Study 3-5

SPECIAL-STATUS AMPHIBIANS – FOOTHILL YELLOW-LEGGED FROG HABITAT MODELING

November 2010

1.0 Project Nexus

Yuba County Water Agency's (YCWA or Licensee) continued operation and maintenance (O&M) of the Yuba River Development Project (Project) has a potential to affect the special-status[1] amphibian, foothill yellow-legged frog (FYLF) (*Rana boylii*), which is considered a State Species of Special Concern by the California Department of Fish and Game (CDFG).

2.0 Resource Management Goals of Agencies and Indian Tribes with Jurisdiction Over the Resource Studied

[Relicensing Participants - This section is a placeholder in the Pre-Application Document (PAD). Section 5.11(d)(2) of 18 CFR states that an applicant for a new license must in its proposed study *"Address any known resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied."* During 2010 study proposal development meetings, agencies advised Licensee that they would provide a brief written description of their jurisdiction over the resource to be addressed in this study. If provided before Licensee files its Proposed Study Plan and Licensee agrees with the description, Licensee will insert the brief description here stating the description was provided by that agency. If not, prior to issuing the Proposed Study Plan, Licensee will describe to the best of its knowledge and understanding the management goals of agencies that have jurisdiction over the resource addressed in this study. Licensee]

3.0 Study Goals and Objectives

The goal of this study is to develop habitat-flow relationships for FYLF in stream reaches in which FYLF are known to breed and that are potentially affected by the Project.

[1] Special-status amphibians are considered those species: 1) found on National Forest System land and formally listed by the United States Department of Agriculture Forest Service as a Sensitive Species or a Management Indicator Species; 2) listed under the federal Endangered Species Act (ESA) as Proposed or a Candidate for listing as endangered or threatened or proposed for delisting; 3) listed under the California Endangered Species Act (CESA) as Proposed for listing as endangered or threatened or proposed for delisting; or 5) formally listed by California Department of Fish and Game as a Species of Concern. For the purpose of this study proposal, species listed as threatened or endangered under the ESA or CESA are addressed separately.

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Study objectives include:

- Develop a two-dimensional model for FYLF eggs and tadpoles in sections of Project-affected streams in which they occur.
- Using the model 1) determine the range of flows that provide suitable FYLF breeding habitat; and 2) assess the potential effects of seasonal flow changes resulting from Project operations on habitat durability (i.e., persistence of suitable habitat at specific locations).

4.0 Existing Information and Need for Additional Information

FYLFs lay egg masses and tadpoles occur within a relatively narrow range of stream habitat conditions (*i.e.*, meso- and microhabitat types, water velocities, depths, and substrates). At the scale of a stream reach, egg laying usually occurs in the following areas: upstream/downstream end of lateral bar, side of lateral bar, pool tail-out, edge of run, edge of island or braided channel (Figure 5.0-1). Within these breeding areas, egg masses tend to be deposited at depths greater than 4 centimeters (cm) and less than 40 cm (Kupferberg 1996, Lannoo 2005, Lind 2005, Lind et al. 2008, PG&E 2008); at velocities less than 13.5 centimeters per second (cm/s) (Kupferberg 1996, Lind 2005, PG&E 2008); and on cobble, boulder, or less commonly, gravel substrates in edgewater habitats (Kupferberg 1996, Lind 2005, PG&E 2008). Tadpoles generally use shallow edgewater areas with low water velocities and high amounts of epiphytic diatoms and detritus (Kupferberg et al. 2008, Lind et al. 2008, PG&E 2008). FYLF post-metamorphic life stages are semi-aquatic and move more freely between habitats than aquatic life stages, but are likely influenced by the proximity of canopy cover to aquatic habitats (PG&E 2008). Because FYLF habitat availability and suitability are closely related to flow conditions, instream hydraulic habitat modeling has been advanced as a predictive tool to assess flow effects on this species.

A variety of instream habitat models have been developed to express the relationship between instream flows and habitat conditions for aquatic organisms, particularly fish, including both one-dimensional modeling (1-D) and two-dimensional modeling (2-D). One-dimensional models using habitat suitability criteria to predict habitat availability under specified flows are widely employed and can be easily applied to long sections of rivers (Bovee 1982, Milhous et al. 1989). Beca (2008) suggests that 2-D models are better suited for areas of complex flow patterns, such as on channel bends or in braided channels, provided that topography is mapped at high precision; however, the results cannot be directly applied to a larger area than is modeled (Hydropower Reform Coalition 2005). In a relatively uniform channel, 1-D models can predict whether FYLF egg masses would be stranded due to changes in flow; but in more complex streams, multiple, closely spaced transects might be required to predict longitudinal variation in water velocities, such as might be associated with a point bar (Osborne et al. 1988, Ghanem and Hicks 1992). In contrast, 2-D models may more accurately predict flows at finer resolution corresponding to smaller scale habitats (Ghanem et al. 1996, Crowder and Diplas 2000). Limitations of 2-D modeling include relatively high cost, site-specific results (*i.e.*, limited representation of the stream beyond the specific location of the study site), and difficult calibration (Beca 2008).

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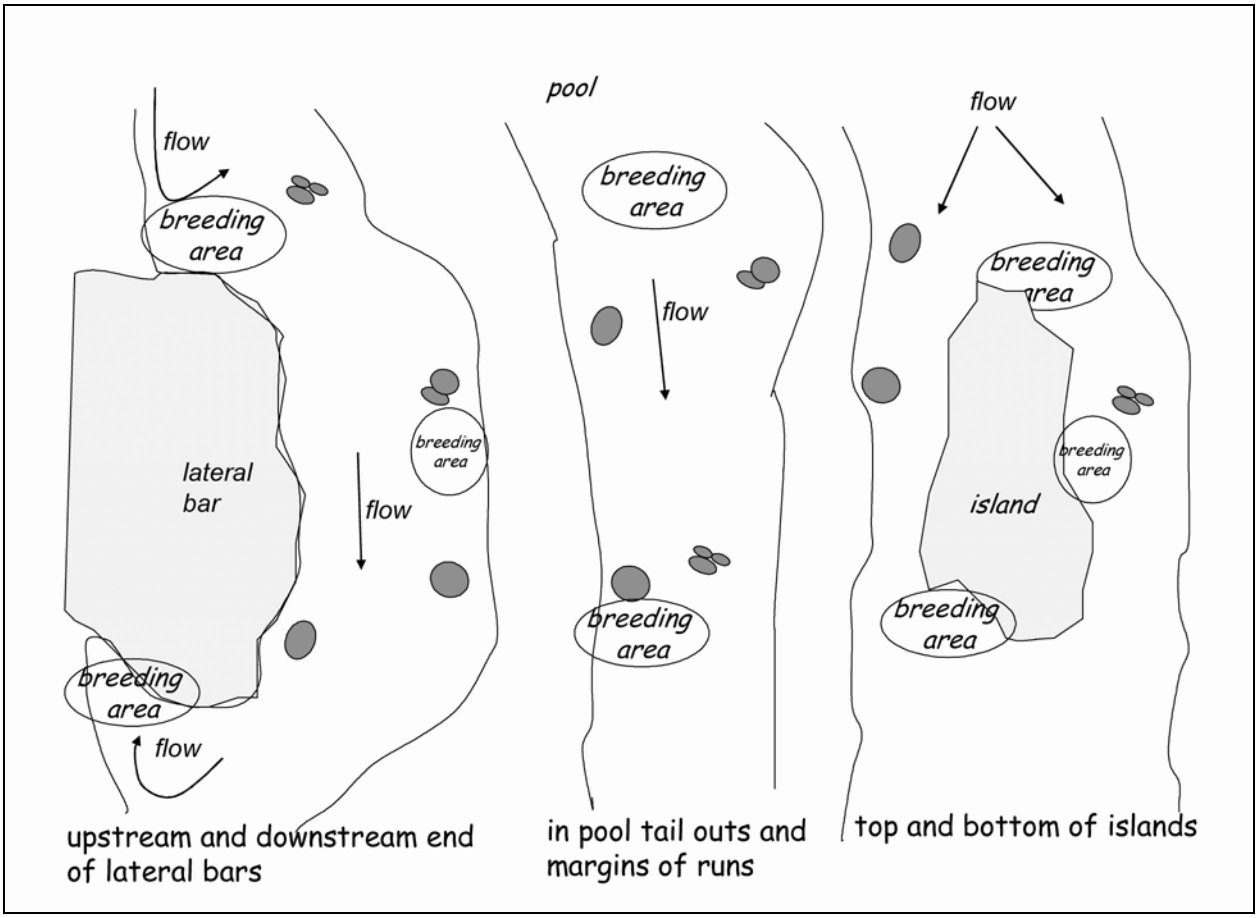

Figure 4.0-1. Diagrammatic representation of typical FYLF breeding areas in large creeks and rivers, based on research from North Coast and Sierra Nevada streams similar to those streams downstream of the Yuba River Development Project.

In general, the value of habitat models (such as 1-D or 2-D instream flow models) relative to empirically collected data, is that they allow for evaluation of a large number of stream flow levels once the basic field data have been collected. Empirically collected data typically provide a snapshot of habitat conditions at a few flow levels and cannot be extrapolated to other flow levels. However, data collected at single flows are complementary to modeled data and can be used to provide validation of the model outputs, if both methods are applied in the same reach.

While some information regarding breeding of FYLF in Project-affected stream reaches is available, Licensee's Special-status Amphibians – Foothill Yellow-Legged Frog Survey Study will identify breeding areas, which will be modeled using this study.

5.0 Study Methods and Analysis

5.1 Study Area

FYLF aquatic habitat will be modeled using the 2-D method in Project-affected stream reaches where FYLF breeding is documented to occur by Licensee's Special-Status Amphibians – Foothill Yellow-Legged Frog Surveys Study (Study 3.4), or is otherwise documented to occur.

If YCWA proposes an addition to the Project, the study area will be expanded if necessary to include areas potentially affected by the addition.

5.2 General Concepts and Procedures

The following general concepts and practices apply to the study:

- Personal safety is the most important consideration of each fieldwork team.
- Licensee will make a good faith effort to obtain permission to access private property where needed well in advance of entering the property.
- Field crews may make minor variances to the FERC-approved study in the field to accommodate actual field conditions and unforeseen problems. When minor variances are made, Licensee's field crew will follow the protocols in the FERC-approved study.
- When Licensee becomes aware of major variances to the FERC-approved study, Licensee will issue an e-mail to the Relicensing Contact List describing the variance and reason for the variance. Licensee will contact by phone the Forest Service (if the variance is on National Forest System land), USFWS, SWRCB and CDFG to provide an opportunity for input regarding how to address the variance. Licensee will issue an e-mail to the Relicensing Contact List advising them of the resolution of the variance. Licensee will summarize in the final study report all variances and resolutions.
- Licensee's performance of the study does not presume that Licensee is responsible in whole or in part for measures that may arise from the study.
- Global Positioning System (GPS) data will be collected using either a Map Grade Trimble GPS (sub-meter data collection accuracy under ideal conditions), a Recreation Grade Garmin GPS unit (3 meter data collection accuracy under ideal conditions), or similar units. GPS data will be post-processed and exported from the GPS unit into Geographic Information System (GIS) compatible file format in an appropriate coordinate system using desktop software. The resulting GIS file will then be reviewed by both field staff and Licensee's relicensing GIS analyst. Metadata will be developed for deliverable GIS data sets.
- Licensee's field crews will record incidental observations of aquatic and wildlife species observed during the performance of this study. All incidental observations will be reported in the appropriate Licensee report (e.g., incidental observations of special-status fish recorded during fieldwork for the Special-Status Turtles – Western Pond Turtle Study will be reported in Licensee's Stream Fish Populations Study report). The purpose of this effort is not to

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conduct a focus study (i.e., no effort in addition the specific field tasks identified for the specific study) or to make all field crews experts in identifying all species, but only to opportunistically gather data during the performance of the study.

- Field crews will be trained on and provided with materials (e.g. Quat) for decontaminating their boots, waders, and other equipment between study sites. Major concerns are amphibian chytrid fungus, and invasive invertebrates (e.g. zebra mussel, *Dreissena polymorpha*). This is of primary importance when moving: 1) between tributaries and mainstem reaches; 2) moving between basins (e.g. Middle Yuba River, Yuba River, and North Yuba River); and 3) moving between isolated wetlands or ponds and river or stream environments.

5.3 Study Methods

The study includes five steps: 1) select sites; 2) survey channel geometry and map substrate; 3) collect hydraulic measurements; 4) develop habitat model; and 5) prepare report. Each step is described below.

Licensee will obtain all necessary permits prior to fieldwork.

5.3.1 Step 1 - Study Site Selection

Licensee will locate and delineate 2-D study sites in the field during fall 2012. Licensee, with at least 2 week advance notice, will invite interested Relicensing Participants into the field to comment on study sites. One model will be developed in each of three river segments, assuming FYLF breeding is documented is each reach. If breeding is not documented in a reach by Licensee's Special-Status Amphibians – FYLF Surveys Study, modeling will not occur in that reach. The three reaches in which modeling may occur include: 1) on the Middle Yuba River and Yuba River from Our House Diversion Dam to New Colgate Powerhouse; 2) on Oregon Creek from the Log Cabin Diversion Dam to the confluence with the Middle Yuba River; and 3) on the North Yuba River from New Bullards Bar Dam to the confluence with the Middle Yuba River.

At least 2 weeks in advance of the the field visit with interested Relicensing Participants, Licensee will identify preliminary 2-D sites and provide Relicensing Participants with written materials including maps and technical rational for the preliminary sitings. Licensee will use the following guidelines in 2-D site selection:

- <u>Locating the Site</u>
  - ➢ Choose a site in each reach in which 2-D modeling will occur:
    - ✓ that has the common dominant breeding habitat types for that reach and preferably includes a known FYLF breeding site
    - ✓ with the goal of including at least two mesohabitat units
    - ✓ from the potential set of study sites developed based on the above criteria, choose a site with the most potential project effects

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- Size of Modeled Area
  - Each modeled site will:
    - ✓ have an area that ranges from a minimum of approximately 250 m^2 (*i.e.,* small streams) to a maximum of approximately 5,000 m^2 (*i.e.,* larger rivers)
    - ✓ have a data point density appropriate for the hydraulic modeling requirements and calibration in FYLF breeding areas to meet standard acceptable 2-D modeling error

To the extent reasonable, FYLF 2-D habitat modeling sites will be co-located with other relicensing study sites.

5.3.2 Step 2 – Survey Channel Geometry and Map Substrate

Topographic and hydraulic data for each study site will be collected during summer and fall 2012, as described below.

5.3.2.1 Bed Topography

Vertical and horizontal data will be collected by standard differential (X-Z) and coordinate plane (X-Y) survey techniques. A robotic total station and a manual total station survey instrument will be used with temporary vertical and horizontal benchmarks to measure channel topography and water surface elevations (WSE). Streambed elevations will be measured well above the ordinary high water level at each 2-D site.

Study site boundaries will be fixed and delineated with a cross-sectional transect and marked with a handheld Global Positioning System (GPS) instrument. The downstream boundary of the 2-D site will serve as the primary location to measure changes in river stage relative to stream discharge.

Topographic data will be collected at a data point density appropriate for the hydraulic modeling requirements and calibration in FYLF breeding areas to meet standard acceptable 2-D modeling error. Data point density will range from 0.5 meters (m) by 0.5 m in the near-shore areas where FYLF habitat is likely to occur, to point densities of approximately 2 m by 2 m in simple mid-channel or floodplain areas. In areas of low habitat quality, such as deep pools and in infrequently inundated and high-bank zones, topographic point densities may exceed 2 m by 2 m.

Remote Sensing Methods

The following description is only applicable in the event that remote sensing is the preferred method for topographic suvey for a particular site. A decision on whether to use remote sensing will be made by Licensee once the 2-D FYLF study sites are identified. For such a site, the River 2-D model will be developed from a combination of aerial and ground surveys of the river valley. The site will be flown to collect imagery used to produce a photogrammetric survey of the entire channel width extending upstream and downstream well beyond the delineated boundaries. Portions of the channel that may be submerged or out of view due to vegetation

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coverage, shadow, or other reasons will be surveyed on the ground as described above. Supplemental ground suveys will also capture the top of bank, channel toe, and channel thalweg.

The control for both the photogrammetry and the ground survey will be based on an appropriate numbr of geo-referenced benchmarks for the size and configuration of the site. The horizontal datum for the control will be NAD 83 (ft) California State Plane 2 coordinates and the vertical datum will be NAVD 88 (ft).

5.3.2.2 Substrate Mapping

Substrate will be delineated based on the categories listed in Table 5.3.2-1, which correspond to substrate class codes standard to FYLF habitat use data collection (Seltenrich and Pool 2002). Using coordinate plane survey techniques (X-Y) and referencing the site's horizontal benchmark grid, field crews will collect substrate data as distinct polygons to cover the entire area of the 2D site. The use of a Trimble S-6 robotic total station with a survey controller will allow field personnel to track the polygon coverage and insure that each topographic data point has a corresponding substrate value.

Table 5.3.2-1. FYLF 2D Model substrate size

Code	Category	Size (mm)	Size (in)
1	Silt/Clay/Mud	--	--
2	Sand	< 2	< .08
3	Gravel	2 – 64	0.08 - 2.5
4	Cobble	64 – 256	2.51 - 10.07
5	Boulder	> 256	> 10.07
6	Bedrock	--	--
7	Other	--	--

5.3.3 Step 3 – Collect Hydraulic Measurements

Water surface elevation (WSE), discharge, and spot validation depths and velocities will be collected at each FYLF 2-D model site at three calibration flows. These hydraulic parameters will be measured using a combination of standard methods and techniques described below.

Validation spot velocities and WSE measurements will span the entire longitudinal profile of the FYLF 2-D model site. Discharges will be measured according to standard United States Geological Survey (USGS) methods with a minimum of 20 cells per cross section (Rantz 1982). Hydraulic data collection methods may vary somewhat between study reaches, depending on hydraulic and channel variations.

5.3.3.1 Target Calibration Flows

The target calibration flow is the discharge released at the control point (i.e., Project dam or diversion), whereas the measured calibration flow represents the actual volume of water that reached the FYLF 2-D model site as measured with a calibrated flow meter. The source of any differences between target and measured flows primarily depended on the accuracy of flow

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control at the upstream control point and intervening accretion between the control point and the FYLF 2-D model site.

The target calibration flows selected for each 2-D stream reach wil be the same as those selected for the one-dimensional (1-D) study at that stream reach (See Licensee's Instream Flow Study Proposals.)

5.3.3.2 Discharge and Water Surface Elevation

Stage/discharge measurements will be obtained at the three calibration flows to assess the relationship between stage and discharge at the bottom of the FYLF 2-D model site. Discharge through the site will be measured using Swoffer brand calibrated manual velocity meters at an appropriate cross section near the upstream end of the 2-D site. Swoffer meters are accurate at velocities ranging from 0.1 to 25.0 feet per second (fps).

5.3.3.3 Validation Depths and Velocities

At each calibration flow, depths and mean column velocities will be collected at spot locations throughout the wetted channel using a calibrated velocity meter mounted on a USGS top-set wading rod. All spot depths and velocities will be spatially referenced to the site grid using a total station and covered the entire longitudinal profile of the site. Starting at the downstream site boundary, crews will take approximately 4 to 8 depth and velocity measurements across the width of the wetted channel. Field crews will progress upstream until they reach the inflow boundary of the 2-D site. The longitudinal spacing between spot cross-section measurements will vary by site but will generally be 30 feet or less. The goal will be to collect at least 100 individual spot measurements per calibration flow.

5.3.4 Step 4 – Develop Habitat Model

Habitat Suitability Criteria (HSC), or indices, define the range of conditions that a particular species lifestage is known to inhabit. Variables defined with FYLF HSC curves include depth, mean column velocity, and bottom substrate. HSC values range from 0 to 1.0, indicating habitat conditions that are unsuitable to optimal, respectively, for a species/lifestage. The HSC provide the biological criteria input into the River2D hydraulic model that converts physical habitat simulation data into Weighted Usable Area (WUA) or a suitable habitat index for evaluation of various flow scenarios on the particular species and lifestage(s) of interest.

Licensee will use the same FYLF HSC that are included in Nevada Irrigation District application filed with FERC for a New License for the Yuba-Bear Hydroelectric Project and by Pacific Gas and Electric Company application filed with FERC for a New License for its Drum-Spaulding Project.

5.3.4.1 Hydraulic and Habitat Modeling

Hydraulic modeling for all 2D reaches will be conducted using the River2D model. The main input parameters for the River2D model are channel surface topography, bed roughness (in the

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form of an effective roughness height), upstream and downstream hydraulic boundary conditions (water levels or flow magnitude), eddy viscosity, and initial inflow water surface elevation. The output from a simulation includes water depth, water surface elevation, stream velocity, shear velocity, and unit discharge at each mesh node. Velocity magnitude is found by dividing the unit discharge by depth. All output data from River2D will be post-processed, analyzed, and presented in various graphical formats.

A single River2D mesh at the middle calibration flow will be used to calibrate the model for the range of discharges. Calibrating from the middle flow produced the least bias when modeling to the highest and lowest flow of interest. Unless otherwise decided in consultation with Relicensing Participants the Licensee will use the middle flow mesh for ease of comparison and habitat analysis.

Two-dimensional hydraulic models will be calibrated in consultation with Relicensing Participants. Licensee will use a stage-wise approach with target criteria for model performance. The four stages are as follows:

5.3.4.1.1 <u>Stage I: Bed Roughness (Ks) Parameter Calibration Procedures</u>

Ks will initially be defined as about the D100 (in meters) of bed material observed in the channel and 1 to 2 times D100 in densely vegetated areas. The term Ks is scientific notation for bed roughness factor and the term D100 is refers to gradation of material in the river. D100 represents the largest grain size found in the river (100 percent of the rocks in the river would be that size or smaller) in the study reach it represents a cobble of size 0.2 meters.

Ks will be varied as necessary to match observed water surface elevations using the default transmissivity of TR=0.1.

The sensitivity of the model to the Ks parameter may be limited by the mathematical description of bed roughness in the model (see page 23 of the River2D model documentation). If this limit is surpassed during the calibration process, Ks will be defined as the lowest value tested before sensitivity is lost. An optimal value of Ks will be chosen for the study reach based on the results from all three calibration flow scenarios.

5.3.4.1.2 <u>Stage II: Transmissivity (TR) Calibration Procedures</u>

If variation of the Ks parameter is not sufficient to match observed water surface elevations, the transmissivity will be adjusted in an attempt to improve the correlation with observed data.

The optimal Ks parameter will be used during transimissivity calibration tests.

A minimum value of TR=0.001 will be used in the calibration tests to maintain stability of the model.

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5.3.4.1.3 Stage III: Model Performance Check

Based on the model calibration procedures described above, differences (averaged across all nodes) between the modeled and observed data points will be calculated for water surface elevation, depth, and velocity. These differences will be tabulated and evaluated for reasonableness. In addition, observed and modeled water surface elevations, depths, and velocities for the low, medium, and high calibration flows will be plotted. Modeled and observed water surface long profiles of the 2D site will also be plotted.

5.3.4.1.4 Stage IV: Identification of Data Outliers in Calibrated Model

Data outliers in the model will generally defined as those sample points where the differences between observed and the modeled parameter (WSE, depth, or velocity) are greater than twice the average difference magnitude of all points measured for a particular flow scenario. Nodes that meet these criteria for any parameter of WSE, depth, or velocity will be tabulated and graphed for evaluation. The identification of outliers will be more for understanding the limits and peculiarities of the model results and whether outliers occurred in optimum habitat areas, rather than for direct model calibration.

Once hydraulic calibration is complete hydraulic models will be run initially at five flows; the low, middle, and high calibration flow, 40 percent of the low calibration flow, and 250 percent of the high calibration flow. Flow versus habitat relationships will be generated at these flows to be used in collaboration with the Relicensing Participants to determine what range of additional flows will need to be modeled.

The range of simulated flows will be determined in consultation with Relicensing Participants. Habitat analyses will include WUA in both tabular and graphical format, effective WUA in tabular and graphical format, and depth and velocity nodal effective habitat in graphical format.

5.3.5 Step 5 – Prepare Report

Licensee will prepare a report that includes the following sections: 1) Study Goals and Objectives; 2) Methods and Analysis; 3) Results; 4) Discussion; and 5) Description of Variances from the FERC-approved study proposal, if any. Licensee plan to make the report available to Relicensing Participants when completed. The report will be included in the License Application as appropriate.

6.0 Study-Specific Consultation

The following are specific areas for which the Licensee will consult with the Relicensing Participants:

- License, with at least 2 week advance notice, will invite interested Relicensing Participants into the field to comment on study sites. At least 2 weeks in advance of the the field visit with interested Relicensing Participants, Licensee will identify preliminary 2-D sites and

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provide Relicensing Participants with written materials including maps and technical rational for the preliminary sitings. It is anticipated the site viist will occur in fall 2012.

- Licensee will consult with the Relicensing Participants during hydraulic and habitat modeling. Relicensing participants will be consulted in each of the 4 stages described in Section 5.3.5 above.

7.0 Schedule

Licensee anticipates the schedule to complete the study as follows assuming the PAD is filed on November 1, 2010, and FERC issues its Study Determination by October 4, 2011. Note that this study must follow the Special-Status Amophibians – Foothill Yellow-Legged Frog Surveys Study, because that study will identify where FYLF breeding occurs, from which model sites will be selected:

Study Site Selection (Step 1) .... September - October 2012
Field Work (Steps 2 & 3)..November 2012 through June 2013
Data Entry, QA/QC, & Analysis (Step 4)... May through August 2013
Report Preparation (Step 5) .... September through October 2013

8.0 Consistency of Methodology with Generally Accepted Scientific Practices

The study methods discussed above are consistent with the study methods followed in several other relicensings. The methods presented in this study plan also are consistent with those used in recent relicensings in California.

9.0 Level of Effort and Cost

[Relicensing Participants – Licensee will include a cost range estimate for this study in its Proposed Study Plan. Licensee]

10.0 References Cited

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