species most at-risk of extinction in the near future. Last year, due to lack of ability to regulate water temperatures in the Sacramento River in September and October, water temperature rose to greater than 60°F. This reduced early lifestage survival (eggs and fry) from Keswick to Red Bluff from a recent average of approximately 27% (egg-to-fry survival estimates averaged 26.4% for winter-run Chinook salmon in 2002-2012) down to 5% in 2014. Consequently, 95% of the year class of wild winter-run Chinook was lost last year.
6. **Winter-run Chinook egg and hatchings (alevin in the gravel) are extremely sensitive to high temperatures**. Winter-run experience increased levels of mortality during egg and alevin development when water temperatures rise above 56°F, coupled with other potential stressors, including water quality, disease, predation, competition, habitat availability, contaminants and food availability.

Poor results of Temperature Management in 2014:

Despite projections and modeling efforts in 2014, Shasta Reservoir ran out of sufficiently cold water in September 2014. After this point, there was insufficient cold water available for release to the Sacramento River to manage temperatures. This lack of ability to regulate temperature was a primary factor contributing to the loss of 95% of last year's year class of wild Sacramento River winter-run Chinook.

All of the agencies that worked to develop this plan are committed to taking all steps within their collective responsibility and authority to minimize the risk of a second year-class failure to this endangered species of salmon. Losing two out of three year classes would be devastating to the viability of this species.

The hindcast report of last year's operations highlighted how the TCD side gates factored into elevated river temperatures last year, along with the significant role of ambient meteorological conditions on seasonal temperature management. To address these limitations, this plan builds additional conservatism into the modeling assumptions, including utilizing a 10% meteorological conditions outlook (*i.e*. using the warmest 10% temperature projections) over the next 90 days to predict seasonal temperatures. These changes are expected to better predict actual cold water pool management this year. But there is still a high level of risk and uncertainty, given the very poor inflows, low reservoir levels and warm air temperatures being projected for the season.

New information compelled revisions to the May 2015 temperature plan:

The six agencies worked with the Sacramento River Settlement Contractors in early May to come up with a strategy for water releases in the Sacramento River for the remainder of the year. At that time, based on cold water pool projections, the agencies projected that there was a reasonable likelihood that 56°F could be attained throughout the season.

In late May, Reclamation notified NMFS and the State Water Board that the updated Shasta Reservoir temperature profile was noticeably warmer than the data used in the April temperature

plan, and that the change was beyond the typical reservoir warming experienced in past years in April and May. Current temperature modeling indicates that a temperature objective of 56°F downstream to the temperature compliance point at Bonnyview Bridge, Redding, California (Sacramento River above Clear Creek, CDEC ID: CCR) would be very difficult this year and that a modified temperature plan was warranted. Reclamation has examined the April temperature data and has concluded that much of the shift in temperature readings was due to an instrument calibration error (causing earlier temperature readings to read cooler than actual). In addition, unusually warm air temperatures and a lack of snowmelt runoff contributed to warmer than expected inflows into Shasta Reservoir this spring.

Subsequent temperature profiles in Shasta Reservoir, when input into the temperature model, forecasted significantly warmer water temperatures than previously expected. The model results indicated a lack of ability to meet the NMFS Biological Opinion and Water Rights Decision 90-5 requirement of a maximum daily average water temperature of 56°F at any compliance point in the river throughout the temperature-control season (through October). Reclamation modeled various Keswick release scenarios, including June through August releases at 7,000 cfs and 7,500 cfs (Supplemental Graphics, Figures 4 and 5, respectively).

Plan Components:

A. 2015 Shasta Temperature Management Plan Goals

Considering the information developed to date, the six agencies developed the following overarching goals for a new plan:

- Maintain access to essential water supplies for California communities throughout the Central Valley Project (CVP)/State Water Project (SWP) system.
- Avoid the severe winter-run Chinook mortalities of last year— develop temperature management criteria and related operations that reduce the risk of a second year-class failure by carefully expending very limited cold water pool resources over the course of the season (June though late October). The overall strategy is to manage for warmer temperatures earlier in the season in order to reduce risk of running out of cold water and catastrophic losses later in the season.
- Recognize the major uncertainties associated with predicting how 2015 will transpire given the extreme conditions and uncertain weather and prepare to manage around well-informed "real time" operations based upon ever-changing current conditions.
- Retain integrated system operations and flexibility for end users/water districts to devise local solutions to assist in plan implementation as the season progresses.
- Maintain Delta outflows, consistent with the current Temporary Urgency Change Petition (TUCP).

B. Shasta Temperature Management Plan Objectives

These overarching goals led to the following plan objectives:

- Biological objectives:
    - Target 57°F at CCR, not to exceed 58°F unless going above is needed to conserve cold water pool based on real-time temperature management team guidance.
    - Develop a base operation that meets this temperature objective and delays last TCD side gate operation until mid-October (target October 15th).

- Develop a rigorous real-time management process (see below) that carefully tracks river temperatures, air temperatures, and biological metrics to ensure that water releases are made for the sole purpose of optimizing limited cold water pool resources throughout the season.
- Minimize the potential for fall-run Chinook redd dewatering in October and November.
- Retain wildlife refuge water supply planning objectives to the maximum extent feasible, consistent with previous considerations.

- Water Supply Objectives:
  - Maintain access to essential water supplies for California communities.
  - Specify minimum end of September storage of 120 thousand acre-feet in Folsom Lake.
  - Specify minimum end of October storage of 900 thousand acre-feet in Lake Oroville.
  - Provide some level of south Delta exports to address health and safety concerns for City of Tracy and South Bay Aqueduct municipal supplies, which rely on diversions directly from the Delta.
  - Facilitate water transfers to the extent possible as part of overall water operations plans.

- Retain integrated system operations and flexibility for local solutions:
  - Retain commitment to meet Delta objectives (outflow and salinity) in the TUCP.
  - Work to manage south of Delta exports to achieve San Joaquin Valley refuge management objectives based on allocations.
  - Commit to working with Sacramento River Settlement contractors and others in real-time to minimize water supply impacts.
  - Minimize impact on/affects to non-CVP water users (*e.g.*, Feather River service area, SWP, other system operators).
  - Release a volume of transfer water from Shasta Reservoir in October through November 15 whenever ambient air temperatures drop and river temperatures are suitable.
  - Reshape project releases in November/December (consistent with fall-run Chinook needs) in order to meet critical needs South of Delta.
  - Flexibly implement the Coordinated Operations Agreement in order to achieve overall system goals.

C. **Shasta Temperature Management Plan Base Operations**

- Establish 7,250 cubic feet per second (cfs) as a base flow from Keswick Dam in June and July.
- Modeled Keswick releases in other months that achieve the above objectives are: August: 7,250 cfs; September: 6,500 cfs; October: 5,000 cfs. These are subject to adjustment by the real-time monitoring and decision making group based on performance of the plan in June and July.

D. **Shasta Temperature Management Plan Real-time Management**

The above guidelines in section "C" are for base operations--actual operations will be decided using a real-time monitoring and decision making process that includes representatives from the relevant Federal and State agencies. This decision making process may yield adjustments to base operations depending on real-time conditions on the ground (*e.g.*, real-time water temperatures and resulting cold water pool volume).

Reclamation will convene the real-time monitoring and decision making group at least weekly, and more frequently if necessary to inform decisions about temperature operations. The agencies also acknowledge the expertise of water districts and irrigation districts to operate their systems in partnership with the agencies to optimize results and minimize impacts. The agencies expect to work closely during real-time operations with such districts.

Decisions on real-time adjustments to base operations will be made using the following principles:

- Attaining temperatures close to 57°F as possible at CCR, while monitoring in real-time temperatures near the Highway 44 Bridge to assess what temperatures the majority of redds are actually exposed to (assuming spawning will be at or upstream of the Highway 44 Bridge).
- Based on projected temperatures, and if it appears that they will exceed 58°F at CCR, Reclamation will call a meeting to determine what actions are most advisable given salmon life-stage and projected ability to withstand additional adverse effects of temperatures. Actions which could be implemented include: TCD gate changes, bypassing power and other operational adjustments, allowing short-term exceedances above 58°F at CCR as long as night-time temperatures are low, and possibly increasing Keswick releases above 7,250 cfs. Releases above the base flow have a negative cumulative effect on thermal mass, cold water and possible timing of side gate operations, and therefore require careful consideration.
- Because overall seasonal temperature management, and most importantly the timing of future side gate operations, appears very sensitive to managing through heat waves, additional consideration will be given to optimal procedures for longer heat spells which are most likely to occur in July.
- If air temperatures are cooler, and 57°F is attainable at CCR, real-time adjustments may be made to reduce Keswick releases below 7,250 cfs in order to conserve thermal mass and cold water for later in the season, as long as 58°F at CCR is not exceeded.
- CDFW will monitor observed redd locations, particularly the most downstream redd and redds at risk of being dewatered and report results on a weekly basis. While this is not a comprehensive survey due to redds that are in deep water above Highway 44, it will provide a general distribution of redds. It will also provide a way of tracking the duration and peak of spawning which will inform temperature management decisions.
- NMFS will track temperature exposures and report on cumulative estimated mortalities on at least a bi-weekly basis. NMFS is also in the process of deploying

new automated temperature fiber optic cables behind Shasta Dam and within Keswick Reservoir.

E. Additional Monitoring Commitments:

- Reclamation and NMFS will deploy new automated temperature fiber optic cables behind Shasta Dam and within Keswick Reservoir and use the data and information collected to make adjustment decisions.
- Reclamation will monitor temperatures near the Highway 44 Bridge to assess what temperatures the majority of winter-run redds are actually exposed to. (New CDEC station: SAC)
- The agencies will monitor weather conditions and forecasts, and adjust releases and TCD gate operations accordingly. For example:
    - The River Assessment for Forecasting Temperature (RAFT) model will be used to better anticipate the need for management actions and help predict effectiveness of different real-time operations options.
    - Seasonal temperature management appears to be very sensitive to heat-storms, so the agencies will devise optimal procedures for longer heat spells (most likely to occur in July).
    - If air temperatures from June through August are substantially below what was forecast, there may be additional opportunities to increase releases in September and October for other purposes, while still meeting temperature objectives.
- CDFW will monitor observed redd locations, particularly the downstream distribution of redds, throughout the temperature management season. They will also monitor those redds at potential risk of being dewatered as flows are ramped down in the fall.
- The agencies will meet as often as needed to share and review information, and/or make real-time decisions or adjustments, but no less than weekly.

F. Commitment to advance new peer reviewed temperature model review

Changing climatic conditions are not easily reconciled in the current temperature model used by Reclamation, and model outputs defining projected TCD side gate operations and river temperatures can be inaccurate, creating circumstances contributing to increased egg and alevin to fry mortality of winter-run Chinook salmon. To address these limitations:

- NMFS and Reclamation will co-chair a new model review technical working group that will identify the shortcomings with the existing modeling tools and will make recommendation about short-term fixes to the current tool or defer changes to a new model.
- In addition, Reclamation and NMFS-Southwest Fisheries Science Center are working on a multiyear effort to develop a Temperature Decision Support Tool that includes a reservoir temperature model coupled with the existing RAFT model[2] that forecasts downstream river temperatures using real-time meteorological conditions. This model may have some applicability for forecasting water temperatures resulting from differing operational plans, and will incorporate peer reviews and iterative technical workshops to inform its development and implementation in the future.

[2] http://oceanview.pfeg.noaa.gov/RAFT/stream.html

- Future efforts will use NOAA Climate Prediction Center forecasts, NOAA National Weather Service assistance, and more conservative meteorology as input to future model runs, rather than the median projections used in 2014 and prior years.
- The agencies will develop a plan for independent peer review of these models and tools.
- Through all of these steps, the agencies can and will improve on temperature management from here forward to more accurately project TCD operations and downstream river temperatures to manage potential effects on listed and special status species.

G. **Non-operational measures for winter-run Chinook protection**

- Livingston Stone National Fish Hatchery is a small conservation hatchery for this species. FWS has increased capacity at Livingston Stone National Fish Hatchery production for winter-run from the typical 120 adults broodstock to accommodate up to 400 adults.
- Other non-operational decisions are being made in the same time frame as this decision for benefit of winter-run Chinook salmon, including decisions on recreational and commercial fishing.
- The agencies will continue to actively investigate other project elements that make sense, including:
    - applying reflective paint or other shading on the penstocks into Whiskeytown Reservoir, and
    - accelerating acquisitions related to the installation of the Oak Bottom Temperature Curtain in Whiskeytown Reservoir, decreasing the exposure of cold water from Trinity to sunlight as it travels through the powerhouse and exposed pipes that to help ensure this cold water remains cold.
- The agencies will continue to seek input from stakeholders to develop other non-flow actions that may help minimize overall impacts (*e.g.*, predation control strategies and/or restoration, hatchery, *etc*.).

Summary

Given the very limited cold water resource, not all needs can be met with higher summer flows from Shasta Reservoir. The agencies have addressed several of the most critical areas of concern, and believe that the elements of the new plan described here allow flexibility for the agencies to continue working with other water entities and partners to find local solutions to the remaining needs.

Based on the temperature model predictions and RAFT model predictions at the 10% meteorological forecast (Supplemental Graphics, Figure 6), habitat conditions are predicted to be substantially better than last year, because temperature control will not be lost in the September timeframe. Actual performance of the plan will depend heavily on real-time management and actual air temperatures observed.