POTENTIAL RESOURCE ISSUE:

Aquatic resource habitat quantity and quality.

Basin Plan objectives compliance.

PROJECT NEXUS:

Project operations and potential Project betterments modify or could modify the flow regime in the bypass reaches and the peaking reach, and storage levels in Project reservoirs, thereby influencing instream water temperatures.

POTENTIAL LICENSE CONDITION:

- Instream flow releases.

STUDY OBJECTIVE(S):

- Characterize the relationship between flow and water temperature in bypass reaches and the peaking reach using an appropriate model supported by existing water temperature data from the bypass reaches and peaking reach.
- Characterize water temperature conditions in the bypass reaches and the peaking reach for the existing and unimpaired flow regimes.
- Document the availability of cold water temperature refugia in Project bypass reaches where water temperatures exceed established technical evaluation criteria.
- Assess the potential effects of global warming on water temperatures over the period of the Federal Energy Regulatory Commission license.

EXTENT OF STUDY AREA:

- The study area for water temperature modeling includes: five stream reaches in the Middle Fork American River between French Meadows Reservoir and the confluence with the North Fork American River; two stream reaches in the Rubicon River between Hell Hole Reservoir and Ralston Afterbay; and one reach in the North Fork American River between the Middle Fork American River confluence and Folsom Reservoir (Table AQ4-1 and Figure AQ4-1). Water temperature models also are proposed for French Meadows and Hell Hole reservoirs. Duncan Creek and Long Canyon Creek (including the North and South Forks of Long Canyon Creek) will not be included in the temperature modeling study area because PCWA has committed to not divert flow from these streams during the summer, after July 1st, in the new license. The highest summer water temperatures occur in late July and early August (PCWA 2006) and water temperature during this period will not be affected by the Project.

STUDY APPROACH:

- Summarize water temperature data from the 2005-2006 Water Temperature Study (e.g., PCWA 2006), including seasonal patterns and daily averages, minimums, and maximums as a function of time and location in the bypass and peaking reaches. Summarize the thermal profiles in the Project reservoirs. Also summarize the

temperature data upstream of Project facilities. Summarize meteorological conditions (relative humidity, wind speed, solar radiation, air temperature) in the study area based on the meteorological data collected in the 2005-2006 Water Temperature Study (e.g., PCWA 2006).

- Establish a Water Temperature Modeling Subgroup to provide oversight and technical review of modeling procedures/decisions.
- Select and develop appropriate reservoir and river water temperature models with seasonal, daily, and within-day temperature modeling capability, as necessary for specific study reaches. RMA-2 and RMA-11 (King 1994; King 1997) are proposed for the river temperature modeling. RMA has dynamic flow routing capability and within-day temperature modeling capability. CE-QUAL-W2 (Cole and Wells 2004) or CE-QUAL-R1 (Environmental Laboratory 1986) will be used for the reservoir water temperature modeling. CE-QUAL-W2 will be used if suitable bathymetric data are available. The reservoir temperature models at French Meadows and Hell Hole reservoirs will be integrated to characterize the potential effects associated with the French Meadows-Hell Hole Pump Storage potential Project betterment on reservoir release temperatures.
- The models will be developed to simulate water temperatures during the summer months when water temperature may be of most concern to aquatic species. Modeling development steps include:
    - Collect/develop model inputs including channel and reservoir geometry data, solar shading data (topographic and riparian), meteorological data (air temperature, wind speed, relative humidity, solar radiation), hydrology data, and boundary condition flow and water temperature data for the modeled river reaches and reservoirs. Extend the measured Project meteorological data (e.g., 2005–2008) to the 1975–2004 period through correlation with a long-term meteorological station if possible. Suitable meterological stations will be identified and the correlation results will be evaluated as part of this study.
    - Calibrate and validate the hydrodynamics and heat budget portions of the water temperature model(s) with empirical water temperature (river reaches and reservoirs) and meterological data (e.g., use data collected in 2005–2008).
- Characterize modeled water temperatures (i.e., seasonal, daily, within-day temperatures) for existing, unimpaired, and alternative flow conditions. Incorporate available literature predictions of changes in air temperature, relative humidity, wind speed, and solar radiation as a result of global warming into the models to evaluate the resulting effect on water temperature over the anticipated term of the FERC license period (sensitivity analysis).
- Model the potential effects of the French Meadows-Hell Hole Pump Storage potential Project betterment on reservoir temperature regimes and associated instream release temperatures.
- In selected reaches of the lower Rubicon River and the Middle Fork American River, collect water temperature data at tributary inflows and in deep pools to identify the potential availability of water temperature refugia for trout. In particular, review the 2005-2006 Water Temperature Study results (e.g., PCWA 2006) to identify river reaches with summer temperatures above 20 °C. Within these reaches, identify likely tributaries with potential cold water inflows and characterize the extent of the cold water refugia (e.g., amount of tributary habitat, extent of influence in the main channel). Identify two deep

pools upstream and two downstream of the tributary and collect water temperature profiles to examine potential thermal stratification.

- In the Project reaches where water temperature will not be modeled (e.g., Duncan Creek, North Fork Long Canyon Creek, South Fork Long Canyon Creek, and Long Canyon Creek), use existing water temperature and meteorological data to quantify the relationships between air temperature and water temperature.

SCHEDULE:

To be developed in early 2007.

REFERENCES:

Cole, T. M. and S. A. Wells. 2004. CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.2. User Manual; Instruction Report EL-03-1. U.S. Army Corps of Engineers, Washington, DC.

Environmental Laboratory. 1986. CE-QUAL-R1: A numerical, one-dimensional model of reservoir water quality; User's Manual, Instructional report EL-82-1 (Revised Edition), U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, MS.

King, I.P. 1994. RMA-2; A Two-Dimensional Finite Element Model for Flow in Estuaries and Streams, Version 5.1. Department of Civil and Environmental Engineering, University of California, Davis.

King, I.P. 1997. RMA-11 A Three Dimensional Finite Element Model for Water Quality in Estuaries and Streams – Documentation Version 2.5. Department of Civil and Environmental Engineering, University of California, Davis.

Placer County Water Agency (PCWA). 2006. Middle Fork American River Hydroelectric Project (FERC No. 2079), Final 2005 Water Temperature Study Report.

Table AQ4-1. Water Temperature Modeling Reaches.

Study Reach	Bypass Reaches	Peaking Reach	Reservoir	Water Temperature Modeling
Duncan Creek				
Duncan Creek from Diversion to confluence with Middle Fork American River	●			No
Middle Fork American River				
French Meadows Reservoir			●	Yes
Middle Fork American River from French Meadows to confluence with Duncan Creek	●			Yes
Middle Fork American River from confluence with Duncan Creek to Middle Fork Interbay	●			Yes
Middle Fork Interbay			●	Yes[1]
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay	●			Yes
Ralston Afterbay Downstream				
Ralston Afterbay			●	Yes[1]
Middle Fork American River from Ralston Afterbay to confluence with Canyon Creek		●		Yes
Middle Fork American River from confluence of Canyon Creek to confluence with North Fork American River		●		Yes
North Fork American River from confluence with Middle Fork American River to Folsom Reservoir		●		Yes
Rubicon River				
Hell Hole Reservoir			●	Yes
Rubicon River from Hell Hole Reservoir to confluence with South Fork Rubicon River	●			Yes
Rubicon River from confluence with South Fork Rubicon River to Ralston Afterbay	●			Yes
Long Canyon Creek				
North Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	●			No
South Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	●			No
Long Canyon Creek from North and South Fork Long Canyon creeks confluence to confluence with Rubicon River	●			No

[1]These small reservoirs will be modeled using the river temperature model.

Placeholder for Figure AQ4-1

Temperature Modeling Study Reaches

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