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October 14, 2009

VIA ELECTRONIC FILING

Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

RE: Don Pedro Project (FERC Project No. 2299); Response of Turlock and Modesto Irrigation Districts to the Federal Energy Regulatory Commission's July 16, 2009 Order (128 FERC ¶ 61,035) Regarding Instream Flow and Water Temperature Model Study Plans

Dear Secretary Bose:

In its July 16, 2009 Order (128 FERC ¶ 61,035) on Rehearing, Amending License, Denying Late Intervention, Denying Petition, and Directing Appointment of a Presiding Judge for a Proceeding on Interim Conditions ("Order"), the Federal Energy Regulatory Commission ("Commission" or "FERC") directed the Turlock and Modesto Irrigation Districts ("Districts") to develop and implement an instream flow study for, and a water temperature model of, the Tuolumne River below La Grange Dam for the purpose of assisting the Commission in evaluating the potential need for modifying the instream flows required under the current license prior to relicensing.

Specifically, Ordering Paragraph (F) of the Order states, in pertinent part, as follows:

> (F) The Turlock and Modesto Irrigation Districts (Districts) shall develop and implement an IFIM/PHABSIM study plan to determine instream flows necessary to maximize fall-run Chinook salmon and *O. mykiss* production and survival throughout their various life stages. The PHABSIM flow models under the IFIM should evaluate base flows, to include, but not be limited to, 150 cubic feet per second (cfs), 200 cfs, 250 cfs, 300 cfs, and at least 400 cfs. The instream flow study shall also evaluate spring pulse flows of 1,000 to 5,000 cfs and fall pulse flows of up to

> 1,500 cfs from La Grange Dam. In general, the instream flow study shall include the following steps, unless agreed upon otherwise in consultation with the resource agencies: (1) selection of target species or guild, selection or development of appropriate micro- and/or macro-habitat suitability criteria; (2) study area segmentation and study site selection; (3) cross section placement and field data collection; (4) hydraulic modeling; (5) habitat modeling; (6) derivation of total habitat time series, micro- and macro-habitat; (7) determination of habitat bottlenecks; and (8) evaluation of management alternatives and problem resolution. In connection with the IFIM study, the Districts shall also develop a water temperature model to determine the downstream extent of thermally suitable habitat to protect summer juvenile *O. mykiss* rearing under various flow conditions and to determine flows necessary to maintain water temperatures at or below 68 degrees Fahrenheit from La Grange Dam to Roberts Ferry Bridge.
>
> The Districts shall file for Commission approval, within 90 days from the date of this order, their instream flow study plan, to include provisions for developing and completing a water temperature model. The study plan shall include the following: (a) a detailed description of the study and methodologies to be used; (b) a schedule for conducting the IFIM study and water temperature model; and (c) a provision for filing periodic progress reports with the Commission. The Districts shall design and prepare their study plan in consultation with the National Marine Fisheries Service ["NMFS"], the U.S. Fish and Wildlife Service ["USFWS"], and the California Department of Fish and Game ["CDFG"] prior to filing their plan and schedule with the Commission. The Districts shall allow a minimum of 30 days for the agencies to comment and to make recommendations before filing the plan with the Commission. The Districts shall include with the plan documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments and recommendations are accommodated by the plan. If the Districts do not adopt a recommendation, the filing shall include the District's reasons, based on project-specific information.

The revised study plans are provided in Attachments 1 (Instream Flow) and 2 (Water Temperature Modeling) hereto. The documentation of consultation is as follows:

- The Districts distributed their proposed study plans to the pertinent agencies on September 3, 2009, for a minimum of 30 days for agency comments/recommendations (Attachment 3 hereto is a copy of the transmittal letter of September 3, 2009).

- Comments/recommendations from the USFWS were filed with the Commission on October 5, 2009 (Attachment 4 hereto), and comments from CDFG were received by the Districts via fax on October 5, 2009 (Attachment 5 hereto). NMFS did not provide the Districts with any comments/recommendations.

- The Districts' responses to the USFWS and CDFG comments/recommendations are provided in Attachments 6 and 7 hereto, respectively.

The Districts shall implement the study plans following Commission approval, including any changes that may be required by the Commission.

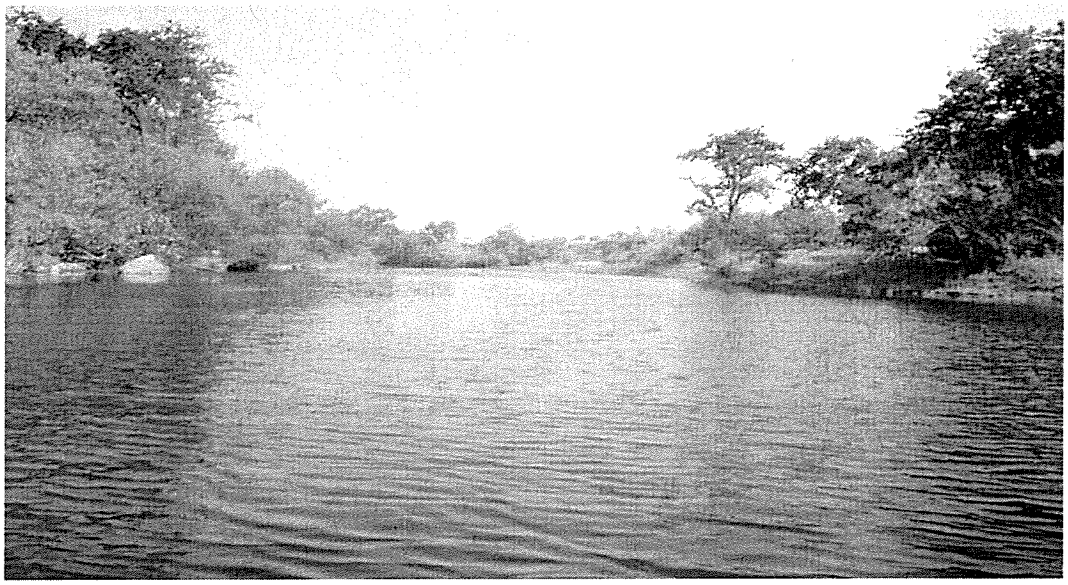
Sincerely,

John A. Whittaker, IV

John A. Whittaker, IV
Attorney For Turlock and Modesto
Irrigation Districts

Attachments:
Attachment 1. Lower Tuolumne River Instream Flow Studies Proposed Study Plan
Attachment 2. Lower Tuolumne River Water Temperature Modeling Study Plan
Attachment 3. Proposed Study Plan Transmittal Letter (dated September 3, 2009)
Attachment 4. USFWS Comments on Instream Flow and Water Temperature Study Plans
Attachment 5. CDFG Comments on Instream Flow and Water Temperature Study Plans
Attachment 6. Districts' Response to USFWS Comments on Instream Flow and Water Temperature Study Plans
Attachment 7. Districts' Response to CDFG Comments on Instream Flow and Water Temperature Study Plans

Attachment 1
Revised Draft Study Plan (PHABSIM)



Lower Tuolumne River Instream Flow Studies
Final Study Plan

Prepared for
Turlock Irrigation District
333 East Canal Drive
Turlock, CA 95380

and

Modesto Irrigation District
1231 11th St.
Modesto, CA 95354

Prepared by
Stillwater Sciences
279 Cousteau Place, Suite 400
Davis, CA 95616

October 2009

Stillwater Sciences

Suggested citation: Stillwater Sciences. 2009. Tuolumne River Instream Flow Studies. Final Study Plan. Prepared by Stillwater Sciences, Davis, California for Turlock Irrigation District and Modesto Irrigation Districts, California.

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1 BACKGROUND AND PURPOSE

The Federal Energy Regulatory Commission (FERC) issued a July 16, 2009 order ("Order") directing Turlock Irrigation District and Modesto Irrigation District ("Districts") to develop and implement an Instream Flow Incremental Method/Physical Habitat Simulation (IFIM/PHABSIM) study of the lower Tuolumne River (FERC 2009). The purpose of the instream flow study is "to determine instream flows necessary to maximize fall-run Chinook salmon *(Oncorhynchus tshawytscha)* and *O. mykiss* production and survival throughout their various life stages." This study plan responds to the Order and provides detailed methods for the proposed approach.

Two prior PHABSIM studies of the lower Tuolumne River have been conducted for the Don Pedro Project (FERC Project No. 2299) as part of the approved FERC Fisheries Study Plan. A 1981 study by CDFG (TID/MID 1992, Appendix 4) was focused within a nine-mile reach (river mile [RM] 50.5–42.0) extending from near the town of La Grange to near Turlock Lake State Recreation Area. A reanalysis of the 1981 CDFG data was also completed by EA Engineering, Science, and Technology (EA) in 1991 on behalf of the Districts (TID/MID 1992, Appendix 5). Selected elements of the CDFG study are summarized in Table 1 below.

Table 1. Selected instream flow model details for studies on the lower Tuolumne River in 1981 and 1992.

Study	Upper RM	Lower RM	Total Transects	Calibration Flows (approx. cfs)			Simulation range (cfs)
				Low	Mid	High	
CDFG reanalysis (TID/MID 1992)	50.5	42.0	19	120	260	410	20–600
USFWS (1995)	52.2	0.0	25 (23 used)	250	600	1,050	25–1,200

In 1992, the second PHABSIM study was conducted by the USFWS (1995), which is also briefly summarized in Table 1. The USFWS study reaches included the entire lower Tuolumne River from La Grange Dam (RM 52.2) downstream to the confluence with the San Joaquin River (RM 0.0), although the most extensive field efforts were focused in riffle and run habitats in the 21-mile reach upstream of Waterford (RM 31) that is most heavily utilized for spawning by salmonid species. Using the results of the USFWS study, the Districts previously responded to an August 2003 information request from FERC staff to develop a flow vs. habitat evaluation that incorporated water temperature effects on Weighted Usable Area (WUA) (Stillwater Sciences 2003).

The rationale for the Order's inclusion of an additional IFIM study is not entirely apparent, especially since both prior studies included simulations for various life stages of *O. mykiss*, in addition to Chinook salmon. In addition to the previous IFIM studies and evaluations, the Districts have also reported on flow fluctuation and juvenile salmonid stranding analyses at flows up to 8,400 cfs (TID/MID 1992, Appendices 14 and 15; TID/MID 2000, Report 2000-6; TID/MID 2005, Appendix E), as well as geographic information system (GIS) based mapping of floodplain inundation surfaces at several flows within this range (TID/MID

2005, Appendix F). The GIS inundation maps were used in a recent assessment of variations in inundation areas at high flows by USFWS (2008). Although data collected from a new study could be combined with data from prior investigations (specifically from the USFWS [1995] study), the recommended study plan detailed below assumes independent, standalone investigations that are not dependent on data from the previous IFIM studies.

2 RECOMMENDED STUDY APPROACH

The instream flow studies are proposed to be separated into a 1-D PHABSIM study from 150 cfs up to at least 400 cfs and a 2-D PHABSIM pulse flow study, which will evaluate spring pulse flows of 1,000 to 5,000 cfs and fall pulse flows of up to 1,500 cfs, as specified in the Order. The 1-D PHABSIM model will estimate habitat availability for various lifestages of Chinook salmon and *O. mykiss* over a range of simulated flow releases included in the FERC Order (150 to at least 400 cfs), as well as in-channel flows up to 1,200 cfs, which corresponds to the flow range in the USFWS (1995) study. The proposed model software is the Riverine Habitat Simulation Model (RHABSIM). This model is an adaptation of the PHABSIM software that was originally developed and maintained by the Instream Flow and Aquatic Systems Group of the U.S. Fish and Wildlife Service in Fort Collins, Colorado (Milhous 1973, Bovee 1982, Milhous et al. 1984). The RHABSIM software, which was developed by Thomas R. Payne and Associates, implements the equivalent algorithms of PHABSIM but features expanded input, output, graphic, and calibration capabilities.

Development and implementation of the IFIM study considers a variety of factors, besides just the hydraulic and habitat suitability criteria (HSC) required for the PHABSIM component of the analysis, to evaluate the suitability of a stream and various flows for the species and life stages of interest. Water temperature is of particular interest since it varies with flow (particularly downstream of large impoundments, such as Don Pedro Reservoir). A water temperature study is planned, based on the results of a HEC-5Q water temperature model (RMA 2008) that will be validated as part of a complementary Tuolumne River water temperature modeling study plan (Stillwater Sciences 2009) included in the Order.

The proposed pulse flow assessment will examine potential responses of salmonid and predator species to spatial variations in inundation area, velocities, and depths in relation to the pulse flows specified in the Order within both in-channel areas as well as temporarily inundated portions of the Tuolumne River floodplain. Although the 1-D PHABSIM methodology is the most commonly used method for flow and habitat assessments within confined channels, the proposed pulse flow assessment will examine the effects of pulse flows for the benefit of migratory salmonid life stages using a 2-D hydraulic model of both in-channel and inundated floodplain areas at flows up to 5,000 cfs. The rationale for the two different methods for the instream flow and pulse flow elements of the study is threefold. First, extension of the IFIM analysis to flows exceeding the bankfull channel width, in the range of 1,500–2,500 cfs in some locations (McBain and Trush 2000), will cause a significant shift in the stage-discharge relationship for the channel. This requires a separate modeling analysis in order to develop a reliably predictive (*i.e.*, log linear) estimate of stage. Second, patchy distribution of floodplain areas makes their treatment as separate, discrete areas more precise, since the conditions at these locations cannot be as reliably extrapolated to other areas of the river. Third, pulse flows are typically of shorter duration and intended for either the attraction/migration of fall spawners or to facilitate outmigration of juvenile fish; detailed evaluation of such flows in a PHABSIM study in order to assess and generalize their microhabitat suitability for spawning, adult holding, or rearing (which is what the associated HSC are developed for) is of limited use in refining potential flow recommendations.

3 METHODS

The methodology presented in the sections below discusses in more detail the steps for performing the proposed instream flow study and reporting results.

3.1 Logistics

Instream flow studies are best performed when targeted calibration flows are consistently maintained during hydraulic field measurements. Stillwater Sciences will coordinate with TID/MID to ensure these flows are available and manageable during field measurements. Stillwater will notify TID/MID, FERC and the agencies if substantive changes in the study design, methods or schedule are anticipated.

To facilitate field staff safety, allow for coordinated water operations, and facilitate agency staff awareness of study activities, the parties listed in Table 2 will be notified by email or telephone in advance of the proposed field sampling. Prior to mobilization, planned river operations by the Districts will be checked to determine if field surveys would be safe under the anticipated flow and all parties will be notified of any delay or modification to the survey schedule.

Table 2. Field work notification.

Contact	Affiliation	Address	Phone and Email
Tim Ford	TID	333 East Canal Dr. Turlock, CA 95380	209.883.8275 tjford@tid.org
Greg Dias	MID	1231 11th Street Modesto, CA 95354	209.526.7566 gregd@mid.org
Tim Heyne	CDFG	P.O. Box 10 La Grange, CA 95329	209.853.2533 x1# theyne@dfg.ca.gov
To be determined during agency comment period	USFWS	--	--
To be determined during agency comment period	NMFS	--	--

3.2 Study Area Segmentation

The proposed study reach extends from the La Grange stream flow gage (USGS No. 11289650) at RM 51.7 downstream to the lower end of the Gravel Mining Reach at RM 34.2 (McBain and Trush 2000). This reach includes the downstream extent of summer *O. mykiss* observations in past snorkel surveys (TID/MID 2009) as well as large majority of the spawning reach for Chinook salmon. As a secondary option, CDFG has recommended that the downstream boundary for the study extend to RM 24 to the downstream end of the In-Channel Gravel Mining Reach (Figure 1). Within the proposed study reach, the river would be divided into segments of similar habitat, geomorphic, and hydrologic character and analyzed independently. The study reach and number/location of segments would be determined as part of the scoping process.

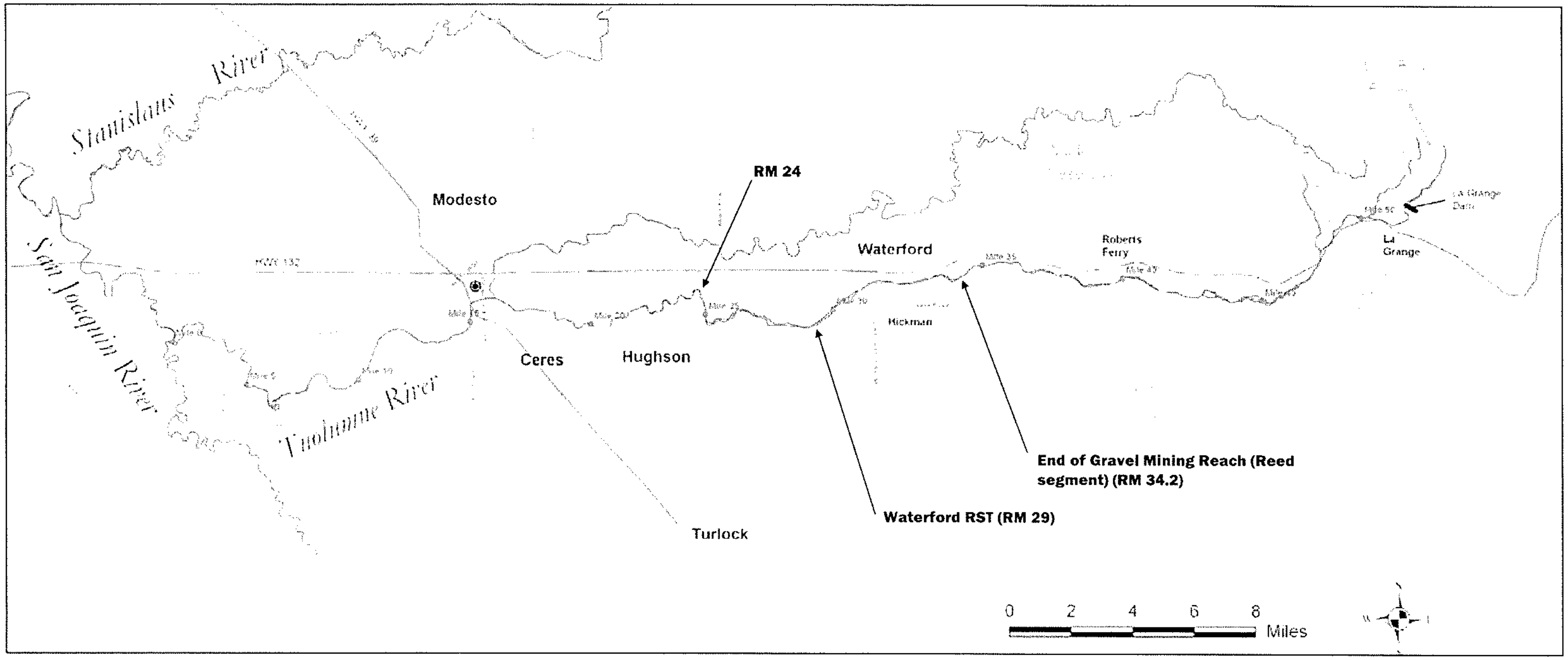


Figure 1. Vicinity map for the lower Tuolumne River IFIM study.

3.3 Habitat Mapping

Within the proposed study reach, existing habitat mapping has been completed down to RM 29.0 below the City of Waterford, as part of *O. mykiss* population estimate surveys being conducted pursuant to the April 2008 FERC Order (Stillwater Sciences, *in prep.*). Data from this current habitat mapping, completed during snorkel surveys during 2008 and 2009, will provide the basis for habitat composition and delineation. Proposed mesohabitat types are listed and described in Table 3.

Table 3. Coarse scale habitat types to be used during instream flow surveys.

Habitat Type	Description
Riffle	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated by cobble or boulder. Gradient moderate (less than 4%).
Run/Glide	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally greater than one foot per second (fts^{-1}).
Pool	Slow flowing, tranquil water with mean column water velocity less than 1 fts^{-1} and depths of 10 ft or greater.

The percent composition of these mesohabitat types are shown in Table 4 for the study reach extending from La Grange Gage (RM 51.7) downstream to the end of the Gravel Mining Reach at RM 34.2 (McBain and Trush 2000), along with a secondary reach extending to the location of the existing rotary screw trap (RST) location downstream of the City of Waterford (RM 29.0). Additional habitat mapping would need to be conducted if areas farther downstream are included in the hydraulic simulations (see Study Area Segmentation section above).

Table 4. Mesohabitat types and percentage occurrence.

Habitat Type	# of Units	Total Length (ft)	% of Reach
La Grange Gage (USGS No. 11289650) to end of Gravel Mining Reach (RM 51.7 to RM 34.2)			
Riffle	55	19,195	21%
Run/Glide	55	55,964	61%
Pool	20	16,888	18%
Totals	130	92,046	100.0%
End of Gravel Mining Reach to downstream of Waterford (RM 34.2 to RM 29)			
Riffle	21	6,077	21%
Run/Glide	20	20,885	72%
Pool	2	1,951	7%
Totals	43	28,913	100%

3.4 IFIM/1-D PHABSIM study

3.4.1 Study site selection

Study sites for instream flow data collection will be established in a stepwise process following guidelines from Bovee (1982). First, the study area will be reviewed for possible segmentation into reaches. Reach segmentation will be based primarily on changes in stream gradient (associated with geomorphic condition), and/or hydrology that may cause habitat types in one reach to display significant hydraulic differences from the same habitat type in another reach (*e.g.*, low gradient riffles in one reach have consistently greater depth or velocity than low gradient riffles in another reach). Stream gradient will be determined using existing topographic data and displayed as a longitudinal profile of elevation versus river mile within the study area.

Second, areas for study sites will be identified. Sites that contain the full complement of common (>10–15% of stream length in the reach) and modelable (*e.g.*, not high gradient riffles or other areas with high air entrainment or significantly non-laminar flow) habitat units in a safe and legally accessible section of stream will be identified. Within these areas, study sites will be established via consensus with the fish resource agencies. In the event consensus is not achieved on study sites, they will be determined by randomly selecting a starting habitat unit (using a random number table or similar device) among the least common habitat unit types. From that starting habitat unit, transect locations will be established in adjacent habitat units (heading upstream or downstream) until the requisite transects are placed in the specified habitat units, as described below. Where possible, sites will be co-located in areas where data have been collected for other studies in order to maximize the potential for integrated data analysis.

An exception to the above protocol will be implemented for habitat units at known spawning sites. Analysis for these units will preferentially target historical high-use spawning sites for Chinook salmon, based on prior surveys and redd counts.

3.4.2 Transect selection

Within each study site, transects will be placed in each habitat unit to be sampled either by professional judgment and concurrence of the transect selection team, or based on a stratified random sampling protocol. The stratified random sampling protocol would involve random placement of transects within strata of similar hydraulic characteristics within each habitat unit, except where such placement would result in transects running through a hydraulic anomaly or other feature (*e.g.*, re-circulating or vertical flow, brush in channel, etc.) that cannot be accurately modeled. In these cases. the transect will be relocated (either placing the transect using professional judgment and concurrence among the transect selection team, or by specifying an arbitrary distance up or downstream of the original location). Transects will be distributed in run, riffle, and pool habitat types. No transects will be placed in habitat units located on private property without the consent of the landowner.

Transect placement will target locations where there is no more than a 0.1 foot difference in stage across the transect and where the velocity profile across the transect is dominantly perpendicular to the transect. Areas with transverse flows, across-channel variation in water surface elevations, or flow contractions/expansions will be avoided.

A sufficient number of transects will be established to model approximately three replicates of each major habitat unit type in the reach (*i.e.*, runs, riffles, and pools), with the number of replicates dependent on the relative proportions of the major habitat unit types (*i.e.*, there may be more than three replicates of the most common unit type, and fewer of the least common unit type). It is expected that relatively hydraulically homogeneous habitat units will require 1–3 transects per replicate; relatively heterogeneous habitat units will require 2–5 transects per replicate. The final number of transects proposed for the reach will depend on habitat complexity as well as target resource values in the reach, and will be determined during a field site visit with concurrence of agency representatives. If there is not agreement on the appropriate number of transects, the issue will be referred to FERC for final determination.

3.4.3 Field data collection

Target calibration flows will be relatively evenly spaced (on a log scale) and selected to allow the models to simulate in-channel flows over a range covering the current minimum flow (50 cfs) up to approximately 1,000+ cfs, with a target of having the lowest simulated flow at no less than 0.4 of the lowest calibration flow and the highest simulated flow at most 2.5 times the highest calibration flow. The proposed target calibration flow ranges are as follows:

- low flow calibration: approximately 100 cfs;
- middle flow calibration: 250 cfs; and
- high flow calibration: 600 cfs.

Velocity data sets will be collected at all transects at the middle calibration flow, and water surface elevation (WSE) will be collected along each transect at all calibration flows.

3.4.3.1 Hydraulic data

Hydraulic data collection and recording will use standard procedures and guidelines for PHABSIM field studies (Trihey and Wegner 1981; Milhous et al. 1984). In general, hydraulic data collection includes establishing independent elevation reference benchmarks for level control, as well as semi-permanent headpins and tailpins at each transect. Water surface elevations will be measured using an auto-level and stadia rod along each transect at each calibration flow; WSE will be measured near each bank (to the nearest 0.01 foot), and in mid-channel areas where a significant difference between the near-bank WSE exists. A level loop survey tied to the local benchmark will be conducted at each calibration flow to ensure the accuracy of each survey. Benchmark and transect locations will be recorded with a GPS, where feasible.

The local benchmarks established for each transect will serve as the reference elevations to which all elevations (streambed and water surface) are tied. The benchmarks will consist of items that will not change elevation over time, such as lag bolts driven into trees, painted bedrock points, or local infrastructure. Benchmarks will be tied together, where practical, for the upstream and downstream transects at each site, for efficient analysis and QA/QC procedures.

Channel cross section profiles above the highest measured calibration flow will be surveyed (to the nearest 0.1 foot) with a stadia rod and auto-level or total station to establish the overbank channel profile up to or beyond the water's edge at the highest flow to be modeled, with sufficiently close spacing of verticals to document changes in slope. In-channel profiles will be calculated by subtracting the depth of water measured during the velocity measurements from the average WSE. Additional topographic data collection for each transect will include stage-of-zero-flow (SZF) elevation, which is the controlling elevation within or downstream of the transect line below which flow ceases.

Temporary and permanent staff gage readings and time-of-day will be recorded at the beginning and end of each transect measurement to check that the stage had not changed appreciably during the transect measurement nor the calibration flow measurement for the entire study site.

Depths and mean column water velocities will be measured across each transect at the middle calibration flow. The number of cells sampled for depth and velocity is based on a goal of retaining a minimum of 20–25 stations that would remain in-water at the low calibration flow. Discharge measurements will be collected at each calibration flow following techniques outlined in Rantz (1982). Discharge measurements will be made at each grouping of transects in hydrologically distinct areas using either an existing habitat transect (if deemed suitable) or at some other suitable transect established solely for measuring discharge. These discharge measurements will be used in conjunction with data from the La Grange gaging station (USGS No. 11289650) to determine more precisely the calibration flow and account for accretion, if any, within the study reach.

3.4.3.2 Velocity measurements

Velocity measurements will be made using a Marsh-McBirney Flo-mate pressure transducer-type velocity meters (Hach Corporation, Loveland CO), mounted on standard top-set USGS wading rods. Velocities will be measured at six-tenths of the depth (0.6 depth) when depths were less than 2.5 feet, and at two-tenths (0.2 depth) and eight-tenths (0.8 depth) of the depth when depths equal or exceed 2.5 feet or when the expected velocity profile is altered by an obstruction immediately upstream. In instances of increased turbulence or obstructions, measurements may be taken at all three depths (0.2, 0.6, and 0.8) and a weighted average calculated (Bovee and Milhous 1978). Where transects have a series of water depths greater than approximately 3.5 feet, depth and velocity will be measured using an Acoustic Doppler Current Profiler (ADCP) mounted on a mini-cataraft. The ADCP uses acoustic pulses to measure water velocities and depths across the channel. The ADCP is connected by cable to a power source and a radio modem with data transmitted to a shore-based laptop computer.

3.4.3.3 Substrate data

Data collection at each transect will include substrate and/or cover codes compatible with proposed species HSC. Substrate composition and cover types will be recorded in the field at each cross section location where channel geometry data are collected. Substrate coding, as applicable and feasible (depending on nature of source data), will be adapted to the coding systems specified in Table 5a (from USFWS and CDFG) and/or Table 5b (from prior mapping of the lower Tuolumne River for the Coarse Sediment Management Plan [McBain & Trush 2004]).

Table 5a. Proposed substrate types for the Lower Tuolumne IFIM study. [Use of these codes is subject to final decisions on habitat suitability criteria for substrate]

Substrate Type	Particle Size (inches)
Sand/Silt	< 0.1
Small Gravel	0.1 – 1
Medium Gravel	1 – 2
Medium/Large Gravel	1 – 3
Large Gravel	2 – 3
Gravel/Cobble	2 – 4
Small Cobble	3 – 4
Small Cobble	3 – 5
Medium Cobble	4 – 6
Large Cobble	6 – 8
Large Cobble	8 –10
Large Cobble	10 –12
Boulder/Bedrock	> 12

Table 5b. Coarse sediment size gradation chart showing particle size class descriptions and sizes.

<table>
<tr><th colspan="2">Particle Size Class</th><th>Particle Size (mm)</th><th>Particle Size (in)</th></tr>
<tr><td rowspan="8">Boulder</td><td rowspan="2">Very Large</td><td>4,096</td><td>161.2</td></tr>
<tr><td>2,896</td><td>114.0</td></tr>
<tr><td rowspan="2">Large</td><td>2,048</td><td>80.6</td></tr>
<tr><td>1,448</td><td>57.0</td></tr>
<tr><td rowspan="2">Medium</td><td>1,024</td><td>40.3</td></tr>
<tr><td>724</td><td>28.5</td></tr>
<tr><td rowspan="2">Small</td><td>512</td><td>20.1</td></tr>
<tr><td>362</td><td>14.2</td></tr>
<tr><td rowspan="4">Cobble</td><td rowspan="2">Large</td><td>256</td><td>10.1</td></tr>
<tr><td>181</td><td>7.1</td></tr>
<tr><td rowspan="2">Small</td><td>128</td><td>5.0</td></tr>
<tr><td>90.5</td><td>3.6</td></tr>
<tr><td rowspan="11">Gravel</td><td rowspan="2">Very Coarse</td><td>64.0</td><td>2.5</td></tr>
<tr><td>45.3</td><td>1.8</td></tr>
<tr><td rowspan="2">Coarse</td><td>32.0</td><td>1.2</td></tr>
<tr><td>22.6</td><td>0.9</td></tr>
<tr><td rowspan="2">Medium</td><td>16.0</td><td>0.6</td></tr>
<tr><td>11.3</td><td>0.4</td></tr>
<tr><td rowspan="2">Fine</td><td>8.00</td><td>0.3</td></tr>
<tr><td>5.66</td><td>0.2</td></tr>
<tr><td rowspan="3">Very Fine</td><td>4.00</td><td>0.2</td></tr>
<tr><td>2.83</td><td>0.1</td></tr>
<tr><td>2.00</td><td>0.1</td></tr>
</table>

Notes:
1. Adapted from McBain & Trush 2004
2. Particle sizes less than 2mm are classified as sand (2-0.063mm), silt (0.063-0.0093mm), and clay (<0.0093mm).

3.4.4 Hydraulic modeling

The hydraulic models used for instream flow studies utilize the data collected in the field for calibration of water surface elevations, discharge, and velocities over a range of flow simulations. The hydraulic modeling will result in output files of hydraulic parameters (depths, velocities, etc.) used in the habitat analysis.

3.4.4.1 Stage-discharge calibration

Stage-discharge relationships are developed from measured discharge and water surface elevation (WSE) using an empirical log/log formula (commonly referred to as IFG-4), or by using a channel conveyance method (referred to as MANSQ). Using the log/log and channel conveyance methods, each transect is treated independently. The IFG-4 method requires a minimum of three sets of stage-discharge measurements and an estimate of SZF for each transect. The quality of the stage-discharge calibration using the IFG-4 method is evaluated by examination of mean error and slope output from the model. MANSQ only requires a single stage-discharge pair, though additional pairs are advisable for validation, and uses Manning's equation to determine a stage-discharge relationship (Bovee and Milhous 1978). In situations where irregular channel features occur on a cross section, for instance bars or terraces, MANSQ is often better at predicting higher stages than IFG-4. MANSQ is most often used on riffle or run transects and is not suitable for transects that have backwater effects from downstream controls, such as pools. It can also be useful as a test and verification of log/log stage discharge relationships.

The Water Surface Profile (WSP) program for use in developing stage-discharge predictions can also be used, but due to its limited application for riffle and run habitat, and its reliance on additional hydraulic control transects, it is not expected to be used extensively in this study, although it may be applicable for certain pool habitat simulations. For the purposes of this study, the IFG-4 program is proposed as the primary method for developing the stage-discharge relationship.

3.4.4.2 Velocity calibration

The preferred method for simulating water velocities is the "one-flow" option. This technique uses a single set of measured velocities to predict individual cell velocities over a range of flows. Simulated velocities are calibrated to measured data and a relationship between a fixed roughness coefficient (Manning's 'n') and depth is developed. In some cases, roughness is modified for individual cells if substantial velocity errors are noted at simulation flows. Velocity adjustment factors (VAFs) are examined to detect any significant water velocity deviations and determine if velocity changes at simulated flows remain consistent with changes in stage and total discharge.

3.4.4.3 Calibration metrics

Various calibration metrics will be used as target values to evaluate performance of the IFG-4 hydraulic model. Although these are not strict thresholds to determine usefulness of the data, an effort will be made to calibrate the model to these standards.

- A beta value (a measure of the change in channel roughness with changes in streamflow) between 2.0 and 4.5;
- Mean error in calculated versus given discharges less than ten percent;
- No more than a 25% difference for any calculated versus given discharge
- No more than a 0.1 foot difference between measured and simulated WSELs
- Mean stage-discharge regression error for all transects less than 10%, and 5% or less for 90% of the transects.
- Velocity Adjustment Factor (VAF) values of 0.2 to 5.0 with a pattern of monotonic increase with an increase in flows and values between 0.90 and 1.10 at the calibration flow.

3.4.5 Target species and habitat suitability criteria (HSC)

Proposed HSC for the current instream flow study will consider the following target species and lifestages:

- *O. mykiss:* adult, spawning, fry, and juvenile.
- Fall-run Chinook salmon: spawning, fry, and juvenile.

Existing HSC data will be compiled for the target species and lifestages, in collaboration with the agencies, to create a database of curves that can be reviewed for applicability to the proposed study. Habitat suitability criteria from prior lower Tuolumne River studies (Tables 6 and 7 will be included in the HSC database for consideration. The database of curves will be reviewed in consultation with the agencies, and screening criteria applied as necessary to minimize the number of curves for further consideration. Proposed screening criteria will include the following, although no single criterion will be used to qualify or disqualify a curve from further consideration.

- Minimum of 150 observations
- Clear identification of fish size classes
- Depth and velocity HSC
- Category II or III data (Bovee 1986)
- Comparable stream size and morphology (*e.g.*, hydrology, stream width and depth, gradient, geomorphology, etc.)
- Source data from the lower Tuolumne River (or other Central Valley streams)
- Habitat availability data collected
- Data collected at high enough flow that depths and velocities are not biased by flow availability
- Availability of presence/absence data

Table 6. Habitat suitability criteria summary from 1981 CDFG IFIM study.

Species	Lifestage	Depth	Velocity	Substrate	Source
Chinook	Spawning	Yes	Yes	Yes	Site-specific
Chinook	Fry	Yes	Yes	All suitable	Unknown
Chinook	Juvenile	Yes	Yes	All suitable	Unknown
Rainbow	Adult	Yes	Yes	Yes	Raleigh et al. (1984)
Rainbow	Juvenile	Yes	Yes	Yes	Raleigh et al. (1984)

Table 7. Habitat suitability criteria summary from USFWS (1995) IFIM study.

Species	Lifestage	Depth	Velocity	Substrate	Source
Chinook	Spawning	Yes	Yes	Combined Substrate / Embeddedness Code	Bovee (1978)
Chinook	Fry	Yes	Yes	All suitable	Bovee (1978)
Chinook	Juvenile	Yes	Yes	All suitable	Bovee (1978)
Rainbow	Adult	Yes	Yes	Combined Substrate / Embeddedness Code	Bovee (1978)
Rainbow	Juvenile	Yes	Yes	Combined Substrate / Embeddedness Code	Bovee (1978)

Following a review and discussion of applicable HSC curves, existing curves may be selected and/or modified for use on the proposed study, or site-specific HSC curves may be developed as deemed appropriate in collaboration with technical experts from the stakeholder group. If there is not agreement on HSC curves to use, the issue will be referred to FERC for final determination.

3.4.6 Habitat modeling

Habitat will be modeled using the HABSIM submodel provided in the RHABSIM software (analogous to HABTAE, HABTAT, etc.). The habitat model combines the hydraulic and HSC components to generate the weighted usable area (WUA), in square feet per 1,000 ft of stream) of the stream for each species and life stage at each simulated flow. The standard option of multiplying individual variable suitabilities (velocity*depth*substrate or cover) for cell centroids will be used to calculate WUA. This output will be proportioned over all habitat types (using the relative abundance of each habitat type and transect as a weighting factor) to obtain the reach-wide estimate of WUA by life-stage. An example of the transect weighting procedure is depicted in Figure 2. WUA versus flow curves will be developed to aid in the interpretation of these habitat flow relationships.

3.4.7 Total habitat time series

A habitat time series (HTS) analysis (Bovee 1982) is proposed for flows up to a maximum of approximately 1,000 cfs (the upper end of the hydraulic modeling range). The HTS analysis uses the WUA versus flow relationship and combines it with current or alternative hydrologic conditions to generate WUA by day under selected flow regimes (including accretion estimates) for different water year types. Figure 3 presents a conceptual example of HTS results. Daily flow values for the study reach under varying water-year types will be obtained from USGS gage records and used for the analysis. The Total HTS results will be used as the first step in calculation of an Effective Habitat Time Series described below.

3.4.8 Effective habitat time series development

In addition to the standard WUA results as described in the Habitat Modeling and Total Habitat Time Series sections, a secondary analysis showing the "effective" WUA (eWUA) will be conducted. This analysis relates to summertime water temperature suitability for *O. mykiss*, and integrates both micro- and macro-habitat considerations. The results from the HEC-5Q water temperature model (Stillwater Sciences 2009) over a range of flows will be combined with the summer WUA results so that areas ("macrohabitats") with unsuitable water temperatures are excluded from the total WUA sum. In other words, if a given reach has 100,000 square feet of suitable habitat (WUA) based on hydraulic microhabitat conditions at flow 'X', but 30 percent of the reach at flow 'X' is above a critical temperature threshold for the species life stage of interest, the eWUA would be 70,000 square feet. This type of analysis was previously conducted, at a coarser level by Stillwater Sciences (2003), using a combination of the 1992 IFIM evaluation for the lower Tuolumne River (USFWS 1995) and the earlier SNTEMP model results (TID/MID 1992, Appendix 18). The methods are explained more fully in Bovee (1982).

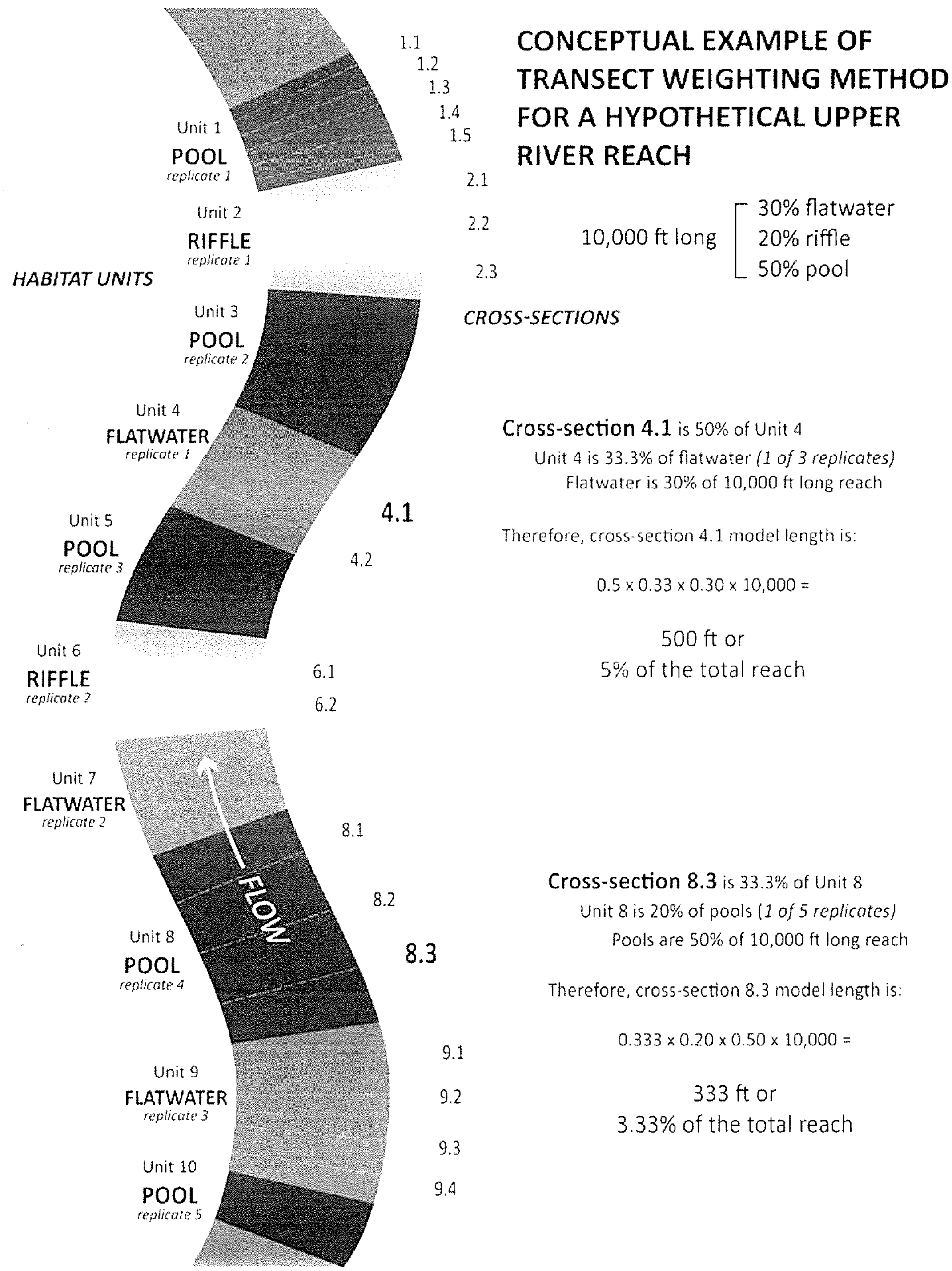


Figure 2. Conceptual example of transect weighting method for reach extrapolations proposed for the lower Tuolumne River IFIM study.

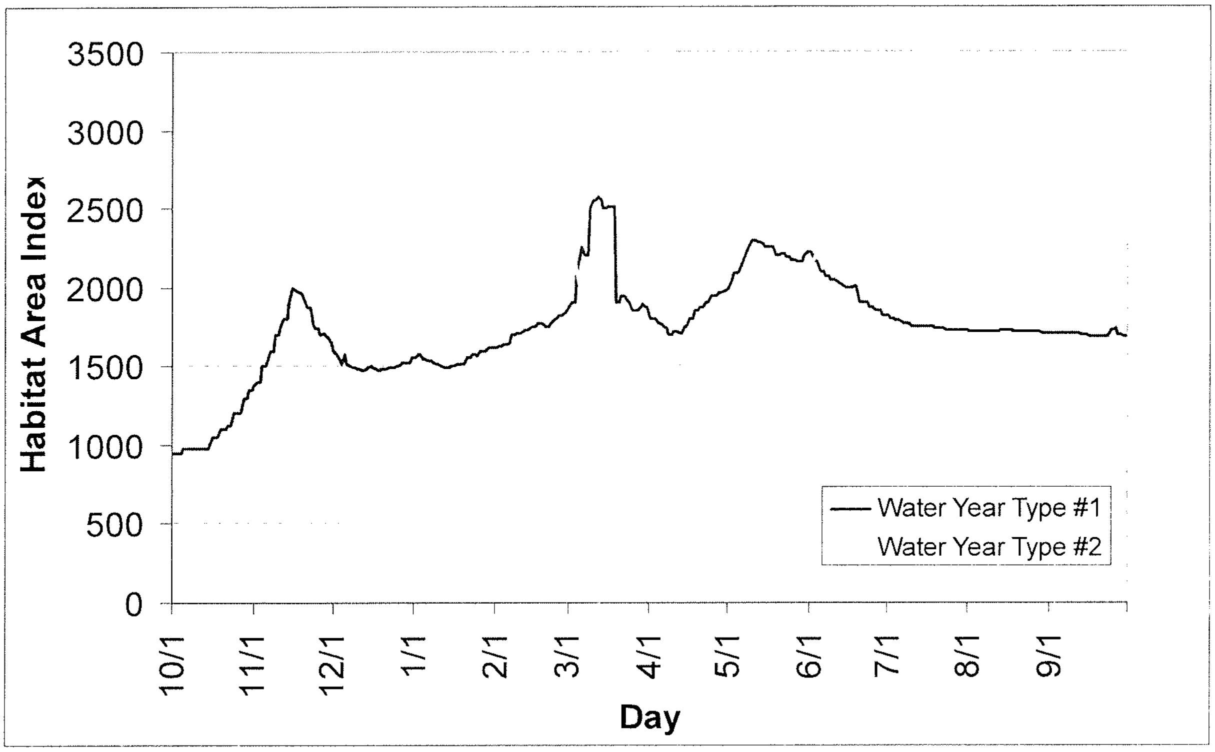


Figure 3. Conceptual example total habitat time series output for the IFIM study.

3.5 Pulse flow assessment

The pulse flow assessment will evaluate spring pulse flows of 1,000 to 5,000 cfs and fall pulse flows of up to 1,500 cfs, as specified in the Order. The detailed approach involves use and expansion of existing topographic maps of the lower Tuolumne River floodplain (RM 52–RM 29), combined with development of a high flow stage-discharge relationship for these same areas as inputs to the River2D hydraulic model (Steffler and Blackburn 2002) or similar two-dimensional modeling software (such as MD-SWMS). The objectives of the assessment are to: 1) gather empirical data on the relationship between water temperature and flow during pulse flow events, and 2) assess habitat usability and habitat segmentation for lower Tuolumne River fish species during pulse flow conditions.

3.5.1 Pulse flow study site selection

Study sites for the pulse flow assessment will include up to four (4) locations upstream of RM 29 (including the gravel-bedded portion of the river used most extensively by salmonids between RM 34.2 to RM 51.7), in addition to other restoration sites (*e.g.*, special run/pool [SRP] 9) where there is existing 2-D modeling data. Study site selection will include areas where significant floodplain inundation is expected at flow ranges up to 5,000 cfs.

3.5.2 Cross section and topography development

Existing LiDAR coverage of the lower Tuolumne River floodplain (RM 52–29), originally developed from aerial surveys of 21 September 2005 at river flows of 321 cfs will be used to for development of the model cross sections and topography. A digital elevation model (DEM) will be used within GIS to develop hydraulic model cross sections, with bathymetric data below the 321 cfs water surface developed (where necessary) using standard survey methods described in Section 3.4.3.1. The existing LiDAR coverage will be point-checked for accuracy, and if significant topographic changes are detected, options for obtaining updated LiDAR coverage will be investigated.

3.5.3 High flow stage discharge relationships

Stage discharge relationships at high flows will be developed at each pulse flow study site within the lower Tuolumne River using either standard survey techniques (where timing and flow conditions allow) or pressure transducers (InSitu® miniTroll) placed in a protective PVC pipe housing and mounted along the active river channel using rebar and foundation stakes. If possible, the pressure transducer elevations will be established using a total station (Sokkia® SET600 or similar) and prism to tie in to an established local benchmark. If this is not possible, the pressure transducer elevation will be tied to an installed temporary benchmark.

The stage recorders will be set at a 15-minute interval and will record corresponding stages to lower Tuolumne River flows of up to 5,000 cfs. Test flows for the pulse flow assessment will include 2,000 cfs, 3,000 cfs, and 5,000 cfs to develop the high flow stage discharge relationship. In the event that the following hydrology conditions are met in the first year of study, tests will occur during the March–May period.

a. The estimated 60-20-20 Index (using 50% exceedance probability) for the then current water year based upon the CDWR within-month March runoff forecast update following March 15 is at least 4.2, provided that (1) daily computed natural flows for both the Tuolumne and San Joaquin Rivers in excess of 50,000 cfs are excluded and (2) the Tuolumne River comprises at least 31% of the index.
b. The 60-20-20 Index for the immediately preceding water year was at least 4.2.
c. The target flow shall be subject to any flow and/or timing limitation required by the VAMP study.
d. The target flow shall be subject to any flow and/or timing limitation required by the Corps of Engineers.

In the event that these high flow conditions are not necessitated by naturally occurring wetter hydrologic conditions (resulting in flood releases in excess of the 301 thousand acre-feet (TAF) annual FERC flow requirements), the Districts will delay data collection for up to 2 years or may alter the intermediate test flows above.

3.5.4 2-D hydraulic model development

River2D model input includes a) topography of the river channel; b) roughness of the channel expressed as a roughness height; c) discharge; and d) downstream water surface elevation. The topography will be developed from the existing LiDAR-derived DEM (subject to the constraints noted in Section 3.5.2 above), whereas elevation data will be developed from the stage discharge relationships described above. Channel roughness will be based on a combination of this topography and professional judgment as a calibration parameter in addition to changes in the finite element network to achieve representative modeled water depths at a given discharge. As an additional calibration, model outputs will be compared to existing flood area inundation maps (TID/MID 2005, Appendix F) previously developed at a wide range of flows (100, 230, 620, 1,100, 3,100, 5,300, and 8,400 cfs).

3.5.5 2-D model simulations and anticipated results

The calibrated 2-D model will be used to simulate flow routing and velocity vectors in both the in-channel areas at pulse flows of 1,000 cfs and 1,500 cfs. In addition, the model will be used to simulate intermediate high flows of 2,500 cfs up to 5,000 cfs. The results of the pulse flow assessment will be used to examine habitat suitability for migratory life stages of lower Tuolumne River salmonids as well as habitat preferences of predators such as largemouth bass *(Micropterus salmoides)* and smallmouth bass *(M. dolomieu)*. During high flows (*e.g.*, spring pulse flows), outmigrating salmon smolts generally use more central portions of the channel, while bass likely seek lower velocities and warmer water near channel margins, as previously examined at individual in-channel restoration sites (McBain & Trush and Stillwater Sciences 2006).

For example, hydraulic modeling conducted at a restored in-channel mining pit ("Special Run Pool" or SRP 9) for pre- and post-project conditions using the River 2D model (Steffler and Blackburn 2002) indicates that the project increases habitat segregation between bass and outmigrating Chinook salmon and may provide a "safe-velocity corridor" for outmigrant salmon during relatively low flow conditions (McBain & Trush and Stillwater Sciences 2006). Modeling for the SRP 9 study suggested that, due to distinct differences in habitat usability between bass and salmon, this effect will occur at predictable flow thresholds in specific habitat types (*e.g.*, riffles and unrestored mining pits habitats). Because high flows may help to spatially separate predators and salmon smolts, the pulse flow study may provide a mechanistic linkage between reductions in the exposure of juvenile salmon to predation at high flows.

Lastly, the pulse flow study will be coordinated with any test flows that examine movement patterns of juvenile Chinook salmon in ongoing rotary screw trap (RST) monitoring, or high flows that are released in relation to fall spawner attraction flows.

3.6 Management alternatives

Management alternatives for the lower Tuolumne River will be considered following completion of the IFIM study and pulse flow assessment detailed in this plan, as well as the Water Temperature study (Stillwater Sciences 2009) included in the Order. Results of these investigations will be evaluated in the context of available information from other studies of the lower Tuolumne River and consideration of other beneficial uses of Tuolumne River water cited in the San Joaquin River Basin Plan (CVRWQCB 1998) and including: agricultural supply (AGR), cold freshwater habitat (COLD), fish migration (MIGR), municipal and domestic supply (MUN), water contact recreation (REC1), noncontact recreation (REC2), fish spawning (SPWN), warm freshwater habitat (WARM), and wildlife (WILD).

4 REPORTING

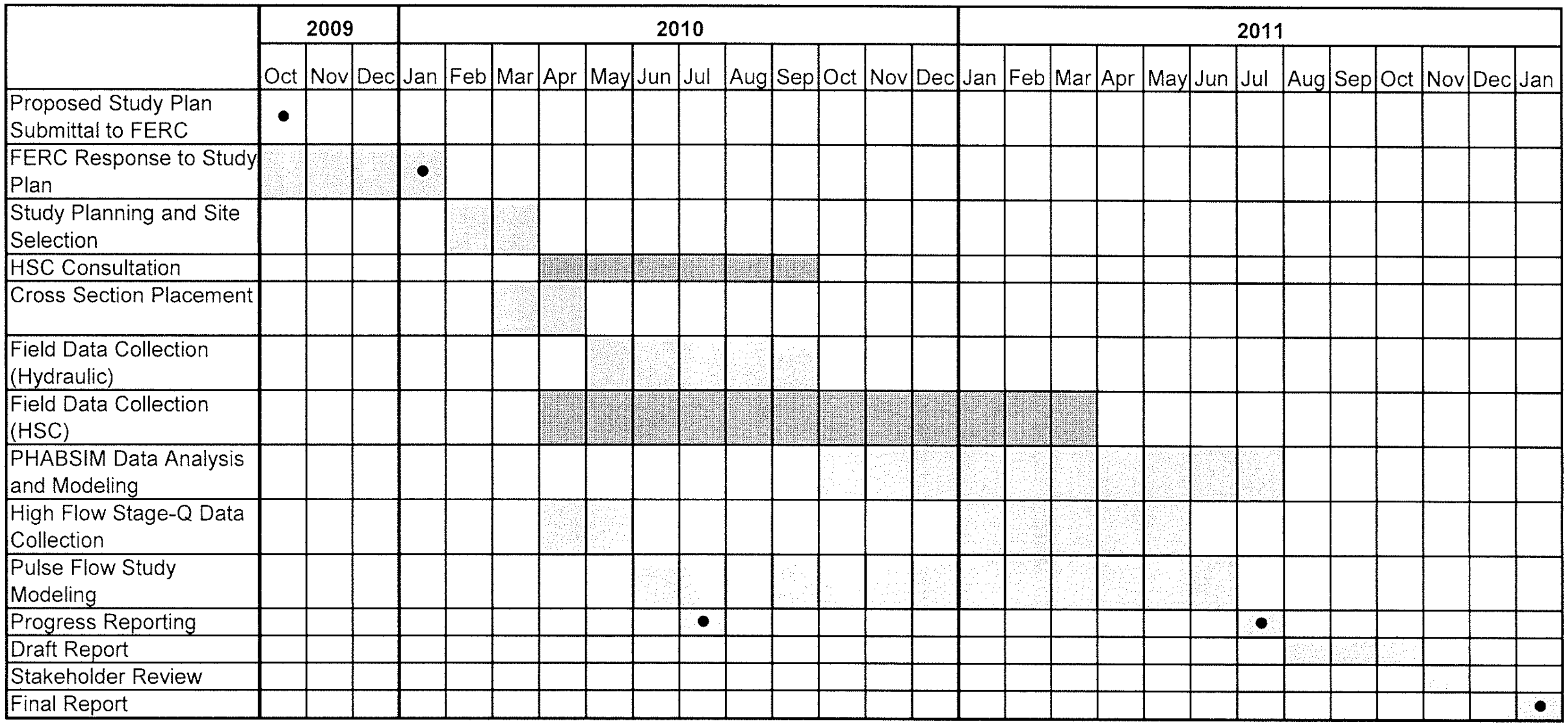
A progress report of the Year 1 and Year 2 data collection efforts, including any changes to the proposed study plan, will be made to the Commission by July 1 in each of two years (2010 and 2011). Following completion of the field studies and analysis, a draft report will be prepared detailing the study methods and results. The draft report will be circulated to the stakeholders for a 30-day review period. Comments will be addressed in a final report that will be filed with FERC within 60 days from the end of the 30-day review period.

5 SCHEDULE

A proposed schedule is provided in Table 8, and graphically represented in Figure 4. The schedule is predicated on an anticipated study plan acceptance date from FERC. A major factor in the proposed schedule is the development of HSC. Although existing HSC are proposed for the lower Tuolumne River, the proposed schedule assumes that site-specific HSC could be necessary for one or more species or life stages, and analytical and reporting tasks are scheduled accordingly. Lastly, for the pulse flow assessment, stage data collection for the highest flow ranges (up to 5,000 cfs) may be delayed from 2010 until appropriate wet year hydrology occurs (flood releases in excess of the 301 TAF annual FERC flow requirements.

Table 8. Proposed schedule for lower Tuolumne River instream flow study implementation.

Item	Dates (duration)	Days from FERC Approval of Study Plan
Proposed Study Plan Submittal to FERC	October 14, 2009	--
FERC Response to Study Plan	January 12, 2010 (90d)	
Study Planning and Site Selection	January 13 to March 13, 2010 (60d)	60
Habitat Suitability Criteria Consultation	March 13 to September 9, 2010 (150d)	240
Cross Section Placement	March 14 to April 27, 2010 (45d)	105
Field Data Collection (Hydraulic)	April 28 to September 24, 2010 (150d)	255
Habitat Suitability Criteria Field Data Collection (if necessary)	April 1, 2010 to March 31, 2011 (365d)	443
Data Analysis (presuming HSC field data collection or 2011 high flow data collection)	April 1, 2011 to July 29, 2011 (120d)	563
High Flow Stage Discharge Data Collection	March 31, 2010 to June 1, 2010 (62d) or January 15, 2011 to June 1, 2011 (137d)	505
Pulse Flow Study Data Analysis and Modeling	June 1, 2010 to June 30, 2011 (394d)	534
Progress Reporting	July 1, 2010 and July 1, 2011	--
Draft Report	October 27, 2011 (90d)	653
Stakeholder Review	November 26, 2011 (30d)	683
Final Report	January 25, 2012 (60d)	743



Note: HSC consultation and field data collection tasks are somewhat independent of other schedule elements of the IFIM Study, but are shown to provide context.

• indicates due date

Figure 4. Proposed schedule for implementation of FERC-ordered instream flow studies.

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Attachment 2
Revised Draft Study Plan (Water Temperature Model)

Lower Tuolumne River Water Temperature Modeling
Final Study Plan

Prepared for
Turlock Irrigation District
333 East Canal Drive
Turlock CA 95380

and

Modesto Irrigation District
1231 11th St
Modesto, CA 95354

Prepared by
Stillwater Sciences
2855 Telegraph Ave. Suite 400
Berkeley, CA 94705

October 2009

Stillwater Sciences

Suggested citation: Stillwater Sciences. 2009. Tuolumne River Water Temperature Modeling Final Study Plan. Prepared for Turlock Irrigation District and Modesto Irrigation District. Prepared by Stillwater Sciences, Berkeley, California. October.

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1 BACKGROUND AND PURPOSE

The Federal Energy Regulatory Commission (FERC) issued a July 16, 2009 order ("Order") wherein Ordering paragraph (F) directed the Turlock Irrigation District (TID) and the Modesto Irrigation District (MID) to develop a water temperature model in conjunction with instream flow studies of the lower Tuolumne River (FERC 2009). The purpose of the temperature model is "to determine the downstream extent of thermally suitable habitat to protect summer juvenile *Oncorynchus mykiss* rearing under various flow conditions and to determine flows necessary to maintain water temperatures at or below 68 degrees Fahrenheit from La Grange Dam to Roberts Ferry Bridge". The Order further directs the Districts to include study plan elements of methodologies, schedules, progress reports, and consultation with fishery agencies ("Agencies", including the California Department of Fish and Game, National Marine Fisheries Service, and U.S. Fish and Wildlife Service) in developing the plan.

To examine potential water temperature management scenarios for the benefit of lower Tuolumne River salmonids, two overall study questions will be examined in response to the July 16, 2009 FERC Order:

1. What flows are required to maintain summer water temperatures (MWAT) of 68°F or less downstream to Roberts Ferry Bridge at river mile (RM) 39.5?
2. What is the relationship between flow and water temperature at various time periods during the year in specified reaches of the lower Tuolumne River?

Two existing water temperature models have been previously developed for the lower Tuolumne River. Using water temperature and meteorological data collected from 1978–1988, a stream network temperature (SNTEMP) model (Theurer et al. 1984) was previously developed for the lower Tuolumne River during the late 1980's (TID/MID 1992, Appendix 18). The SNTEMP model used channel and basin geometry along with local meteorological data (i.e., air temperature, relative humidity, solar insolation, and wind speed) collected at the Modesto CIMIS weather station (with corrections for differences in elevation) to predict 5-day average instream temperatures from La Grange Dam (RM 52.2) to near the San Joaquin River confluence (RM 2.6) at various times throughout the year under different flow release scenarios. This SNTEMP model was used in conjunction with results of the CDFG instream flow study of habitat areas for key salmonid life stages (Appendices 4 and 5, TID/MID 1992) and the USFWS instream flow study (USFWS 1995), both conducted under the Don Pedro Project FERC fisheries study plan, in the development of the current flow schedule under Article 37 of the current Don Pedro Project (FERC No. 2299) license (FERC 1996).

More recently, a HEC-5Q model was developed for the Tuolumne River and other tributaries of the San Joaquin River as part of a CALFED-funded temperature model (RMA 2008). The Tuolumne River HEC-5Q sub-model was calibrated using updated water temperature and meteorological data collected from 1996–2006. Based upon statements at a November 2007 training session provided by the model developer, RMA Associates, the model reproduces this historical temperature record to within 1–2°F (0.6–1.1°C) depending upon river location and time of year. This performance is more precise than the previous SNTEMP Model, which had a predicted error of ± 2.7°F (1.5°C) with a 90% confidence interval of ± 5°F (3.0°C) (TID/MID 1992, Appendix 18). The model also has output on 6-hour intervals, providing more discrete time intervals than the SNTEMP model.

2 RECOMMENDED STUDY APPROACH

In response to the Order, TID and MID (the "Districts") propose to use the existing HEC-5Q model to simulate water temperatures at various flows and times of year. The study approach is to first validate the existing water temperature model against water temperature data not used in the initial model calibration. Second, the validated HEC-5Q model, will be used to test a series of flow scenarios to determine the flows needed to maintain specified water temperatures at particular river locations at various times of the year. Ultimately, the water temperature model predictions developed in this study will be used in conjunction with instream flow incremental methodology (IFIM) predictions of weighted usable area (WUA) developed under a separate study plan (Stillwater Sciences 2009). For example, IFIM estimates of WUA of suitable habitat meeting particular life-stage-specific criteria (i.e., depth, velocity, and substrate) determined at a particular flow and time of year will be superimposed upon areas meeting particular water temperature criteria to create an estimate of effective WUA, or EWUA.

3 STUDY AREA

As shown in Figure 1, the study area extends from La Grange Dam (RM 52.2) downstream to the San Joaquin River confluence (RM 0.0). The upper reach from La Grange to Robert's Ferry Bridge (RM 39.5) specified in the Order represents the downstream extent of most summer *O. mykiss* observations in past snorkel surveys (TID/MID 2009). It also contains the Dominant Spawning Reach (down to RM 46.6) and the Dredger Tailing Reach (down to RM 40.3) which typically have the majority of Chinook salmon spawning activity (McBain and Trush 2000).

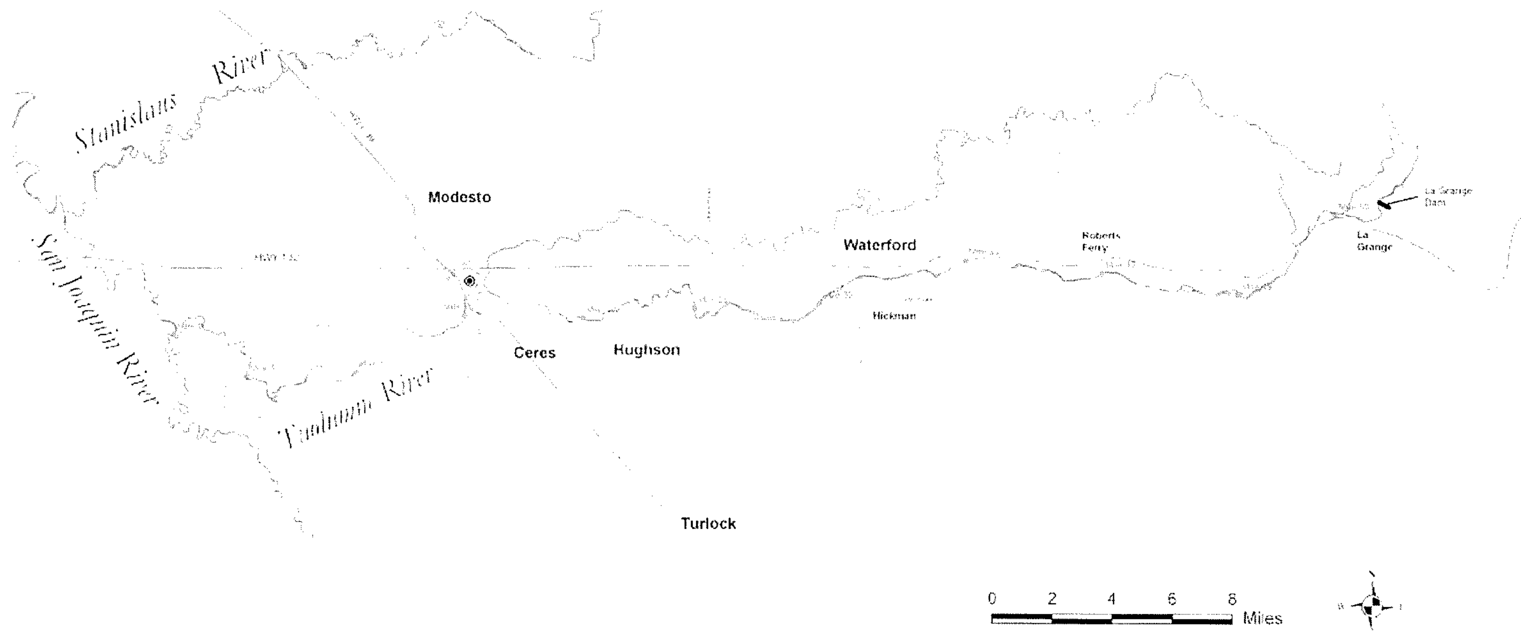

Figure 1. Vicinity map for the Tuolumne River water temperature modeling study.

4 METHODS

The methodology presented in the following sections of this study plan discuss in more detail the steps needed to be performed in order to complete the proposed water temperature modeling study, to inform the complementary IFIM study (Stillwater Sciences 2009), and to report the results to FERC and interested parties.

4.1 Validate Existing HEC-5Q Water Temperature Model

Water temperatures have been recorded continuously by the Districts at various locations in the lower Tuolumne River since 1986 (TID/MID 2005). The HEC-5Q model will be validated against 1996–2009 thermograph data not used in the original model calibration. Data used in the original model calibration may be used if no data independent of the model are available. Because no documentation of the original model calibration was provided in the final CALFED summary report (RMA 2008), an initial step in this process will be to request documentation of thermograph locations, temperature data, and periods of record used in the model calibration so that unbiased goodness of fit statistics can be developed (i.e., observed vs. predicted temperatures) and model uncertainties can be identified. As noted in Section 5, delays in collection of the final HEC-5Q calibration data may result in changes to the proposed schedule. All data records and available metadata (i.e., thermograph model, measurement time-step, specified accuracy, etc) used in the validation exercise will be provided as an electronic data Appendix to the final report.

As recommended by the Agencies, the following temperature modeling goodness of fit metrics are adapted from Theurer et al (1984) using both 6-hr averaged (minimum time-step of the HEC-5Q model) as well as daily averaged thermograph data:

- Maximize the correlation coefficient ($R^2 \leq 1.0$) between modeled and observed water temperatures at individual thermograph locations, as well as across all locations not used in the original calibration data set.
- Determine the fraction of observed temperatures deviating from modeled temperatures by more than 0.5°C, 1°C, and 1.5°C
- Determine any trends in the residual errors (observed minus modeled) either spatially (across several locations) or temporally (at individual locations).

If the goodness of fit results indicate large errors between observed and predicted temperatures, updated model uncertainty estimates will be developed for particular locations or times of year.

4.2 Scenario Development

In addition to an evaluation of the current FERC (1996) flow schedules and the actual flow releases during the 1996–2009 periods as part of the model validation exercise (Section 4.1), the initial scenario will use the validated HEC-5Q model to determine the summer flows necessary to maintain 68°F downstream to Roberts Ferry Bridge (RM 39.5). While these flows are expected to range between 100–400 cfs, the initial model scenario flow range will be expanded if necessary.

In addition to the initial scenario included in the FERC Order (Study Question 1), four additional scenarios corresponding to Study Question 2 were recommended by the Agencies in their review of the Draft Study Plan that correspond to their recommended interim conditions for the protection of various life stages of California Central Valley steelhead (*O. mykiss*) and Fall–run Chinook salmon (*O. tshawytscha*).

1. What flows are required to maintain a summer MWAT of 18°C (64.4°F) downstream of La Grange Dam to Roberts Ferry Bridge (RM 39.5)?
2. What flows are required to maintain a MWAT of 18°C (64.4°F) downstream of La Grange Dam to the confluence with the San Joaquin River (RM 0) from October 15 to December 1?
3. What flows are required to maintain a MWAT of 13°C (55.4°F) downstream of La Grange Dam to Roberts Ferry Bridge (RM 39.5) from October 15 to February 15?
4. What flows are required to maintain a MWAT of 15°C (59.0°F) downstream of La Grange Dam to the confluence with the San Joaquin River (RM 0) from March 20 to May 15.

In addition, alternative scenarios (i.e., temperature, location, timing, etc.) may also be evaluated that draw upon findings from the literature or field observations, such as information provided to FERC by the Districts, CCSF, and the Agencies.

4.3 Model Simulations and Analysis

The HEC-5Q model will be used to determine the downstream extent of suitable water temperatures for key *O. mykiss* and *O. tshawytscha* life stages under normal and extreme meteorology. As with any temperature model, using the HEC-5Q model as a predictive tool is limited by the availability of meteorological data corresponding to the conditions of interest (e.g., hottest week of spring or summer), However, various reservoir operation and release scenarios may be simulated against the period-of-record meteorology to generate a range of predicted temperatures for various locations in the river under varying meteorologic conditions. It should be noted that since the reservoir operations modeling component of the existing HEC-5Q is not adequately reflective of actual basin hydrology and District operations of Don Pedro Reservoir, corresponding water storage estimates under various scenarios and water-year types will not be addressed as part of this Study Plan.

4.4 Develop Report

A documentation report will be prepared summarizing the results of the temperature model study, describing the HEC-5Q modeling background, validation, scenario development, model simulations and analysis. The report will include graphics depicting the longitudinal flow versus water temperature relationship under varying meteorologic conditions in order to allow a thermal analysis of various flow regimes. The report will be provided to the Agencies for review and comment prior to submittal to FERC. Periodic progress reports will be prepared as milestone steps under Section 5.

5 SCHEDULE

A proposed schedule is provided in Table 1 and Figure 2. The schedule is predicated on an anticipated study plan acceptance by FERC on or about January 12, 2010, and assumes timely response by the model developer and CDFG in providing requested calibration data and documentation (Section 4.1). In the event that the these responses are not received on a timely basis, or in the event that the validation of the existing model reveals major inconsistencies with observed temperatures in the lower Tuolumne River, the schedule below may be adjusted in consultation with FERC and the stakeholders.

Table 1. Proposed schedule for implementation of FERC-ordered Temperature Modeling Study Plan.

Item	Dates (duration)	Days from FERC Approval of Study Plan
Develop Study Plan and Submit to FERC for Approval	October 14, 2009	--
FERC Response to Study Plan	January 12, 2010 (90d)	
Validate Existing Water Temperature Model	January 13 to April 12, 2010 (90d)	90
Scenario Development	January 13 to May 31, 2010 (139d)	139
Model Simulations and Analysis	June 1 to July 30, 2010 (60d)	199
Progress Report	July 30, 2010 (NA)	199
Prepare Report	October 28, 2010 (90d)	289
Instream Flow and Effective Habitat Evaluations	September 27, 2011 (180d)	623

Item	2009			2010												2011								
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Proposed Study Plan Submittal to FERC	●																							
FERC Response to Study Plan				●																				
Validate Existing Water Temperature Model																								
Initial Scenario Development and																								
Model Simulations																								
Progress Report										●														
Report													●											
Instream Flow and Effective Habitat																								

Figure 2. Proposed timeline for implementation of FERC-ordered Temperature Modeling Study Plan.

6 REFERENCES

FERC (Federal Energy Regulatory Commission). 1996. Reservoir release requirements for fish at the New Don Pedro Project, California. FERC Project No. 2299-024, FERC, Office of Hydropower Licensing, Washington, D.C.

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Attachment 3
Proposed Study Plan Transmittal Letter (dated September 3, 2009)

TURLOCK IRRIGATION DISTRICT

September 3, 2009

(via e-mail)

Tim Heyne
California Dept. of Fish and Game
P.O. Box 10
La Grange, CA 95329

Kim Webb
U.S. Fish and Wildlife Service
2800 Cottage Way, W-2605
Sacramento, CA 95825

Maria Rea
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento, CA 95814-4708

RE: FERC Project 2299 -- Instream Flow and Water Temperature Study Plans

Dear Fishery Agency representatives:

The accompanying proposed study plans are being presented to you in compliance with the FERC *Order on rehearing, amending license, denying late intervention, denying petition, and directing appointment of a presiding judge for a proceeding on interim conditions on Rehearing* (Order) issued July 16, 2009.

The Order states on page 45 in Paragraph (F) that the Districts shall allow a minimum of 30 days for the agencies (National Marine Fisheries Service, U.S. Fish and Wildlife Service, and California Department of Fish and Game) to comment and to make recommendations before filing the plan(s) with the Commission.

We invite your review, comments and suggestions. Please forward them to me <u>no later than 5 p.m. PDT on Monday, October 5, 2009</u>. They must be received by that time to allow consideration before the plans are finalized and submitted to the FERC by October 14, 2009.

This transmittal sheet, along with the proposed study plans, is also being sent electronically to the parties to the proceeding identified in the Order on page 8, Paragraph 13. Please contact me at 209-883-8375 if you have any questions.

Sincerely,

Tim Ford

Tim Ford
Aquatic Biologist

Cc: Modesto Irrigation District, City and County of San Francisco, U.S. Department of the Interior, San Francisco Bay Area Water Users Association, Stanislaus Flyfishermen, Friends of the Tuolumne, Conservation Groups

TID
WATER & POWER

Attachment 4
USFWS Comments on Instream Flow and Water Temperature Study Plans

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In reply refer to:

Tim Ford, Aquatic Biologist
Turlock Irrigation District
333 East Canal Drive
Post Office Box 494
Turlock, California 95381

OCT 5 2009

Subject: Don Pedro Hydroelectric Project, FERC # 2299, Tuolumne River, California – Service Comments on Instream Flow and Water Temperature Study Plans

Dear Mr. Ford:

In its July 16, 2009 Order on Rehearing, Amending License, Denying Later Intervention, Denying Petition, and Directing Appointment of a Presiding Judge for a Proceeding on Interim Conditions (Order), the Federal Energy Regulatory Commission (Commission or FERC) directed the Turlock and Modesto Irrigation Districts (Districts) to develop and implement an instream flow study for, and a water temperature model of, the Tuolumne River below La Grange Dam. Specifically, paragraph F of the Commission Order states:

> *The Turlock and Modesto Irrigation Districts (Districts) shall develop and implement an IFIM/PHABSIM study plan to determine instream flows necessary to maximize fall-run Chinook salmon and O. mykiss production and survival throughout their various life stages. The PHABSIM flow models under the IFIM should evaluate base flows, to include, but not be limited to, 150 cubic feet per second (cfs), 200 cfs, 250 cfs, 300 cfs, and at least 400 cfs. The instream flow study shall also evaluate spring pulse flows of 1,000 to 5,000 cfs and fall pulse flows of up to 1,500 cfs from La Grange Dam. In general, the instream flow study shall include the following steps, unless agreed upon otherwise in consultation with the resource agencies: (1) selection of target species or guild, selection or development of appropriate micro- and/or macro-habitat suitability criteria; (2) study area segmentation and study site selection; (3) cross section placement and field data collection; (4) hydraulic modeling; (5) habitat modeling; (6) derivation of total habitat time series, micro- and macro-habitat; (7) determination of habitat bottlenecks; and (8) evaluation of management alternatives and problem resolution. In connection with the IFIM study, the Districts shall also develop a water temperature model to determine the downstream extent of thermally suitable habitat to protect summer juvenile O. mykiss rearing under various flow conditions and to determine flows necessary to maintain water temperatures at or below 68 degrees Fahrenheit from La Grange Dam to Roberts Ferry Bridge.*

By letter dated September 3, 2009, the Districts distributed draft instream flow and water temperature modeling study plans for review by the resource agencies. The Fish and Wildlife Service (Service) is providing the following comments on those Instream Flow and Water Temperature Study Plans.

The Districts' plans raise a number of concerns, as outlined specifically below. In addition, the Service has two overarching issues with the Districts' proposed plans. First, a Physical Habitat Simulation System (PHABSIM) flow model does not address all of the essential habitat needs of the migratory phases of anadromous species, such as Central Valley fall-run Chinook salmon and Central Valley steelhead (*O. mykiss*). Further, the PHABSIM flow model does not address the effects of flow on potential biotic limiting factors (e.g., predation, food, contaminants, disease, etc.) or abiotic factors (e.g., unscreened diversions) within or outside of the Tuolumne River. Habitat needs and potential limiting factors are critical to the Commission's ultimate determination here, as to what measures may be necessary to protect the salmonid species. Accordingly, the PHABSIM flow model should not be used by itself to develop an instream flow schedule for the Don Pedro Project that will sustain and protect the Central Valley steelhead and Central Valley fall-run Chinook salmon populations in the Tuolumne River. The District's Instream Flow Incremental Methodology (IFIM) study plan should specifically state that the objectives of the study are to determine the instream flows necessary to maximize Chinook salmon and *O. mykiss* production and survival only for the resident phases of these species, particularly for adult Central Valley steelhead. The District's study plan should indicate that other methods will be needed to assess the flows for the migratory phases of these species. The studies for the migratory phases are to be determined based on the Agencies' recommended interim measure elements, which include fish health assessments, temperature monitoring, tissue (genetic) sampling, paired rotary screw trap studies, escapement surveys, and adult age composition. Although the Order requires an instream flow study of the spring and fall pulse flows intended for the migratory phases of these species, typical habitat suitability criteria and weighted usable area estimates cannot be used to evaluate the benefits of these flows. Therefore, the Districts should state that the sole objective of the late winter and spring pulse flow studies is to demonstrate the relationship between pulse flows and the area of inundated floodplain habitats throughout the Tuolumne River. Other data will be used to assess the importance of inundated floodplain habitat and the duration and timing needed for floodplain inundation, whereas the instream flow studies will determine the flow that optimizes the amount of inundated habitat.

Second, the HEC-5Q water temperature model that was developed for the Tuolumne River and other tributaries of the San Joaquin River by AD Consultants and RMA was thoroughly reviewed by all the San Joaquin River Basin Stakeholders from 2005 through 2008 and should not be revised by the Districts or their consultants without the approval of the Service and other agencies. There is no reason why the existing model should not be used to determine the flows needed to maintain the specified water temperature targets under a range of climatic conditions and reservoir storage levels as well as manage the reservoir storage to prevent the release of unsuitably warm water. In addition, the Service believes that water temperature is highly important to the survival of salmon and *O. mykiss* and so the results of the water temperature analysis should not combined with weighted usable area estimates into a single habitat based index to provide the sole assessment of the instream flow needs of the fish.

SPECIFIC COMMENTS

We provide the following specific comments on the District's September 3 letter.

Instream Flow Study Plan

1. Study Segment Delineation - Study segments should be delineated based on differences in flow. Bovee (1995) recommends that the cumulative change in flow within a segment be less than ten percent.

2. Mesohabitat Mapping – Mesohabitats for alluvial channels, such as the Tuolumne River, should be delineated using the following geomorphically-based habitat mapping system. This habitat mapping system uses 12 mesohabitat types: bar complex glides, bar complex pools, bar complex riffles, bar complex runs, flatwater glides, flatwater pools, flatwater riffles, flatwater runs, side channel glides, side channel pools, side channel riffles, and side channel runs (Snider et al 1992). Definitions of the habitat types are given in Table 1. Aerial photos should be used in conjunction with direct observations to determine the aerial extent of each habitat unit. The location of the upstream and downstream end of each habitat unit should be recorded with a Global Positioning System (GPS) unit. The habitat units should be also delineated on the aerial photos. Following the completion of the mesohabitat mapping, the mesohabitat types and number of each habitat type in each segment should be enumerated, and shapefiles of the mesohabitat units should be created in a Geographic Information System (GIS) using the GPS data and the aerial photos. The area of each mesohabitat unit should be computed in GIS from the above shapefiles.

3. Field Reconnaissance and Study Site Selection – Study sites for modeling spawning should be placed in high spawning use areas and study sites for rearing should be selected to adequately represent the mesohabitat types present in each segment. Using a mesohabitat-based approach for modeling spawning habitat fails to take into account salmonids' preference for spawning in areas with high gravel permeability (Vyverberg et al 1996), while having sites only in high-use spawning areas indirectly takes into account characteristics of spawning habitat, such as permeability and upwelling, which are key characteristics of spawning habitat and are not captured by depth, velocity and substrate (Gallagher and Gard 1999). The assumption is that high-use spawning areas have high gravel permeability since salmonids are selecting these areas for spawning. For spawning, the study reach should be surveyed, with the location of the upstream and downstream ends of spawning areas recorded with a GPS unit and the numbers of redds in each spawning area recorded. The spawning study sites selected should be those with the highest number of redds observed during the above survey. The upstream and downstream end of each spawning study site should be selected to correspond to the upstream and downstream ends of spawning areas recorded with the GPS unit. There should be at least five spawning study sites per study segment.

Table 1. Habitat type definitions.

Habitat Type	Definition
Bar Complex	Submerged and emergent bars are the primary feature, sloping cross-sectional channel profile.
Flatwater	Primary channel is uniform, simple and without gravel bars or channel controls, fairly uniform depth across channel.
Side Channel	Less than 20% of total flow.
Pool	Primary determinant is downstream control - thalweg gets deeper as go upstream from bottom of pool. Fine and uniform substrate, below average water velocity, above average depth, tranquil water surface.
Glide	Primary determinants are no turbulence (surface smooth, slow and laminar) and no downstream control. Low gradient, substrate uniform across channel width and composed of small gravel and/or sand/silt, depth below average and similar across channel width (but depth not similar across channel width for Bar Complex Glide), below average water velocities, generally associated with tails of pools or heads of riffles, width of channel tends to spread out, thalweg has relatively uniform slope going downstream.
Run	Primary determinants are moderately turbulent and average depth. Moderate gradient, substrate a mix of particle sizes and composed of small cobble and gravel, with some large cobble and boulders, above average water velocities, usually slight gradient change from top to bottom, generally associated with downstream extent of riffles, thalweg has relatively uniform slope going downstream.
Riffle	Primary determinants are high gradient and turbulence. Below average depth, above average velocity, thalweg has relatively uniform slope going downstream, substrate of uniform size and composed of large gravel and/or cobble, change in gradient noticeable.

Study sites for rearing should be randomly selected to ensure unbiased selection of the study sites. The upstream and downstream end of each rearing study site should be selected to correspond to the upstream and downstream ends of the mesohabitat units selected. The rearing study sites should have a total length of two miles of river. The rearing study sites should include, in total, at least three mesohabitat units of each of the following mesohabitat types: pool, run, riffle, and glide. The proportion of habitat types in the rearing sites should roughly correspond to the proportion of habitat types in each study segment.

4. Habitat Modeling – Habitat modeling should be conducted using a two-dimensional (2-D) model rather than 1-D PHABSIM. 2-D model inputs include the bed topography and bed roughness, and the water surface elevation at the downstream end of the site. The amount of habitat present in the site is computed using the depths and velocities predicted by the 2-D model, and the substrate and cover present in the site. The 2-D model avoids problems of transect placement, since data is collected uniformly across the entire site. The 2-D model also has the potential to model depths and velocities over a range of flows more accurately than 1-D PHABSIM because it takes into account upstream and downstream bed topography and bed roughness, and explicitly uses mechanistic processes (conservation of mass and momentum), rather than Manning's Equation and a velocity adjustment factor (Leclerc et al. 1995). Other advantages of 2-D modeling are that it can explicitly handle complex hydraulics, including transverse flows, across-channel variation in water surface elevations, and flow contractions/expansions (Ghanem et al. 1996, Crowder and Diplas 2000, Pasternack et al. 2004). With appropriate bathymetry data, the model scale is small enough to correspond to the scale of microhabitat use data with depths and velocities produced on a continuous basis, rather than in discrete cells. The 2-D model, with compact cells, should be more accurate than 1-D PHABSIM, with long rectangular cells, in capturing longitudinal variation in depth, velocity and substrate. The 2-D model should do a better job of representing patchy microhabitat features, such as gravel patches. The data can be collected with a stratified sampling scheme, with higher intensity sampling in areas with more complex or more quickly varying microhabitat features, and lower intensity sampling in areas with uniformly varying bed topography and uniform substrate. Bed topography and substrate mapping data can be collected at a very low flow, with the only data needed at high flow being water surface elevations at the up- and downstream ends of the site and flow, and edge velocities for validation purposes. In addition, alternative habitat suitability criteria, such as measures of habitat diversity, can be used.

A. 2-D Model Quality Assurance/Quality Control (QA/QC)

A PHABSIM transect should be placed at the upstream and downstream end of each site. See PHABSIM section for standards for developing stage/discharge relationships for upstream and downstream end of sites.

Data collected between the upstream and downstream transects should include: 1) bed elevation; 2) northing and easting (horizontal location); 3) substrate; and 4) cover. These parameters should be collected at enough points to characterize the bed topography, substrate and cover of the sites. Bed topography points need to be collected at a minimum density of 40 points/100m^2 in all areas of the selected study sites. Data should be collected at least up to the location of the water's edge at the highest flow to be simulated. Bed topography data should be collected at a higher density of points in areas with rapidly varying topography and patchy substrate and cover, and lower densities of points in areas with more uniform topography, substrate and cover. The accuracy of the bed elevations should be 0.1 foot, while the accuracy of the northings and eastings should be at least 1.0 foot[1]. The bed topography data can be collected with a total station, a survey-grade Real-time Kinematic (RTK) GPS, or for deeper areas, a combination of Acoustic Doppler Current Profiler (ADCP) traverses across the channel and total station to record the initial and final northing and easting of each traverse, or a combination of depth sounder and RTK GPS.

[1] All bed topography points will need to be accurate to within 0.1 foot. An accuracy level of 0.1 foot is the scientific standard for modeling salmonid habitat. While Light Detection and Ranging (LiDAR) and other methods may have their uses for coarse scale hydraulic modeling, we believe that the amount of vertical error involved with LiDAR makes it unacceptable for use in juvenile salmonid habitat modeling.

Substrate and cover data should be collected using the categories in Tables 2 and 3. The northings and eastings of the transect headpins and tailpins should be determined with the total station or RTK GPS so that the topography for the transects can be incorporated into the bed topography of the sites. Additional topography data should be collected for one channel width upstream of the upstream transect to improve the accuracy of the flow distribution at the upstream end of the sites.

At least 50 velocity measurements, with the northing and easting of each velocity measurement determined with the total station or RTK GPS, should be collected (in addition to the velocities measured at the upstream and downstream transects and measured by the ADCP, if used) to validate the hydraulic predictions of the 2-D model. The locations of these velocity measurements should be distributed throughout the site. Velocities should be measured to the nearest 0.01 ft/s at 0.6 of the depth for 20 seconds using either a Price AA or Marsh-McBirney velocity meter. The flow present during validation velocity data collection should be detemined from gauge readings, if available. If gauge data is not available, the flow present during validation velocity data collection should be measured.

The topographic data described above should be combined with the bed topography from the upstream and downstream transects to create the initial bed file. The bed file contains the horizontal location (northing and easting), bed elevation and initial bed roughness value for each point. The initial bed roughness values should be determined from the substrate and cover data using the values in Table 4. If the topography data collected upstream of the upstream transect does not extend at least one channel width upstream of the top of the site, a one-channel-width artificial extension should be added upstream of the measured topography data to enable the flow to be distributed by the model when it reaches the study area, thus minimizing boundary conditions influencing the flow distribution at the upstream transect and within the study site. A utility program, R2D_BED (Steffler 2002), should be used to define the study area boundary and to refine the raw topographical data triangulated irregular network (TIN) by defining breaklines[2] going up the channel along features such as thalwegs, tops of bars and bottoms of banks. Breaklines should also be added along lines of constant elevation. An additional utility program, R2D_MESH (Waddle and Steffler 2002), should be used to define the inflow and outflow boundaries and create the finite element computational mesh for the RIVER2D model.

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[2] Breaklines are a feature of the R2D_Bed program which force the TIN of the bed nodes to linearly interpolate bed elevation and bed roughness values between the nodes on each breakline and force the TIN to fall on the breaklines (Steffler 2002).

Table 2. Substrate codes, descriptors and particle sizes.

Code	Type	Particle Size (inches)
0.1	Sand/Silt	< 0.1
1	Small Gravel	0.1 – 1
1.2	Medium Gravel	1 – 2
1.3	Medium/Large Gravel	1 – 3
2.3	Large Gravel	2 – 3
2.4	Gravel/Cobble	2 – 4
3.4	Small Cobble	3 – 4
3.5	Small Cobble	3 – 5
4.6	Medium Cobble	4 – 6
6.8	Large Cobble	6 – 8
8	Large Cobble	8 – 10
9	Boulder/Bedrock	> 12
10	Large Cobble	10 – 12

R2D_MESH uses the final bed file as an input. Mesh breaklines[3] should be defined which coincide with the final bed file breaklines. Additional mesh breaklines should then be added between the initial mesh breaklines, and then additional nodes should be added as needed to improve the fit between the mesh and the final bed file and to improve the quality of the mesh, as measured by the Quality Index (QI) value. A QI value of at least 0.2 is considered acceptable (Waddle and Steffler 2002).

The computational mesh should be run to steady state at the highest flow to be simulated, and the water surface elevations (WSELs) predicted by RIVER2D at the upstream end of the site should be compared to the WSELs predicted by PHABSIM at the upstream transect. A stable solution will generally have a solution change (Sol Δ) of less than 0.00001 and a net flow (Net Q) of less

[3] Mesh breaklines are a feature of the R2D_MESH program which force edges of the computation mesh elements to fall on the mesh breaklines and force the TIN of the computational mesh to linearly interpolate the bed elevation and bed roughness values of mesh nodes between the nodes at the end of each breakline segment (Waddle and Steffler 2002). A better fit between the bed and mesh TINs is achieved by having the mesh and bed breaklines coincide.

Table 3. Cover coding system.

Cover Category	Cover Code
No cover	0
Cobble	1
Boulder	2
Fine woody vegetation (< 1" diameter)	3
Fine woody vegetation + overhead	3.7
Branches	4
Branches + overhead	4.7
Log (> 1' diameter)	5
Log + overhead	5.7
Overhead cover (> 2' above substrate)	7
Undercut bank	8
Aquatic vegetation	9
Aquatic vegetation + overhead	9.7
Rip-rap	10

than one percent (Steffler and Blackburn 2002). In addition, solutions for low gradient streams should usually have a maximum Froude Number (Max F) of less than one. Calibration is considered to have been achieved when the WSELs predicted by RIVER2D at the upstream transect is within 0.1 foot of the WSEL predicted by PHABSIM. In cases where the simulated WSELs at the highest simulation flow varies across the channel by more than 0.1 foot, the highest measured flow within the range of simulated flows should be used for RIVER2D calibration. The bed roughnesses of the computational mesh elements should then be modified by multiplying them by a constant bed roughness multiplier (BR Mult) until the WSELs predicted by RIVER2D at the upstream end of the site matched the WSELs predicted by PHABSIM at the top transect. BR Mult values should lie within the range of 0.3 to 3.0. The minimum groundwater depth should be adjusted to a value of 0.05 to increase the stability of the model. The values of all other RIVER2D hydraulic parameters should be left at their default values (upwinding coefficient = 0.5, groundwater transmissivity = 0.1, groundwater storativity = 1, and eddy viscosity parameters $\varepsilon_1 = 0.01$, $\varepsilon_2 = 0.5$ and $\varepsilon_3 = 0.1$).

Table 4. Initial bed roughness values. For substrate code 9, use bed roughnesses of 0.71 and 1.95, respectively, for cover codes 1 and 2. Bed roughnesses of zero should be used for cover codes 1 and 2 for all other substrate codes, since the roughness associated with the cover is included in the substrate roughness.

Substrate Code	Bed Roughness (m)	Cover Code	Bed Roughness (m)
0.1	0.05	0.1	0
1	0.1	1	0
1.2	0.2	2	0
1.3	0.25	3	0.11
2.3	0.3	3.7	0.2
2.4	0.4	4	0.62
3.4	0.45	4.7	0.96
3.5	0.5	5	1.93
4.6	0.65	5.7	2.59
6.8	0.9	7	0.28
8	1.25	8	2.97
9	0.05	9	0.29
10	1.4	9.7	0.57
		10	3.05

Velocities predicted by RIVER2D should be compared with measured velocities to determine the accuracy of the model's predictions of mean water column velocities. The criterion used to determine whether the model was validated was whether the correlation between measured and simulated velocities was greater than 0.6. The model would be in question if the simulated velocities deviated from the measured velocities to the extent that the correlation between measured and simulated velocities fell below 0.6.

After the RIVER2D model is calibrated, the flow and downstream WSEL in the calibrated cdg file should be changed to simulate the hydraulics of the site at the simulation flows. The cdg file for each flow contains the WSEL predicted by PHABSIM at the downstream transect at that flow. Each cdg file should be run in RIVER2D to steady state. Again, a stable solution will generally have a Sol Δ of less than 0.00001 and a Net Q of less than 1%. In addition, solutions should usually have a Max F of less than one.

B. 1-D PHABSIM QA/QC

Transects should be placed in locations where there is no more than a 0.1 foot difference in WSEL across the transect and where the velocity profile across the transect is entirely perpendicular to the transect. Transects generally cannot be placed in areas with transverse flows, across-channel variation in water surface elevations, or flow contractions/expansions. Vertical benchmarks should be established for each transect to serve as the reference elevations to which all elevations (streambed and water surface) are tied. Vertical benchmarks should consist of items that will not change elevation over time, such as lag bolts driven into trees or painted bedrock points. Vertical benchmarks should be tied together for the upstream and downstream transects, so that water surface elevations at these transects can be compared to ensure that water is not running uphill.

The data collected at each transect should include: 1) WSELs measured to the nearest 0.01 foot at a minimum of three significantly different stream discharges using standard surveying techniques (differential leveling); 2) at least 20 wetted streambed elevations per transect determined by subtracting the measured depth from the surveyed WSEL at a measured flow; 3) dry ground elevations to points above bankfull discharge surveyed to the nearest 0.1 foot; 4) mean water column velocities measured at the points where bed elevations are computed; and 5) substrate and cover classification at these same locations (Tables 2 and 3) and also where dry ground elevations were surveyed. When conditions allow, WSELs should be measured along both banks and in the middle of each transect. Otherwise, the WSELs should be measured along both banks. If the WSELs measured for a transect are within 0.1 foot of each other, the WSELs at each transect should be derived by averaging the two to three values. If the WSEL differ by greater than 0.1 foot, the WSEL for the transect should be selected based on which side of the transect was considered most representative of the flow conditions. If there is a hydraulic control downstream of a given transect, the stage of zero flow in the thalweg downstream of that transect should be surveyed in using differential leveling.

The range of flows to be simulated should go up to 8,400 cfs. Water surface elevations should be collected at a minimum of three relatively evenly spaced calibration flows, spanning approximately an order of magnitude. The calibration flows should be selected so that the lowest simulated flow is no less than 0.4 of the lowest calibration flow and the highest simulated flow is at most 2.5 times the highest calibration flow.

For the *IFG4* model to be considered to have worked well, the following standards must be met: 1) the beta value (a measure of the change in channel roughness with changes in streamflow) is between 2.0 and 4.5; 2) the mean error in calculated versus given discharges is less than ten percent; 3) there is no more than a 25% difference for any calculated versus given discharge; and 4) there is no more than a 0.1 foot difference between measured and simulated WSELs. A beta value greater than 4.5 generally indicates that a hydraulic control downstream of the transect was not surveyed in, resulting in an erroneously low stage of zero flow value. *MANSQ* is considered to have worked well if the second through fourth of the above criteria are met, and if the beta value parameter used by *MANSQ* is within the range of 0 to 0.5. The first *IFG4* criterion is not applicable to *MANSQ*. *WSP* is considered to have worked well if the following criteria are met:

1) the Manning's n value used falls within the range of 0.04 - 0.07; 2) there is a negative log-log relationship between the reach multiplier and flow; and 3) there is no more than a 0.1 foot difference between measured and simulated WSELs. The first three *IFG4* criteria are not applicable to *WSP*. An additional QA/QC measure for *IFG4* or *MANSQ* is to check and see if water is flowing uphill at any of the simulated flows – if this is present, it usually indicates that the extrapolation of WSELs beyond the range of measured WSELs has broken down, and in such cases *WSP* should be used to develop the stage-discharge relationship for the upstream transect. The Froude numbers should be <1.0. The acceptable range of Velocity Adjustment Factor (VAF) values is 0.2 to 5.0 and the expected pattern for VAFs is a monotonic increase with an increase in flows.

5. Habitat Suitability Criteria (HSC) – The resident and anadromous forms of *Oncorhynchus mykiss*, including age classes 1+ and 2+, sub-adults, adult holding and summertime habitat conditions, need to be considered. Cover and adjacent velocity will be needed for all HSC observations, in addition to depth and mean water column velocity at the fish location (Service 2005). The Service measures average water column velocities when collecting HSC data. Average water column velocity data need to be collected for all HSC velocity and adjacent velocity measurements. There needs to be a minimum of 150 observations for each life stage and species (Bovee 1986).

The habitat suitability criteria in Service (1995) should not be used since they are likely biased towards low depths and velocities. The criteria used should use the recent advances in techniques for developing habitat suitability criteria for instream flow studies (adjustment of depth habitat suitability criteria for spawning to account for low availability of deep waters with suitable velocity and substrate, use of logistic regression to develop criteria, use of cover and adjacent velocity criteria for rearing) since 1995. Criteria should be developed on the Tuolumne River or the criteria in Service (2008a and b) should be used.

Most habitat utilization curves for salmonid spawning suggest that spawning salmonids, such as Chinook salmon and steelhead, prefer shallow conditions (typically depths of one to two feet). However, such curves may simply reflect that there is very little deeper areas present in streams which have suitable (good) velocities and substrates. Gard (1998) presents a method to adjust depth habitat utilization curves for spawning to account for low availability of deep waters with suitable velocity and substrate. To modify the depth curve to account for the low availability of deep water having suitable velocities and substrates, a sequence of linear regressions (Gard 1998) is used to determine the relative rate of decline of use versus availability with increasing depth. The depth correction methodology has been published in a peer-reviewed journal (Gard 1998) and has been applied on six streams (Merced River, American River, Sacramento River, Butte Creek, Yuba River and Clear Creek). The methodology has consistently shown that most of the decline in spawning habitat use with increasing depth is due to the low availability of deeper waters with suitable velocities and substrates, and not because salmonids will select only shallow depths for spawning.

Traditionally, habitat suitability criteria are created from observations of fish use by fitting a nonlinear function to the frequency of habitat use for each variable (depth, velocity, and substrate or cover). One concern with this technique is the effect of availability of habitat on the observed frequency of habitat use. For example, if a cover type is relatively rare in a stream, fish will be found primarily not using that cover type simply because of the rarity of that cover type, rather than because they are selecting areas without that cover type. Guay et al. (2000) proposed a modification of the above technique where depth, velocity, and cover data are collected both in locations where fish are present and in locations where fish are absent, and a logistic regression is used to develop the criteria. Logistic regressions tend to produce criteria that are shifted towards higher depths and velocities, as compared to criteria based solely on habitat use data, as a result of the limited availability of faster and deeper conditions (Service 2008a, b). Unoccupied observations need to be collected to be used for developing logistic regression criteria (Manly et al. 2002). There needs to be a minimum of 300 unoccupied observations for each life stage and species. The use of logistic regression in developing HSC is now considered the standard best approach in the scientific literature (Knapp and Preisler 1999, Parasiewicz 1999, Geist et al. 2000, Guay et al. 2000, Tiffan et al. 2002, McHugh and Budy 2004) for developing habitat suitability criteria. For example, McHugh and Budy (2004) state:

> "More recently, and based on the early recommendations of Thielke (1985), many researchers have adopted a multivariate logistic regression approach to habitat suitability modeling (Knapp and Preisler 1999; Geist et al. 2000; Guay et al. 2000)."

Adjacent velocity can be an important habitat variable as fish, particularly fry and juveniles, frequently reside in slow-water habitats adjacent to faster water where invertebrate drift is conveyed (Fausch and White 1981). Both the residence and adjacent velocity variables are important for fish to minimize the energy expenditure/food intake ratio and maintain growth. The concept of adjacent velocity criteria was included in the original PHABSIM software, through the Adjacent Velocity Habitat Analysis (HABTAV) program (Milhous et al. 1989, pages v.69-78), but has rarely been implemented, and has been envisioned as primarily applying to adult salmonids, where the fish reside in low-velocity areas, but briefly venture into adjacent fast-velocity areas to feed on invertebrate drift. In studies for both the Yuba and Sacramento Rivers, the adjacent velocity criteria has been developed based on an entirely different mechanism, namely the transport of invertebrate drift from fast-water areas to adjacent slow-water areas where fry and juvenile salmonids reside via turbulent mixing (U.S. Fish and Wildlife Service 2008b). Adjacent velocity is an important aspect of anadromous juvenile salmonid rearing habitat that has been overlooked in previous studies. Fry and juvenile anadromous salmonid rearing criteria show a consistent preference for composite cover (instream woody plus overhead) (U.S. Fish and Wildlife Service 2008b). Composite cover likely is an important aspect of juvenile salmonid habitat because it reduces the risk of both piscivorous and avian predation. While cover is frequently used for anadromous juvenile salmonid rearing, the simplicity of the cover categories (typically no cover, object cover, overhead cover and object plus overhead cover) misses the importance of woody composite cover for anadromous juvenile salmonid rearing.

6. Biological Verification – Biological verification data should be collected to test the hypothesis that the compound suitability predicted by the River2D model is higher at locations where redds, fry or juveniles were present than in locations where redds, fry or juveniles were absent. The collected biological verification data are the horizontal locations of redds, fry and juveniles. The horizontal locations of redds, fry and juveniles found during surveys should be recorded with a total station or RTK GPS. For redds, depth, velocity, and substrate should also be measured. For fry and juveniles, depth, velocity, adjacent velocity, and cover should also be measured. The horizontal locations of where redds, fry or juveniles were not present (unoccupied locations) should also be recorded with a total station or RTK GPS. The hypothesis that the compound suitability predicted by the River2D model is higher at locations where redds, fry and juveniles were present than in locations where redds, fry and juveniles were absent should be statistically tested with a Mann-Whitney U test (Zar 1984). The combined habitat suitability predicted by River2D should be determined at each fry and juvenile observation location in the sites where redds, fry and juvenile locations were recorded with a total station or RTK GPS. The River2D cdg files should be run at the flows present in the study sites for the dates that the biological verification data was collected. The horizontal location measured for each observation should be used to determine the location of each observation in the River2D sites. The horizontal locations recorded with a total station or RTK GPS where redds, fry or juveniles were not present should be used for the unoccupied points. Mann-Whitney U tests (Zar 1984) should be used to determine whether the combined suitability predicted by River2D was higher at locations where redds, fry or juveniles were present versus locations where redds, fry or juveniles were absent. Biological verification needs to be conducted at the microhabitat scale (1 ft^2 grid) to determine if the combined suitability of occupied locations is greater than the combined suitability of unoccupied locations. This data is needed to verify the accuracy of the model's predictions regarding habitat availability and use (Gard 2006).

6. Habitat Time Series – In section 3.4.7, Total Habitat Time Series, the Districts suggest that the habitat time series analysis will be developed based on monthly average flows. We disagree with the development of a habitat time series based on monthly average flows and strongly recommend that the Districts develop the habitat time series based on daily flows.

GENERAL COMMENTS

Non-migratory life history stages, primarily fry and parr juvenile salmon, utilize inundated floodplain habitats for rearing; the modeled range of flows less than 1,000 cfs will not assess the benefits of inundated floodplain habitats. Neither PHABSIM nor Riverine Habitat Simulation Model (RHABSIM) are designed to assess the effects of high flows flushing organic matter and terrestrial invertebrates into the river to augment the food base for juvenile salmon and trout. Instead, the Districts should determine the relationship between flow releases and the amount of floodplain habitat that becomes inundated throughout the entire river at flows of 1,000 cfs, 1,500 cfs, 2,000 cfs, 2,500 cfs, 3,000 cfs, 4,000 cfs and 5,000 cfs. Rotary screw trap estimates of the survival rates of fry (Waterford estimates) to a smolt-size at the Grayson sites along with fish health assessments should be used to evaluate the effectiveness of the amount, duration, and location of floodplain inundation.

While LIDAR data are not sufficiently accurate for microhabitat assessments, such data would be sufficiently accurate for a macrohabitat assessment, such as determining the relationship between flow and the amount of floodplain habitat. It is our understanding that there are 2005 LIDAR data for the entire river. Our recommendation would be to combine this data with bathymetry data to develop a River2D model of the entire river to determine the relationship between flow and the amount of floodplain habitat. Our understanding is that bathymetry data are available from McBain and Trush for the upper portion of the Tuolumne River (upstream of the 7/11 bridge) and from the U.S. Army Corps of Engineers for the lower portion of the Tuolumne River (from the San Joaquin River to just upstream of Modesto). The Districts would still need to collect bathymetry data from just upstream of Modesto to the 7/11 bridge. Existing GIS information on vegetation cover produced by the California Gap Analysis Project could be used to specify bed roughness values for the LIDAR data. In this regard, it should be noted that it would be important to use spatially varying bed roughness values for the River2D model to improve the hydraulic calibration of the River2D model. The rating tables for the U.S. Geological Survey gages on the Tuolumne River at Modesto (Gage Number 1129000) and Below La Grange Dam (Gage Number 11289650) could be used to provide the downstream boundary condition and upstream calibration information for a River2D model of the entire river.

The Districts plan to use effective Weighted Usable Area (WUA) to identify habitat bottlenecks (page 13). However, this analysis cannot incorporate many biological bottlenecks, such as food limitations or predation and so are inappropriate. This analysis should be dropped from the planned studies.

In section 3.5.3, High Flow Stage Discharge Relationships, the Districts indicate they will only release the high calibration flows during a wet water year type and when certain flow management criteria are met. The Districts also suggest that, if the criteria are not met during the first year of the study, the high flow calibration releases may be deferred for up to two years. We encourage the Districts to make every effort to deliver the high calibration flows as soon as possible so that the study can be completed sooner rather than later. We believe this is in the spirit of the Commission Order.

Water Temperature Study Plan

Issue 1. The Districts' study plan has the objective of answering the following two questions:

1. What flows are required to maintain maximum weekly average summer water temperatures (MWAT) of 68°F from La Grange Dam downstream to Roberts Ferry Bridge at river mile (RM) 39.5.
2. What is the relationship between flow and water temperature at various times during the summer in the upper reaches of the lower Tuolumne River?

The Service recommends that the study questions should be revised and expanded to reflect the Agencies recommended interim flow measures:

1. What flows are required to maintain maximum weekly average summer water temperatures (MWAT) of 18°C (64.4°F) from La Grange Dam downstream to Roberts Ferry Bridge at river mile (RM) 39.5.
2. What flows are required to maintain maximum weekly average water temperatures (MWAT) of 18°C (64.4°F) from La Grange Dam downstream to the confluence with the San Joaquin River (RM 0) from October 15 to December 1.
3. What flows are required to maintain maximum weekly average water temperatures (MWAT) of 18°C (64.4°F) from La Grange Dam downstream to the confluence with the San Joaquin River (RM 0) from October 15 to December 1.
4. What flows are required to maintain maximum weekly average water temperatures (MWAT) of 13°C (55.4°F) from La Grange Dam downstream to Roberts Ferry Bridge at river mile (RM) 39.5 from October 15 to February 15.
5. What flows are required to maintain maximum weekly average water temperatures (MWAT) of 15°C (59.0°F) from La Grange Dam downstream to the confluence with the San Joaquin River (RM 0) from March 20 to May 15.
6. What is the minimum pool for Don Pedro that is needed to achieve the above in-river temperature objectives?
7. Are there modifications to Don Pedro that would allow a smaller minimum pool and still meet the above in-river temperature objectives.

Issue 2, Validation, page 5. The Districts intend to validate the existing HEC5Q with data that they collected since 1986. If there are discrepancies between their observed data and the model's predictions that are greater than 2°F, the Districts indicate that they might modify the temperature model. The Service recommends that if substantial discrepancies are discovered, the Districts should be required to prove to the Agency oversight team that their temperature measurements are valid before modifications to the model are considered.

Issue 3, Initial Scenario, page 6. The Districts intend to model flows ranging from 100 cfs to 400 cfs in addition to the Article 37 flows and the actual flows released from 1996 to 2009. The Service recommends that the seven questions regarding the thermal requirements for the Agencies interim flow measures listed above should be fully addressed in the initial scenario development phase.

The District's suggestion that they only need to maintain maximum weekly average water temperatures of 68°F between La Grange Dam and the Roberts Ferry Bridge is inconsistent with the Commission Order. In addition, the District's suggestion that they only need to determine the relationship between flow and water temperature "at various times during the summer" is also inconsistent with the Order. In accordance with the Order, the Districts are required to determine the flows that are necessary to ensure that water temperatures between La Grange Dam and the Roberts Ferry Bridge do not exceed 68°F. This is an instantaneous standard based on the timestep of the selected model (which is six hours for the HEC-5Q model) and not a weekly average standard as suggested by the Districts.

Goodness of fit criteria

In section 4.1, Validate Existing Water Temperature Model, the Districts suggest that "unbiased goodness of fit statistics" will be developed. However, the Districts do not present specific goodness of fit criteria. We suggest using the following criteria that have been recommended by U.S. Geological Survey staff (Theurer et al. 1984) to assess "goodness-of-fit":

- Maximize the R^2 value. The maximum value possible for R^2 is 1.0. The closer the value is to 1.0, the better the goodness-of-fit.
- Absolute Mean Error of < 0.5°C
- No more ten percent of the simulated water temperatures should be more than 1°C from the observed water temperatures.
- No single water temperature should be more than 1.5°C from the observed water temperature.
- No obvious trend in the data error either spatially of temporally.

In section 4.2, Initial Scenario Development, the Districts suggest that, in addition to the current FERC (1996) flow schedules and the actual flow releases during the 1996 – 2009 period, flows of 100 – 400 cfs will be evaluated using the water temperature model. The Districts are again reminded that, in accordance with the Order, they are required to determine the flows that are necessary to ensure that water temperatures between La Grange Dam and the Roberts Ferry Bridge do not exceed 68°F. The Order does not include a 100 – 400 cfs limitation on the flows to be evaluated with the model.

In section 5, Schedule, the Districts suggest the model development schedule may be delayed if the Districts do not receive timely responses from the Fish and Wildlife Service and the model developer in providing calibration data and model documentation. While we will make every effort to provide the Districts with available calibration data, the Districts are reminded that the Order does not imply that the existing model cannot be used (without modification) to assess the flow releases needed to meeting the water temperature standards. We suggest that the District's should use the existing HEC-5Q model to provide the results as soon as possible.

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If you have any questions regarding this letter, please contact Dr. Mark Gard of my office at (916) 414-6589.

Sincerely,

M. Kathleen Wood

M. Kathleen Wood
Assistant Field Supervisor

cc:
FERC Service List, Project No. 2299

BEFORE THE
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

CERTIFICATE OF SERVICE

I hereby certify that Don Pedro Hydroelectric Project, FERC #2299, Tuolumne River, California-Service comments on Instream Flow and Water Temperature Study Plans has this day been sent by that service for filing with the Federal Energy Regulatory Commission and served, via deposit in U.S. mail, first-class postage paid, upon each person designated on the service list for Project #2299 complied by the Commission Secretary.

Dated at Sacramento, California, this 5th of October, 2009.

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Attachment 5
CDFG Comments on Instream Flow and Water Temperature Study Plans

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ARNOLD SCHWARZENEGGER, Governor
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October 5, 2009

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Subject: Comments on Don Pedro Project (FERC No. 2299) Instream Flow and Water Temperature Modeling Study Plans

Dear Ms. Bose, Mr. Wise and Mr. Short:

The California Department of Fish and Game (Department) appreciates the opportunity to comment on the Lower Tuolumne River Instream Flow Draft Study Plan and the Lower Tuolumne River Water Temperature Modeling Draft Study Plan. We believe that, if the study plans are modified to address the comments presented below, the results will be useful for identifying minimum flows that are protective of salmon and steelhead in the Lower Tuolumne River.

As background to the Department comments it is important to note that in their July 16, 2009 Order on Rehearing, Amending License, Denying Later Intervention, Denying Petition, and Directing Appointment of a Presiding Judge for a Proceeding on Interim Conditions (Order), the Federal Energy Regulatory Commission (Commission or FERC) directed the Turlock and Modesto Irrigation Districts (Districts) to develop and implement an instream flow study for, and a water temperature model of, the Tuolumne River below La Grange Dam. Specifically, paragraph F of the Commission Order states:

> "The Turlock and Modesto Irrigation Districts (Districts) shall develop and implement an Instream Flow Incremental Methodology (IFIM)/ Physical Habitat Stimulation (PHABSIM) study plan to determine instream flows necessary to

maximize fall-run Chinook salmon and *O. mykiss* production and survival throughout their various life stages. The PHABSIM flow models under the IFIM should evaluate base flows, to include, but not be limited to, 150 cubic feet per second (cfs), 200 cfs, 250 cfs, 300 cfs, and at least 400 cfs. The instream flow study shall also evaluate spring pulse flows of 1,000 to 5,000 cfs and fall pulse flows of up to 1,500 cfs from La Grange Dam. In general, the instream flow study shall include the following steps, unless agreed upon otherwise in consultation with the resource agencies: (1) selection of target species or guild, selection or development of appropriate micro- and/or macro-habitat suitability criteria; (2) study area segmentation and study site selection; (3) cross section placement and field data collection; (4) hydraulic modeling; (5) habitat modeling; (6) derivation of total habitat time series, micro- and macro-habitat; (7) determination of habitat bottlenecks; and (8) evaluation of management alternatives and problem resolution. In connection with the IFIM study, the Districts shall also develop a water temperature model to determine the downstream extent of thermally suitable habitat to protect summer juvenile *O. mykiss* rearing under various flow conditions and to determine flows necessary to maintain water temperatures at or below 68 degrees Fahrenheit from La Grange Dam to Roberts Ferry Bridge."

Lower Tuolumne River **Instream Flow Study Plan**

The Department supports the U.S. Fish and Wildlife Service's recommendation that two-dimensional modeling be used to simulate habitat both for flows that are less than 1,200 cfs and for pulse flows. However, in accordance with the specific requirements of the Commission Order, we offer the following comments on the one-dimensional PHABSIM component and the two-dimensional pulse flow component of the District's study plan:

In section 2, Recommended Study Approach, the Districts propose using the Riverine Habitat Stimulation (RHABSIM) software. The Department has experience with this software package and concurs that it is an appropriate IFIM/PHABSIM modeling tool.

In section 3.2, the Districts suggest that the instream flow model could be extended to the Waterford Rotary Screw Trap at River Mile 29. The Department, however, recommends that the instream flow study extend from La Grange Dam through the Instream Gravel Mining Reach to River Mile 24.0. The Department also recommends using the reach breaks identified by McBain and Trush (2000) (i.e. RM 34.2, RM 40.3, and RM 46.6) to delineate four separate study subreaches between La Grange Dam and RM 24.0.

In sections 3.4.1, Study Site Selection, and 3.4.2, Transect Selection, the Districts suggest that study sites and transects will be selected by random sampling if they can not be established with concurrence of the resource agencies. The Department supports selection of study sites and transects through a collaborative process with the Districts and the other resources agencies. We believe that a collaborative approach is more appropriate than the random sampling alternative noted by the Districts and will lead to results that are more likely to be agreed-upon by the resource agencies.

In section 3.4.3, Field Data Collection, the Districts suggest that velocity calibration data will be collected at the middle calibration flow. Based on experience with other recent projects, the Department recommends collecting velocity calibration data at the high calibration flow – to the extent it is safe to do so. This will allow more accurate extrapolation of the velocity data at higher flows.

In section 3.4.3.3, Substrate Data, the Districts propose a substrate classification system for the Lower Tuolumne IFIM study. The proposed substrate classification system should be expanded to include additional particle size categories. The Department recommends using the following particle size categories, which are consistent with the categories recommended by the U.S. Fish and Wildlife Service:

Substrate Type	Particle Size (inches)
Sand/Silt	< 0.1
Small Gravel	0.1 – 1
Medium Gravel	1 – 2
Medium/Large Gravel	1 – 3
Large Gravel	2 – 3
Gravel/Cobble	2 – 4
Small Cobble	3 – 4
Small Cobble	3 – 5
Medium Cobble	4 – 6
Large Cobble	6 – 8
Large Cobble	8 – 10
Large Cobble	10 – 12
Boulder/Bedrock	> 12

In section 3.4.4.1, Stage-Discharge Calibration, the Districts suggest that the IFG-4 program will be used as the primary method for developing stage-discharge relationships. In order to ensure the most accurate method of simulating stage-discharge relationships and water surface elevations, the Department strongly recommends the use of MANSQ in run and riffle habitats, and the use of WSP in pool habitats.

In section 3.4.5, Target Species and Habitat Suitability Criteria (HSC), the Department recommends that juvenile HSC also consider smolt outmigration.

In section 3.4.6, Habitat Modeling, and in Figure 2, the Districts suggest that cross sections in the same mesohabitat unit be weighted based on the number of cross sections in the unit. The Department recommends that all cross sections in similar mesohabitat unit types within a study reach be given equal weight.

In section 3.4.7, Total Habitat Time Series, the Districts suggest that the habitat time series analysis will be developed based on monthly average flows. The Department disagrees with the development of a habitat time series based on monthly average flows and strongly recommends that the Districts develop the habitat time series based on daily flows.

In section 3.5.3, High Flow Stage Discharge Relationships, the Districts indicate they will only release the high calibration flows during a wet water year type and when certain flow management criteria are met. The Districts also suggest that, if the criteria are not met during the first year of the study, the high flow calibration releases may be deferred for up to two years. The Department encourages the Districts to make every effort to deliver the high calibration flows as soon as possible so that the study can be completed sooner rather than later. We believe this more accurately reflects the spirit of the Commission Order.

In section 3.5.5, 2-D Model Simulations and Anticipated Results, the Districts suggest that the 2-D model will be used to investigate predator habitat, including that of largemouth bass and smallmouth bass. The Department recommends that the Districts follow the specific requirements of the Commission Order, which is to "develop and implement an IFIM/PHABSIM study plan to determine instream flows necessary to maximize fall-run Chinook salmon and *O. mykiss* production and survival throughout their various life stages" rather than to investigate predator habitat conditions.

In addition, the Districts suggest in section 3.5.5 that the focus of the 2-D modeling will be to investigate juvenile outmigration. While the Department believes this is important, it is also important that the Districts use the 2-D model to investigate potential juvenile rearing habitats.

In section 6, Schedule, the Districts suggest that, while the study may start in January 2010, the final report would not be released until January 2012. The Department believes that this time frame is excessive and we recommend a more aggressive implementation schedule.

Lower Tuolumne River **Water Temperature Modeling Study Plan**

However, in accordance with the specific requirements of the Commission Order, we offer the following comments on the Districts Water Temperature Modeling Study Plan:

In section 1, Background and Purpose, the Districts state that the water temperature model will be used to answer the following questions:

- What flows are required to maintain maximum weekly average summer water temperatures (MWAT) of 68°F from La Grange Dam downstream to Roberts Ferry Bridge at River Mile (RM) 39.5.
- What is the relationship between flow and water temperature at various times during the summer in the upper reaches of the Lower Tuolumne River?

The Districts' suggestion that they only need to maintain maximum weekly average water temperatures of 68° F between La Grange Dam and the Roberts Ferry Bridge is inconsistent with the Commission Order. In addition, the Districts' suggestion that they only need to determine the relationship between flow and water temperature "at various times during the summer" is also inconsistent with the Order. In accordance with the Order, the Districts are required to determine the flows that are necessary to ensure that water temperatures between La Grange Dam and the Roberts Ferry Bridge do not exceed 68°F. This is an instantaneous standard based on the timestep of the selected model (which is 6 hours for the HEC-5Q model) and not a weekly average standard as suggested by the Districts.

Goodness of fit criteria

In section 4.1, Validate Existing Water Temperature Model, the Districts suggest that "unbiased goodness of fit statistics" will be developed. However, the Districts do not present specific "goodness of fit" criteria. The Department suggests using the following criteria that have been recommended by U.S. Geological Survey staff (Theurer et al. 1984) to assess "goodness-of-fit":

- Maximize the R^2 value. The maximum value possible for R^2 is 1.0 and the closer the value is to 1.0, the better the "goodness-of-fit".
- Absolute Mean Error of < 0.5°C.
- No more than ten percent of the simulated water temperatures should be more than 1°C from the observed water temperatures.
- No single water temperature should be more than 1.5°C from the observed water temperature.
- No obvious trend in the data error either spatially or temporally.

In section 4.2, Initial Scenario Development, the Districts suggest that, in addition to the current FERC (1996) flow schedules and the actual flows released from 1996 to 2009, flows of 100 – 400 cfs will be evaluated using the validated water temperature model. The Districts are again reminded that, in accordance with the Order, they are required to determine the flows that are necessary to ensure that water temperatures between La Grange Dam and the Roberts Ferry Bridge do not exceed 68°F. The Order does not include a 100 – 400 cfs limitation on the flows to be evaluated with the model.

In section 5, Schedule, the Districts suggest the model development schedule may be delayed if the Districts do not receive timely responses from the Department and the model developer in providing calibration data and model documentation. While the Department will make every effort to provide the Districts with available calibration data, the Districts are reminded that the Order specifically directs them to develop a water temperature model. If the Districts anticipate delays in receiving a response to requests for calibration data and model documentation, they should consider developing a separate and independent water temperature model.

Additionally, the Districts should proceed in a more expeditious manner than is suggested in the schedule of milestones presented in Table 1 – particularly if the Districts proceed with using the **existing** HEC-5Q model. Based on our experience with other water temperature models, we believe that the Districts can easily refine the existing HEC-5Q model and make it available for simulations by early next summer. We believe that this expeditious schedule is consistent with the intent of the Commission Order.

If there are any questions about the Department's comments on the Districts' instream flow and water temperature modeling study plans, please contact Julie Means, Senior Environmental Scientist, at (559) 243-4014 extension 240.

Sincerely,

Jeffrey R. Single, Ph.D.
Regional Manager

References:

McBain and Trush. 2000. Habitat restoration plan for the Lower Tuolumne River Corridor. Prepared by McBain and Trush, Arcata, California for the Tuolumne River Technical Advisory Committee, California.

Theurer, F.D., K.A. Voos, W.J. Miller. 1984. Instream Water Temperature Model. Instream Flow INF. PAP. 16. U.S. Fish and Wildlife Service FWS/OBS-84/15.

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Attachment 6
Response to USFWS Comments

Introductory Comment Responses

USFWS Introductory Comments, Page 2, Paragraph 2

The USFWS states two overarching issues with the Districts' proposed plans. The first is that a PHABSIM "flow model does not address all of the essential habitat needs of the migratory phases of anadromous species." They state that "Further, the PHABSIM flow model does not address the effects of flow on potential biotic limiting factors (e.g., predation, food, contaminants, disease, etc.) or abiotic factors (e.g., unscreened diversions) within or outside of the Tuolumne River" and that "the PHABSIM flow model should not be used by itself to develop an instream flow schedule."

The Districts agree, as a general matter, that evaluation of anadromous fish needs is much more complex than can be addressed with a PHABSIM study, and note that a variety of other important studies related to the Tuolumne River (including many of those the USFWS lists) have been conducted over the past three decades to address many of these issues (studies either ordered by FERC, or otherwise conducted by the Districts or the agencies). However, the July 16, 2009 Order (128 FERC ¶ 61,035) specifically tasked the Districts with developing an IFIM/PHABSIM study plan with 8 elements, and the final study plan is focused on compliance with the Order. The Districts agree that many of these other issues are relevant and important to consider in the overall assessment of anadromous fish issues on the Tuolumne River, and that a PHABSIM flow model should not be used by itself to develop an instream flow schedule. However, USFWS comments on these other issues are not within the scope of the FERC-ordered study plan, and therefore no specific revisions to the study plan have been made in response.

USFWS Introductory Comments, Page 2, Paragraph 3

The USFWS' second overarching issue relates to the HEC-5Q water temperature model and their concern about revision of the model, or the possibility that it would not be used for evaluation of temperature effects.

Since the draft study plan specified that the Districts "propose to use the existing HEC-5Q model to simulate water temperatures at various flows and times of year" (as opposed to developing some other model as allowed for under the Order), there does not appear to be any disagreement over the applicability of this model. With regard to USFWS concern about "revision" of the model, no revisions have been proposed. Validation of the model is included in the final study plan, but validation of water temperature models is standard practice prior to their application for predictive purposes. We disagree with the statement that the model had been thoroughly reviewed by all stakeholders through 2008. That is certainly not the case for the Districts or the consultants preparing this plan.

USFWS Introductory Comments, Page 3, Paragraph 1

The Districts agree with USFWS that combined water temperature and weighted usable area results should not be the "sole assessment of the instream flow needs of the fish." A variety of data presentations and consideration of other study data are likely necessary to develop a more complete understanding of the issues.

Instream Flow Comment Responses

USFWS Specific Comments, Instream Flow Study Plan, Item 1, Study Segment Delineation

As USFWS has indicated, flow is a necessary parameter to consider in the study area segmentation, although it is not the only consideration. The final study plan appropriately considers several parameters that can affect the habitat/flow relationship from one segment to the next, including habitat type, geomorphic character, and hydrologic regime.

USFWS Specific Comments, Instream Flow Study Plan, Item 2, Mesohabitat Mapping

The USFWS proposes a 12-mesohabitat type mapping system (Snider et al. 1992) for the lower Tuolumne River.

Recognizing that the lower Tuolumne River does not have the mesohabitat complexity that the proposed USFWS mapping system assumes, the Districts have previously mapped the upper 16 miles of the gravel bedded reach of the lower Tuolumne River as part of the Coarse Sediment Management Plan (McBain and Trush 2004a; McBain and Trush 2004b) using a similar habitat typing approach as recommended by USFWS. Farther downstream habitat complexity is reduced. The river has been mapped downstream to RM 30 using a simpler approach as part of the 2008–2009 *O. mykiss* snorkel surveys. The final habitat types will be based primarily upon this existing information, with additional habitat typing surveys as needed between RM 30 and the downstream end of the study area. The existing mesohabitat mapping by McBain and Trush and Stillwater Sciences are already in the Tuolumne River GIS and have been previously provided to the agencies as well as posted at the Tuolumne River TAC website. The CDFG GIS riffle atlas has been provided and is available on the website.

USFWS Specific Comments, Instream Flow Study Plan, Item 3, Field Reconnaissance and Study Site Selection

The Districts agree with USFWS that known spawning areas should receive a high priority for establishment of study sites for many of the reasons the USFWS cites, and have revised the study plan to reflect this priority. We note that the first FERC IFIM study done for the project by CDFG in 1981 focused on spawning habitats and were selected based on spawning use and representative conditions.

The USFWS statement that "There should be at least five spawning study sites per study segment" is premature, considering no segment or site data have been evaluated.

USFWS Specific Comments, Instream Flow Study Plan, Item 4, Habitat Modeling
The USFWS commented that habitat modeling should be conducted using a two-dimensional (2-D) model rather than 1-D PHABSIM.

The Districts proposed a 1-D PHABSIM model because (1) it is a standard approach in the evaluation of habitat and flow relationships for rivers affected by hydroelectric projects, (2) it allows for substantial replication of sample transects and extrapolation of those data to other sections of the river, (3) it includes collection of a robust set of empirical data on velocity and depth that allows for calibration to observed conditions, and (4) the 1-D model is considered as generally accepted practice in the scientific community. The Districts believe that it is prudent and appropriate that the study apply methods that reflect generally accepted practice in this field.

The 1-D model proposed by the Districts for in-channel studies has several advantages over a 2-D model.

- It avoids problems associated with replication of sample units and extrapolation of the results, since more habitat units can be sampled with a comparable effort. In contrast, 2-D modeling is a representative reach approach and does not allow for a cost-effective way of developing mesohabitat weighted estimates for an entire study reach.
- The sampling density along each transect in a 1-D model can be sufficiently narrow to capture changes in depth and velocity patterns through empirical measurements (rather than just model simulations), and to be suitable to the scale of microhabitat use data.
- A large number of velocity measurements are made to calibrate the model.
- Studies comparing results from transect based and 2-D analyses of the same site indicate that the results of the habitat (WUA) versus flow responses are very similar, calling into question the analytical gain of the substantially more data intensive 2-D approach.

USFWS Specific Comments, Instream Flow Study Plan, Item 4A, 2-D Model QA/QC
Although a 2-D model is not proposed by the Districts for the in-channel modeling, a 2-D model has been proposed for the overbank areas to evaluate floodplain inundation during pulse flows. Appropriate QA/QC procedures for this element of the study may be dependent on the physical conditions at the sites, the type of equipment necessary to make the measurements, and the nature of existing data available for use in the assessment. Thus, these particular details are most appropriately resolved in a collaborative setting once study sites are selected and study participants have had the opportunity to actually see the river and assess the requirements of the sites.

USFWS Specific Comments, Instream Flow Study Plan, Item 4B, 1-D PHABSIM QA/QC, Paragraph 1
The Districts concur with these objectives for transect placement and benchmarking, and have incorporated these concepts and/or sentences into the text of the final study plan.

USFWS Specific Comments, Instream Flow Study Plan, Item 4B, 1-D PHABSIM QA/QC, Paragraph 2

The Districts concur, with a few minor modifications or clarifications, with these procedures for transect data collection and have incorporated these procedures into the text of the final study plan in cases where they were not already specified.

USFWS Specific Comments, Instream Flow Study Plan, Item 4B, 1-D PHABSIM QA/QC, Paragraph 3

The range of flows to be simulated under this evaluation of the need for interim flow measures pending relicensing will depend on the exact calibration flows, but are expected to cover the full range of in-channel flows specified in section 3.4.3 of the final study plan (e.g., 50–1,000 cfs). The Districts concur with USFWS regarding target spacing of calibration flows (although we note that relatively even "log-scale" spacing needs to be considered), and simulation ranges as a function of calibration flows. Additional detail has been added to the final study plan to clarify this.

USFWS Specific Comments, Instream Flow Study Plan, Item 4B, 1-D PHABSIM QA/QC, Page 10, Paragraph 4

The Districts agree that model performance can be evaluated through use of various metrics, although rigid compliance with a specified threshold in all circumstances may not be useful or appropriate and would need to be evaluated on a case-by-case basis. The metrics suggested by USFWS and others have been added to the final study plan.

USFWS Specific Comments, Instream Flow Study Plan, Item 5, Habitat Suitability Criteria, Page 11, Paragraphs 2-3

The USFWS suggests using cover and adjacent velocity data for HSC curves, excluding consideration of prior HSC used by USFWS on the Tuolumne (USFWS 1995), and including use of somewhat controversial draft data from USFWS (2008a and 2008b).

Development, selection, or modification of HSC is a complex and time consuming exercise that cannot be conclusively or collaboratively determined in an initial draft study plan. Accordingly, the Districts proposed an HSC development *process* as an initial stage of implementing the PHABSIM study plan, and scheduled approximately 5 months to complete the process. The USFWS' suggestions can be considered during that process, in consultation with other stakeholders and technical experts.

USFWS Specific Comments, Instream Flow Study Plan, Item 5, Habitat Suitability Criteria, Page 11, Paragraph 4, and Page 12, Paragraph 1

The USFWS advocates use of their depth modification procedure for developing HSC (Gard 1998). This procedure is not a standard or widely accepted methodology, and the streams where its use has been cited by USFWS are all locations where the author was conducting his own investigations. The Districts do not support use of this method for the following reasons.

- The method tends to result in the highest suitability values for conditions where few or no empirical observations of fish are recorded.

- The heavy reliance of the method on outlier observations tends to skew the analysis toward unrealistic or nonsensical results.
- The method tends to result in maximum suitability for very rare or theoretical conditions, which is of limited usefulness for making management decisions on the ground in a real river system.
- The method has received unfavorable peer review in other forums (e.g., PG&E 2007).

Similarly, the suggested use of logistic regression techniques is not supported by the Districts for several of same reasons listed for the depth modifications cited above, as well as the following.

- It is not a widely accepted or standard methodology for this type of application (YCWA 2007).
- It does not necessarily provide accurate predictions of areas of habitat use by the fish (Pasternack 2008).

Finally, as noted previously, this method does not comply with "generally accepted practice in the scientific community."

USFWS Specific Comments, Instream Flow Study Plan, Item 6, Biological Verification, Page 13, Paragraph 1

These USFWS comments relate to hypothesis testing of their recommended 2-D model performance.

Since 2-D model analysis of in-channel flows is not proposed by the Districts, this verification is not necessary. We note, however, that the extensive tests proposed by USFWS that are necessary for the validation of the 2-D model results (and related habitat suitability) further substantiate the Districts' concerns about the validity of this type of approach.

USFWS Specific Comments, Instream Flow Study Plan, Item 6, Habitat Time Series, Page 13, Paragraph 2

The Districts agree that the habitat time series analysis should be developed on daily flows. The study plan has been modified accordingly.

USFWS General Comments, Pulse Flows, Page 13, Paragraph 3 and Page 14, Paragraph 1

The Districts agree with USFWS that PHABSIM is not "designed to assess the effects of high flows flushing organic matter and terrestrial invertebrates into the river to augment the food base for juvenile salmon and trout" and that ongoing rotary screw trap (RST) studies are valuable to assess the effectiveness of various flow regimes for management of the fisheries resources.

There are relatively few sections of the lower Tuolumne River that have significant areas of natural floodplain that are broadly inundated at anything below the highest flood magnitudes. Unlike the floodplains of the Yolo Bypass or Cosumnes River (which are often cited for their productivity, but which are Valley Floor sites that are nearly flat, undeveloped, and in places are several miles across), the Tuolumne River channel below 9,000 cfs is relatively confined or incised for much of its length, except where unnaturally disturbed by past mining and/or tailing removal. Attempting to model the entire river using River2D would serve little purpose for evaluating pulse flows, and would be enormously costly. The Districts' proposed plan in response to FERC's Order would focus on those areas where floodplain inundation is most likely, and focus the investigation on those areas.

USFWS General Comments, eWUA, Page 14, Paragraph 2
The FERC Order specified that the study plan address "determination of habitat bottlenecks," and an effective Weighted Usable Area (eWUA) analysis was proposed to address this requirement. The eWUA analysis had two elements, one related to water temperature effects, and one related to habitat area bottlenecks by life stage. The USFWS objected to this analysis because of potential bottlenecks such as food availability or predation that are not incorporated.

The Districts agree that an eWUA analysis for life stage bottlenecks (Bovee 1982), albeit responsive to the Order, can be overly simplistic and rely on some controversial assumptions. Therefore, in response to the USFWS request, this element has been dropped from the proposed study.

In contrast, the evaluation of both water temperature and physical habitat are key considerations in evaluating the effective habitat available for anadromous fish resources on the Tuolumne River, and this fact was duly noted by FERC when it required these two studies in the Order. Thus, the Districts believe this water temperature element of the eWUA evaluation is appropriate, and have retained it in the final study plan.

USFWS General Comments, High Flows, Page 14, Paragraph 3
The USFWS has encouraged the prompt provision of flows to conduct the study.

In the spirit of the FERC Order, and consistent with paragraph 108 of the Order, the Districts expect to be able to deliver the high flows of greater than 4,000 cfs at least once in the next four years. This and other elements of the proposed schedule consider the fact that water availability that is not entirely within the control of the Districts, and that the Districts also have other water delivery requirements.

Water Temperature Study Plan USFWS Comment Responses

USFWS Comments, Issue 1, Page 14, Paragraph 4
The USFWS recommends that the study questions should be revised and expanded to reflect the Agencies' recommended interim flow measures (questions 1-7 on page 15).

Although the overall study plan questions have not been modified, additional scenarios corresponding to study question 2 have been added to section 4.2 to address the Agencies recommended interim measures (questions 1, 2, 4, and 5). Note that questions 2 and 3 are identical and that the additional questions regarding reservoir operations modeling to determine necessary active storage levels to reliably attain the above conditions (questions 6 and 7) can be examined separately from the temperature model as a preliminary assessment, but definitive results are beyond the scope of the study plan request in the FERC Order and are thus not included in the final study plan. It is anticipated that these considerations would be further evaluated as part of a larger environmental and economic analysis should any temperature criteria be considered for adoption as interim measures.

USFWS Comments, Issue 2, Validation, Page 15, Paragraph 2
With regards to model validation, USFWS recommends that if substantial discrepancies are discovered between modeled and observed data at locations and times other than those used in the model calibration, the Districts should be required to prove to the Agency oversight team that their temperature measurements are valid before modifications to the model are considered.

All data records and available metadata (i.e., thermograph model, specified accuracy, etc) used in the validation exercise will be provided to the Agencies for review as an electronic data appendix to the final report. It should be noted that the Districts expect the HEC-5Q model to simulate temperatures accurately within reasonable limits. The intent of the HEC-5Q model validation exercise is to ensure that it reflects conditions accurately over a range of meteorology and flow conditions. Nevertheless, very little formal documentation of the completed model was provided to interested parties during the 2007–2008 training periods. It is not known to the Districts to what degree the historical data used in the HEC-5Q model calibration was collected using calibration-checked thermographs and no Quality Assurance Project Plan (QAPP) with calibration checks has been provided. Lastly, no validation data will be excluded other than standard QA issues (e.g., partial day records, sensor reading air temperatures, etc.) and no data will be preferentially selected or excluded with an aim to invalidate the HEC-5Q model.

USFWS Comments, Issue 3, Initial Scenarios, Page 15, Paragraph 3
With regards to the flow ranges evaluated in the initial scenario development, USFWS recommends that the seven questions regarding the thermal requirements for the Agencies interim flow measures listed above should be fully addressed in the initial scenario development phase.

As this comment appears to mirror Issue 1 above, the scenario development (final study plan section 4.2) and simulations (final study plan section 4.3) have been modified to include the four identified scenarios corresponding to the Agencies recommended interim measures (questions 1, 2, 4, and 5 on page 15). In addition, alternative scenarios (i.e., temperature, location, timing, etc.) may also be evaluated that draw upon findings from the literature or field observations, such as information provided to FERC by the Districts, CCSF, and the Agencies.

USFWS Comments,* Selected Temperature Metric, *Page 15, Paragraph 4
The USFWS suggests that the study plan questions related to the attainment of the 68°F temperature standard are not responsive to the July 16, 2009 Order. Specifically, concerns were raised regarding whether the proposed study would determine flows necessary to "ensure that water temperatures between La Grange Dam and the Roberts Ferry Bridge do not exceed 68°F" and that an instantaneous maximum temperature standard should apply.

The selected maximum weekly average summer water temperatures (MWAT) standard will be evaluated along with daily maximum and average temperatures. It should be noted that while the FERC Order did not specify an instantaneous maximum temperature standard, the Agencies' recommended interim flow measures also did not specify a particular averaging period, and that the additional scenarios recommended are based upon an MWAT standard. Although the validated model will be available to run any number of temperature standards that may be considered for adoption as interim measures, it is unlikely that real-time water temperature management operations could respond to conditions in the river at time scales less than 1 day. Further, any proposed real-time operations would be dependent on imprecise air temperature forecasts and that should be considered in regards to any potential temperature management that may be based on the modeled results.

USFWS Comments, Goodness-of fit-criteria, Page 16, Paragraph 1
With regards to goodness-of-fit assessment between modeled and observed temperatures, USFWS suggests using criteria recommended by U.S. Geological Survey staff (Theurer et al. 1984) to assess "goodness-of-fit".

Although the existing HEC-5Q temperature model might fail to meet such restrictive "criteria," the goodness-of-fit assessment (final study plan section 4.1) will incorporate the intent of Agency comments. Because all of the criteria following the first bullet under the goodness-of-fit "criteria" are stated as data acceptance standards rather than goodness-of-fit statistics (i.e., "Absolute Mean Error of ...," "No more [than] ..." etc.), actual exceedance statistics will be calculated at the identified temperature thresholds (i.e., 0.5°C, 1.0°C, 1.5°C, as well as any higher thresholds needed) to provide an assessment of model performance.

USFWS Comments, Initial Scenario Development, Page 16, Paragraph 2
With regards to the flow ranges evaluated in the initial scenario development, USFWS emphasized that the Districts are required to determine the flows that are necessary to ensure that water temperatures between La Grange Dam and the Roberts Ferry Bridge do not exceed 68°F.

The model scenario flow ranges will be increased as needed if simulations indicate that the initial flow ranges are insufficient to meet the 68°F requirement.

USFWS Comments, schedule, Page 16, Paragraph 3

With regards to Districts' statement regarding potential schedule delays, USFWS suggests that the Order does not imply that the existing HEC-5Q model cannot be used (without modification) and that the Districts should provide results as soon as possible.

The selected schedule in the final study plan (section 5) provides initial results on the study plan questions as a progress report by July 2010, with the draft and final reports complete by October 28, 2010, to allow time for Agency review of results and comment prior to incorporation with the interrelated instream flow studies. We believe that the time spent in validating the HEC-5Q model will be far less than that required for new data collection, development of a new model, and subsequent calibration and validation. The Districts will notify all parties on a timely basis should conditions arise that affect the study schedule.

Attachment 7
Response to CDFG Comments

Instream Flow Comment Responses

CDFG Comments, 2-D Model, Page 2, Paragraph 2
For the reasons specified in response to USFWS comments, the Districts do not support 2-D modeling for in-channel flows less than 1,200 cfs. However, the Districts very much appreciate that CDFG has provided timely and focused comments on the specific requirements of the FERC Order.

CDFG Comments, RHABSIM, Page 2, Paragraph 3
Thank you for confirming CDFG concurrence with this study plan proposal for use of the RHABSIM software.

CDFG Comments, Study Reach Length and Segmentation, Page 2, Paragraph 4
The Districts have no objection to extending the study area through the Instream Gravel Mining Reach to RM 24, and have modified the final study plan accordingly as part of one of the study area options. Regarding the recommendation for use of reach breaks (RM 34.2, RM 40.3, and RM 46.6) from McBain and Trush (2000), the Districts note that a variety of different factors should be considered in reach segmentation (including channel morphology). While it is quite plausible that the McBain and Trush reach breaks would be reasonable, the Districts prefer to review all the pertinent reach-break data (including the McBain and Trush data) and collaboratively develop the reach boundaries with Tuolumne River expert stakeholders as part of the site selection process.

CDFG Comments, Site and Transect Selection, Page 2, Paragraph 5
The Districts concur with CDFG that a collaborative approach to site and transect selection is preferred, and will make every effort to implement this approach for this study. It is our staff experience, however, that despite the best of intentions by the majority of the technical team members, the collaborative process for site/transect selection can be easily rendered ineffective by one or a few individuals (for any number of reasons). Therefore, some type of "fall-back" procedure is prudent to allow the study to be implemented on schedule and in compliance with the FERC Order. It is the Districts' hope that such a "fall-back" procedure will be unnecessary.

CDFG Comments, Calibration Flows, Page 3, Paragraph 1
The Districts agree with CDFG that the higher the velocity calibration flow, the better the extrapolation to higher flows above that point. However, a corollary to that general rule is that the velocity calibration data should be collected near a flow where the greatest precision is required (e.g., in the flow range of greatest management interest, or that will occur most frequently, or near proposed minimum flow ranges, etc.), presuming most of the channel width is wetted at that flow. The Districts proposed velocity calibration flow (slightly revised in the current version of the study plan) is an attempt to balance these competing needs, and also allow maximum precision for evaluation of the resource agencies' recent flow proposals.

CDFG Comments, Substrate Data, Page 3, Paragraph 2

The Districts have no objection to use of this substrate classification system as a first choice among various alternatives. We note, however, that the substrate classification system needs to be compatible with the Habitat Suitability Criteria that are selected, so some flexibility is required. The final study plan has been modified to reflect the CDFG-recommended classification system as the first choice among alternatives.

CDFG Comments, Stage-Discharge Calibration, Page 3, Paragraph 3

The Districts proposed the IFG-4 as the primary method for developing the stage-discharge relationship, and its use of the maximum amount of empirical data for estimating that relationship is considered a benefit. However, if the stage-discharge calibration using IFG-4 does not meet model performance standards, the Districts will certainly develop the relationship using either the MANSQ or WSP programs.

CDFG Comments, Smolt Outmigration HSC, Page 3, Paragraph 4

The Districts are not clear on what CDFG is seeking with regard to their recommendation that "juvenile HSC also consider smolt outmigration." HSC are typically applied to resident life stages that select for certain habitat conditions, or for specific locations (such as spawning sites or migration barriers) and their associated habitat conditions that the fish must use or get past. It is not clear how physical habitat HSC (i.e., depth, velocity, substrate) would be applied to a migratory life stage along many miles of river. However, this issue can be discussed during collaborative development of HSC when the study plan is implemented.

CDFG Comments, Transect Weighting, Page 3, Paragraph 5

The proper weighting method (e.g., by transect or habitat type unit) depends on what the metric for replication is (e.g., transect or habitat unit). Whether equal weighting of transects will result in proper representation of the reach depends on how many transects are placed in each habitat unit of a given type (i.e., if all habitat units of a particular type have approximately the same number of transects, equal weighting of transects works fine). A hypothetical example helps illustrate this point. Presume three replicate riffles are sampled, with one of them being relatively complex (riffle "A") and similar to about 33% of the riffles in the reach, and two of them being relatively simple (riffles "B" and "C") and similar to about 67% of the reach. Assume complex riffle "A" requires 6 transects to represent its complexity, and simple riffles "B" and "C" each require 3 transects, for a total of 12 riffle transects. If transects are all weighted equally (i.e., the metric of replication is the transect), hydraulic conditions in riffle "A" will account for 50% (6 of 12 transects) of the riffle habitat in the model, and riffles "B" and "C" will each account for 25% (3 of 12 transects) of the model (totaling the other 50% of the model). Conditions in riffle "A" are therefore over-represented in the model (50% representation instead of 33%) simply because its complexity required more transects. If the unit of replication is the habitat unit type, this issue does not exist.

For this study plan, the Districts are willing to weight transects in similar mesohabitat unit types equally, but this will require placing a similar number of transects in each unit of the same type (which is certainly possible) in order to maintain proper statistical extrapolation of the results. Whether transects are weighted equally will be determined during the scoping process, and a statistically appropriate approach applied in consultation with the agencies.

CDFG Comments, Habitat Time Series, Page 3, Paragraph 6
The Districts agree that the habitat time series analysis should be developed on daily flows. The study plan has been modified accordingly.

CDFG Comments, High Flows, Page 4, Paragraph 1
In the spirit of the FERC Order, and consistent with paragraph 108 of the Order, the Districts expect to be able to deliver the high flows of greater than 4,000 cfs at least once in the next four years. This and other elements of the proposed schedule consider the fact that water availability that is not entirely within the control of the Districts, and that the Districts also have other water delivery requirements.

CDFG Comments, Predator Habitat, Page 4, Paragraph 2
The objective of any predator habitat assessment is simply to provide a better understanding of whether specific instream flows could help maximize survival and production of fall-run Chinook salmon and *O. mykiss* (particularly during the outmigration phase) by concurrently minimizing predator habitat. The Districts believe that an important part of increasing salmonid production is minimizing salmon mortality, particularly because past RST studies indicate a significant loss of juvenile salmon in the predator-rich gravel mining reach.

CDFG Comments, 2-D Model Use, Page 4, Paragraph 3
The Districts expect that the 2-D model results can be used, at the specified sites, to investigate several aspects of juvenile salmonid habitat use, including rearing.

CDFG Comments, Schedule, Page 4, Paragraph 4
The Districts note CDFG's desire for a more aggressive schedule. The currently proposed schedule considers several interdependent scheduling factors, including the timing of FERC's decision on the study plan, the availability and seasonal timing of FERC's specified study flows, and the likely time requirements for collaborative decision-making with the agencies. Essentially all of these factors are out of the control of the Districts, and therefore even the proposed schedule may be optimistic. The Districts will strive for an efficient and productive collaborative process that could accelerate the study schedule.

Water Temperature Study Plan CDFG Comment Responses

CDFG Comments*, Selected Temperature Metric, *Page 4, Paragraph 7
The CDFG suggest that the study plan questions related to the attainment of the 68°F temperature standard are not responsive to the July 16, 2009 Order. Specifically, concerns were raised regarding whether the proposed Study would determine flows necessary to "ensure that water temperatures between La Grange Dam and the Roberts

Ferry Bridge do not exceed 68°F" and that an instantaneous maximum temperature standard should apply.

The selected maximum weekly average summer water temperatures (MWAT) standard will be evaluated along with daily maximum and average temperatures. It should be noted that the FERC Order did not specify an instantaneous maximum temperature standard, the Agencies' recommended interim flow measures also did not specify a particular averaging period, and that the additional scenarios recommended are based upon an MWAT standard. Although the validated model will be available to run any number of temperature standards that may be adopted as interim measures, it is unlikely that real-time water temperature management operations could respond to conditions in the river at time scales less than 1 day. Further, any proposed real-time operations would be dependent on imprecise air temperature forecasts and that should be considered in regards to any potential temperature management that may be based on the modeled results.

CDFG Comments, Goodness-of-fit criteria, Page 5, Paragraph 2
With regards to goodness-of-fit assessment between modeled and observed temperatures, the CDFG suggests using criteria recommended by U.S. Geological Survey staff (Theurer et al. 1984) to assess "goodness-of-fit".

Although the existing HEC-5Q temperature model might fail to meet such restrictive "criteria", the goodness of fit assessment (final study plan section 4.1) will incorporate the intent of Agency comments. Because all of the criteria following the first bullet under the goodness-of-fit "criteria" are stated as data acceptance standards rather than goodness-of-fit statistics (i.e., "Absolute Mean Error of ...", "No more [than] ..." etc.), actual exceedance statistics will be calculated at the identified temperature thresholds (i.e., 0.5°C, 1.0°C, 1.5°C, as well as any higher thresholds needed) to provide an assessment of model performance.

CDFG Comments, Initial Scenario Development, Page 16, Paragraph 3
With regards to the flow ranges evaluated in the initial scenario development, CDFG emphasized that the Districts are required to determine the flows that are necessary to ensure that water temperatures between La Grange Dam and the Roberts Ferry Bridge do not exceed 68°F.

The model scenario flow ranges will be increased as needed if simulations indicate that the initial flow ranges are insufficient to meet the 68°F requirement.

CDFG Comments, schedule delays, Page 16, Paragraph 4
With regards to Districts' statement regarding potential schedule delays, CDFG recommends that if schedule delays are anticipated, the Districts should consider developing an updated temperature model separate and independent from the existing HEC-5Q model.

Although the July 16, 2009 Order does not specify the use of the HEC-5Q model, since the data collection and model development efforts related to a new model would require more time than the approach described in the plan, the Districts recognize the benefits of first evaluating the existing HEC-5Q model to meet the temperature model requirement in the Order. Further, we believe that the time spent in validating the HEC-5Q model will be far less than that required for new data collection, development of a new model and subsequent calibration and validation. The Districts will notify all parties on a timely basis should conditions arise that affect the study schedule

CDFG Comments, completion dates, Page 16, Paragraph 4
With regards to modeling completion dates, CDFG suggests that based on its experience with other water temperature models, it believes that the Districts can easily refine the existing HEC-5Q model and make it available for simulations by early next summer.

The selected schedule in the final study plan (section 5) provides initial results on the study plan questions as a progress report by July 2010, with the draft and final reports complete by October 28, 2010 to allow time for Agency review of results and comment prior to incorporation with the interrelated instream flow studies.

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CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document on the parties designated on the official service list compiled by the Secretary in this proceeding.

Dated at Washington, D.C. this 14th day of October, 2009.

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