POTENTIAL RESOURCE ISSUE:

Aquatic and riparian resources.

PROJECT NEXUS:

Project operations and potential Project betterments modify or could potentially modify the flow regime in the bypass reaches below the reservoirs/diversions and in the peaking reach downstream of Oxbow Powerhouse. The modified flow regime in the bypass and peaking reaches may affect the amount and distribution (temporal and spatial) of aquatic and riparian habitat.

POTENTIAL LICENSE CONDITION(S):

- Instream flow releases.
- Facility modifications.

STUDY OBJECTIVE(S):

The overall study objective is to characterize aquatic and riparian habitat as a function of flow using site specific data and ecological principles and modeling methodologies derived from the literature (e.g., Bovee et al. 1998). The information developed from this study, in combination with other resource studies (e.g., water temperature, bioenergetics, fish passage, fish population, and special-status amphibian and reptile studies), will provide a basis for streamflow-related resource management decisions.

The specific objectives of the study include:

- Quantify the habitat versus discharge relationships for fish, special-status amphibian, benthic macroinvertebrate, and riparian resources in the bypass and peaking reaches.
- Use the habitat versus flow relationships to develop a time series analysis of aquatic habitat under existing and unimpaired flow scenarios in the bypass and peaking reaches.
- Identify the time periods, flow conditions, and life stages when habitat is a limiting factor for fish, benthic macroinvertebrate, special-status amphibian, and riparian populations for the existing and unimpaired scenarios.
- Provide information necessary to quantify the effects of other alternative flow scenarios on aquatic and riparian habitat.

EXTENT OF STUDY AREA:

The study area includes the active channel and floodplain in bypass reaches downstream of Project reservoirs/diversions, the peaking reach below Oxbow Powerhouse, and selected reaches upstream of the Project facilities. The study area is identified in Table AQ1-1 and Figure AQ1-1. Some portions of the study area are very difficult to access due to the rugged terrain (see Figure AQ1-1). Field data will only be collected in portions of the study area that are accessible. The reaches upstream of the Project facilities are being used to interpret riparian vegetation versus flow relationships; therefore, data collection in these reaches will be limited to that purpose.

STUDY APPROACH:

The following describes the general instream flow modeling approach for all streams, including specific methods for the peaking reach. The topics are selection of target species and/or guilds, development of habitat suitability criteria, stratification and study site selection, coordination of study site selection, study site modeling, hydrodynamics modeling, habitat modeling, and methods specific to the peaking reach.

Selection of Target Species and/or Guilds

A species distribution map for special-status amphibians and reptiles, fish, and riparian resources within the bypass and peaking reaches will be generated from the results of the Fish Population, Special-status Amphibian and Reptile, and Riparian technical studies. The Aquatic TWG will use existing information and any pertinent study results to develop a life stage periodicity chart (i.e., season of occurrence) for the aquatic species and riparian vegetation present in each study reach.

The species and life stages (and/or guilds) that will be used for instream flow habitat modeling will be selected based on management importance and/or sensitivity to Project operations. PCWA proposes that most life stages (e.g., juvenile rearing, adult rearing, spawning) of rainbow trout, brown trout, and hardhead and breeding and larval development (tadpoles) for foothill yellow-legged frogs (FYLF) will be modeled. All other aquatic species/life stages will be modeled using a guild approach.

Development of Habitat Suitability Criteria

Habitat suitability criteria (HSC) for each selected species/life stage will be developed in collaboration with the Aquatic TWG. For fish species, HSC criteria will be developed using a two-stage approach. First, existing HSC data will be compiled to create a database of HSC that can be reviewed for applicability to the Project. If concurrence on an acceptable set of HSC can be achieved, no additional data collection will occur. If questions remain about habitat suitability for juvenile or adult brown trout, rainbow trout, or hardhead, then PCWA will collect snorkeling-based habitat suitability criteria data in the bypass reaches for validating or modifying the existing habitat suitability criteria data sets. At least 100 observations, if possible, of each juvenile and adult rainbow trout, brown trout, and hardhead will be collected. Data will be collected on an equal-effort basis for at least 6 different depth and velocity categories. One objective of this effort would be to better understand the “tails” of the existing habitat suitability criteria (e.g., low velocity tail of the velocity criteria curves, deep water tail of the depth criteria curves).

A guild or spatial niche approach will also be developed in collaboration with the Aquatic TWG to provide HSC for the entire species assemblage in the study area (fish, amphibians, benthic macroinvertebrates). Different categories of depth and velocity (e.g., slow-shallow, fast-shallow, deep-slow) will be developed that approximately correspond to the depths and velocities that different species/life stage guilds (e.g., fry) utilize.

HSC for FYLF breeding and larval development (tadpoles) will be developed as part of the Special-Status Amphibian and Reptile Technical Study. Riparian vegetation requirements such as flow recession rates and inundation frequencies and durations, will be developed in the Riparian Resources Technical Study.

Stratification and Study Site Selection

Geomorphology, hydrology, and habitat data collected as part of previous studies (PCWA 2006a; PCWA 2006b; PCWA 2006c) will be used to stratify the bypass and peaking reaches. Instream flow data will be collected and analyzed within these strata. The largest strata will be based on the Rosgen level I classification of the channel, with a secondary stratification based on the flow regime. Within these geomorphic reaches, the river will be stratified based on mesohabitat types. All accessible bypass and peaking reaches (either by aerial video, helicopter, or foot travel) have been mesohabitat mapped (typed) using the most detailed level of mesohabitat typing outlined in McCain et al. (1990) (22 mesohabitat types). These habitat types will be collapsed into a lower level of detail to facilitate river stratification for instream flow modeling. PCWA proposes that the 22 mesohabitat types will be collapsed to approximately 6 types (e.g., pool, run, low gradient riffle, high gradient riffle, cascade, pocket water) for stratification of study sites.

Due to difficult access, study sites will be representative reaches stratified by mesohabitat type. They will typically be 20 to 40 channel widths in length. These stratified representative reaches will contain a full complement of mesohabitat types that can be used to represent the larger geomorphic reach. Study sites will be selected based on the 2006 Rosgen reach delineations, 2006 habitat mapping results, and access. Where possible, the sites will overlap the 2006 Geomorphology and Riparian Habitat quantification study sites (PCWA 2006a). The 2006 Aquatic Habitat Characterization Study results will be used to ensure that the selected study sites contain all major mesohabitat types contained in the larger geomorphic reach and that the mesohabitat units are representative of those in the larger reach.

The proposed number and general locations of the study sites are shown in Table AQ1-1 and Figure AQ1-1. The specific locations and lengths of the study sites (Table AQ1-1) will be selected in the field with concurrence from the Aquatic Technical Working Group (TWG).

Coordination of Study Site Selection

Study site selection will be coordinated with the Special-Status Amphibian Technical Study to insure FYLF habitat is included, where appropriate, within the study site.

Selection of study sites will also be coordinated with the Riparian Vegetation and Geomorphic Technical Study Plans to provide hydrodynamics modeling data for these studies. In addition, several study sites will be located upstream of selected Project diversions and in selected comparison streams (North Fork Middle Fork American River and North Fork American River) for riparian vegetation comparisons (Table AQ1-1 and Figure AQ1-1). These study sites will be selected in coordination with the Riparian Vegetation Technical Study. One to three cross-sections will be established at these sites and three stage-discharge pairs will be collected to develop stage-discharge relationships (Table AQ1-1).

Study Site Modeling

Aquatic habitat modeling will be accomplished by sampling and modeling representative mesohabitat types in each study site with one-dimensional and/or two-dimensional hydrodynamics and habitat models. The results for each mesohabitat type will be weighted and combined to develop a representation of hydrodynamics and habitat for the larger geomorphic reach. The weighting will be based on the percentage of each mesohabitat within the geomorphic reach.

In general, two mesohabitat units of each major mesohabitat type (>10% of the geomorphic reach) will be modeled in each study site. The stratified representative study sites may contain more mesohabitat units than will be modeled. The specific mesohabitat units selected for modeling will be those that are most representative of the mesohabitats in the geomorphic reach. Results from the 2006 Aquatic Habitat Characterization Study will be used to compare mesohabitat types in the geomorphic reach (e.g., average length, width, depth, and substrate) with the mesohabitats in the study site. These data, along with a visual assessment of the representativeness of the mesohabitat units within the study site, will be used to select units to model. Final selection of the transect will be completed in the field in consultation with the Aquatic TWG. We do not recommend random sampling of habitat units or random placement of cross-sections (in the case of one-dimensional modeling) because unrepresentative results can occur when sample sizes are small.

For one-dimensional modeling, cross-sections will be visually placed in the mesohabitat units to best represent the habitat over a range of flows. Typically, one to three cross-sections will be placed in each selected habitat unit. Additional cross-sections may be placed in additional habitat units so the proportion of cross-section samples approximately matches the proportion of mesohabitat types in the geomorphic reach. Mesohabitat types that do not contain significant habitat for the primary target species (e.g., cascades and possibly high gradient riffles) or rare mesohabitat types (<10%) that do not have unique habitat importance will not be modeled. Rare habitat types with unique importance (e.g., spawning, passage) will be sampled. Concurrence regarding the specific mesohabitat units to sample and cross-section placement (i.e., for one-dimensional modeling) will be obtained from the Aquatic TWG.

The study sites where one-dimensional modeling is proposed and the approximate number of cross-sections is shown in Table AQ1-1. The number of cross-sections is based on the assumption that four different mesohabitat types are sampled at each site with two mesohabitat units of each type being represented by an average of 2 cross-sections per mesohabitat unit. Two additional cross-sections were also included for unique habitats. This is approximately 20 cross-sections per site with a total of 232 cross-sections, including 18 cross-sections for riparian vegetation. Overall, this is a large number of cross-sections and an extensive sampling effort.

The sampling effort at four specific study sites is reduced compared to the effort at other sites due to the flow patterns, diversion operations, and reach length. Specifically, flows in the stream reaches on the North Fork Long Canyon Creek, South Fork Long Canyon Creek, and Long Canyon Creek are not affected by Project operation during the summer and fall low flow period when the diversions are not operating. As a result, habitat modeling is primarily limited to quantifying habitat in winter and spring when diversion occurs. In addition, the natural summer/fall flows are very low (e.g., <1 cfs), which limits habitat availability. The fourth site, the geomorphic reach on the Middle Fork American River immediately upstream of Interbay Reservoir, is very short (0.5 miles) and only half of it is accessible. Within these four study sites, a lower number of cross-sections (12) has been proposed (Table AQ1-1).

Two-dimensional modeling will be considered for application at the study sites in the peaking reach (Table AQ1-1), if the habitat and logistics warrant its use. The potential benefits of two-dimensional modeling in the peaking reach are better spatial representation of habitat and efficient integration of various habitat analyses (fish, amphibians, macroinvertebrates, riparian vegetation, sediment transport). Also, how habitat moves spatially with changes in flow is important when flow changes rapidly (e.g., peaking). To efficiently collect large amounts of topography for two-dimensional modeling, however, good site access and good GPS coverage is necessary (the narrow canyon may limit GPS coverage). The most appropriate modeling methodology in the peaking reach (two or one-dimensional) will be determined on the ground in consultation with the Aquatic TWG when the study sites are selected.

Hydrodynamics Modeling Methods

One-dimensional hydraulics models for modeling water surface elevations and velocities across each cross-section will either be PHABSIM (e.g., Milhouse et al. 1989) or equivalent procedures, as appropriate for the study site and specific objectives for the site. These procedures include stage-discharge regressions, Manning's equation, backwater step models (e.g., WSP, HecRas), and IFG4. Two-dimensional models, where used, will include River2D (Steffler and Blackburn 2001) or MD-SWMS (McDonald et al. 2006) or comparable models.

Hydrodynamics (depth, velocity, water surface elevations) will be modeled over a wide range of discharges, appropriate to the project hydrology of each reach. Specific data to be collected using standard techniques include:

- Channel topography, either in the form of cross-sections or three-dimensional topography. Cross-sections will be marked with semi-permanent headpins and approximate GPS locations will be recorded.
- For one-dimensional modeling, empirical water surface elevations will be measured (surveyed) for at least three discharges at each cross-section. For two-dimensional modeling empirical water surface elevations will be measured along the length of each study site at three discharges. The discharges will span the range of flows of interest (low summer base flows to high spring flows). (Table AQ1-1).
- Empirical velocity data will be collected across each cross-section (15-20 locations) at one discharge. The discharge at which the velocities are collected will be greater than or equal to the anticipated highest summer flow of interest in each reach (Table AQ1-2). In the peaking reach, if cross-section modeling is done, velocity data will also be collected at a second intermediate discharge. At all two-dimensional study sites, validation velocities will be collected across several cross-sections at an intermediate or low flow. All velocities will be collected with calibrated velocity meters. Discharges will be measured using standard gaging techniques (Rantz 1982) and/or an acoustic doppler current profiler (ADCP).

Substrate height and vegetation polygons for hydrodynamics roughness will be collected at all two-dimensional modeling study sites.

Habitat Modeling

Habitat modeling will be conducted using an approach consistent with the IFIM approach (Bovee et al. 1998). Where appropriate the habitat modeling will also include a bioenergetics based habitat analysis (e.g., Guensch et al. 2001, Hayes et al. 2000) (see Bioenergetic Technical Study). The specific details of the habitat modeling will be developed in consultation with the Aquatic TWG. The general approach will be as follows:

- Collect substrate and cover information for habitat modeling across each cross-section or in polygons at each two-dimensional modeling site that is compatible with the HSC criteria developed in consultation with the Aquatic TWG.

- Develop habitat modeling algorithms or approaches appropriate for each selected species and life stage or guild in consultation with the Aquatic TWG. As part of this process, conduct a small pilot study on large slow-water pools to assist in the development of a logical habitat modeling approach for large pools.
  - Snorkel three large slow-water pools on the Rubicon River and record fish locations and behavior (e.g., drift versus benthic feeding) related to location and water velocity in the pools. Develop a technical memorandum describing the results and suggestions regarding potential modeling approaches for large, slow-water pools. Include a brief literature review of approaches to modeling large pools.
- Develop habitat versus discharge relationships for each species life stage or guild over a wide range of flows (15 to 30 flows).
- Complete a habitat time series analysis comparing the seasonal and daily distribution of habitat for the existing and unimpaired project hydrology over the period of record (1975 to 2004). Compare and contrast the amount of habitat during different biologically significant time periods (e.g., reproduction, rearing) and identify habitat bottlenecks.
- Coordinate with the Special-status Amphibian and Reptile Study to identify outputs from the instream flow modeling that will assist in analyzing the relationship between instream flow and FYLF habitat.
- Coordinate with the Riparian Resources Technical Study to identify key outputs from the instream flow modeling required for analyzing the relationship between instream flow and establishment and health of riparian vegetation in the bypass and peaking reaches.

Methods Specific to the Peaking Reach

- Summarize existing and unimpaired hydrology data in the peaking reach to characterize between-day and within-day flow fluctuations.
- Install continuous stage monitors and develop rating curves at 3 to 6 key locations throughout the peaking reach to develop a flow fluctuation travel-time/flow attenuation monitoring and modeling relationship.
- Select the modeling sites (Table AQ1-1) to include representative habitat of fish, benthic invertebrate, amphibian, and riparian resources that is sensitive to flow fluctuations. For example, select sites that have fry rearing habitat, potential fish stranding locations, amphibian spawning habitat, and benthic macroinvertebrate habitat.
- Model fish, special-status amphibian, benthic macroinvertebrate, and riparian habitat to address within-day flow fluctuations as a result of peaking flows. This includes effective habitat analysis and stranding analysis for fry, spawning, benthic macroinvertebrates, amphibian egg masses, and tadpoles (e.g., Bovee et al. 1998).
- Conduct a one-time stranding evaluation downstream of Ralston Afterbay. Immediately after the first peaking event in late spring/early summer quantify any stranding in sensitive habitats over a 1000 m of stream.

SCHEDULE:

To be developed in early 2007.

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Table AQ1-1. Instream Flow Study Reaches and Modeling Methods.

Study Reach	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Number of Instream Flow/ Riparian Study Sites	Number of Cross-sections	Approximate Flows for Model Calibration (cfs)[2]				Modeling Methods
						Aquatic Habitat Modeling			Riparian /Geomorphic Modeling	
						Base	Med	High		
Duncan Creek										
Duncan Creek upstream of Diversion			●	1	1-3					Develop stage-discharge relationship for riparian vegetation comparisons
Duncan Creek from Diversion to confluence with Middle Fork American River	●			1	20					1D
Middle Fork American River										
Middle Fork American River upstream of French Meadows Reservoir			●	1	1-3					Develop stage-discharge relationship for riparian vegetation comparisons
Middle Fork American River from French Meadows to confluence with Duncan Creek	●			1	20					1D
Middle Fork American River from confluence with Duncan Creek to Middle Fork Interbay	●			1	12[1]					1D
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay	●			1-2	20					1D

Study Reach	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Number of Instream Flow/ Riparian Study Sites	Number of Cross-sections	Approximate Flows for Model Calibration (cfs)[2] Aquatic Habitat Modeling: Base	Med	High	Riparian /Geomorphic Modeling	Modeling Methods
Ralston Afterbay Downstream										
Middle Fork American River from Ralston Afterbay to confluence with Canyon Creek		●		1	20 or 1 mile[3]					1D/2D
Middle Fork American River from confluence of Canyon Creek to confluence with North Fork American River		●		1	20 or 1 mile[3]					1D/2D
Rubicon River										
Rubicon River from Hell Hole Reservoir to confluence with South Fork Rubicon River	●			1	20					1D
Rubicon River from confluence with South Fork Rubicon River to Ralston Afterbay	●			2	40					1D

Study Reach	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Number of Instream Flow/ Riparian Study Sites	Number of Cross-sections	Approximate Flows for Model Calibration (cfs) [2]: Aquatic Habitat Modeling			Approximate Flows for Model Calibration (cfs) [2]: Riparian /Geomorphic Modeling	Modeling Methods
						Base	Med	High		
Long Canyon Creek										
North Fork Long Canyon Creek upstream of Diversion			●	1	1-3					Develop stage-discharge relationship for riparian vegetation comparisons
North Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	●			1	12[1]					1D
South Fork Long Canyon Creek upstream of Diversion			●	1	1-3					Develop stage-discharge relationship for riparian vegetation comparisons
South Fork Long Canyon Creek from Diversion to confluence with Long Canyon Creek	●			1	12[1]					1D
Long Canyon Creek from North and South Fork Long Canyon creeks confluence to confluence with Rubicon River	●			1	12[1]					1D
Other Tributaries										
North Fork Middle Fork American River			●	1	1-3					Develop stage-discharge relationship for riparian vegetation comparisons
North Fork American River			●	1	1-3					Develop stage-discharge relationship for riparian vegetation comparisons

1 Number of cross-sections slightly reduced due to circumstances in the particular reach. See text for details.
2 Target flows are yet to be determined.
3 If two-dimensional modeling is determined to be the most appropriate method in the reach, up to one mile of habitat will be modeled.

Placeholder for Figure AQ1-1

Instream Flow Study Reaches and Geomorphic Delineations

Non-Internet Public Information

This Figure has been removed in accordance with the Commission regulations at 18 CFR Section 388.112.

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