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, 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 flow 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 may be a limiting factor for fish, benthic macroinvertebrate, special-status amphibian, and riparian populations for the existing and unimpaired scenarios; and
- Provide information necessary to quantify the potential 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 downstream of Oxbow Powerhouse, and selected reaches upstream of the Project facilities. The study area is identified in Table AQ 1-1 and Map AQ 1-1. Some portions of the study area are very difficult to access due to the rugged terrain (see Map AQ 1-1) and thus, field data will only be collected in portions of the study area that are accessible. The reaches upstream of the Project facilities will be 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 (HSC), stratification and study site selection, coordination of study site selection, study site modeling, hydrodynamics modeling, habitat modeling, and methods specific to the peaking reach.

The instream flow study also includes two additional study elements focused on (1) documenting the presence/absence of *Didymospenia geminate*, a nuisance algae, at instream flow transects in the bypass and peaking reaches, and (2) determining the relationship between flow in the Middle Fork American River and flow entering the Horseshoe Bar area.

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 AQ 2 – Fish Population Technical Study Plan (TSP), AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP, and AQ 10 – Riparian Resources TSP. Existing information (e.g., literature and qualified biologist observations) and pertinent study results will be used to develop a life stage periodicity chart (i.e., season of occurrence) for the aquatic species and riparian vegetation present in each study reach in consultation with the Aquatic Technical Working Group (TWG).

The species and life stages (and/or guilds) that will be used for instream flow habitat modeling will be selected in collaboration with the Aquatic TWG based on management importance and/or sensitivity to Project operations. Placer County Water Agency (PCWA) proposes that most life stages (e.g., juvenile rearing, adult rearing, spawning) of rainbow trout, brown trout (where brown trout have been targeted as a management objective), and hardhead and breeding and larval development (tadpoles) for foothill yellow-legged frogs (FYLF) will be modeled. All other aquatic species/life stages are proposed to be modeled using a guild approach.

Development of 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, including HSC that have been used in recent instream flow projects in Sierra Nevada streams, will be compiled to create a database of HSC that can be reviewed for applicability to the Project. If there are uncertainties within the Aquatic TWG related to the appropriate HSC to use or if there are alternative HSC, the alternative HSC will be modeled and a sensitivity analysis will be conducted to identify the effects of alternative HSC on habitat versus flow relationships. If Aquatic TWG concurrence on acceptable sets of HSC can be achieved for individual species and life stages, then no additional data collection will occur. If concurrence is not reached regarding habitat suitability for juvenile or adult brown trout (where brown trout have been targeted as a management objective), rainbow trout, or hardhead, then PCWA will collect snorkeling-based summer/fall habitat suitability criteria data in the bypass reaches for validating or modifying the existing habitat suitability criteria data sets in question. At least 150 observations, if possible, of each juvenile and adult rainbow trout, brown trout, and/or hardhead will be collected. Data will be collected on an equal-effort basis for at least six different depth and velocity categories to minimize any habitat availability bias or sampling bias in the data. Data will be collected at the highest steady summer flow available to maximize the availability of habitat. Specific sampling locations will be selected in collaboration with the Aquatic TWG.

A guild or spatial niche approach will also be developed in collaboration with the Aquatic TWG to provide HSC for the aquatic (fish, amphibians, benthic macroinvertebrates) in the study area. 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 utilized by different species/life stage guilds (e.g., fry).

HSC for FYLF breeding and larval development (tadpoles) will be developed as part of the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP. Riparian vegetation requirements, such as flow recession rates and inundation frequencies and durations, will be developed in the AQ 10 – Riparian Resources TSP.

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 results of the 2005-2006 geomorphic classification of the river channels (PCWA 2007) (Map AQ 1-2) and hydrological management reaches (i.e., reaches that have similar flow regimes as a result of Project operations). Within these geomorphic/hydrologic reaches, the river will be further stratified based on mesohabitat types. All accessible bypass and peaking reaches have been (or will be) mesohabitat mapped (typed) (either by aerial video, helicopter, or foot travel) using the most detailed level of mesohabitat typing outlined in McCain et al. (1990) (i.e., a potential of 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 to aggregate the McCain et al. (1990) mesohabitat types into approximately five types (pool, run, low gradient riffle, high gradient riffle, and cascade) for stratification of the study sites and river reaches. The specifics of this aggregation will be determined based on the results of the 2005-2006 Aquatic Habitat Characterization Study (PCWA 2007) and consultation with the Aquatic TWG. The aggregate mesohabitat types may be different for the large river (e.g., peaking reach), medium river, and small stream reaches.

Due to difficult access, study sites used to represent the different geomorphic/hydrologic reaches will be representative reaches stratified by mesohabitat type. The stratified representative reaches will be at least 20 to 40 channel widths in length (or longer) and will contain a full complement of mesohabitat types that are representative of the larger geomorphic reach. Where possible, the sites will overlap the 2006 Geomorphology and Riparian Habitat quantitative study sites (QSS) (PCWA 2006a). The 2006 Aquatic Habitat Characterization Study results will be used to check 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 preliminary geomorphic/hydrologic management reaches are shown in Table AQ 1-1 and Maps AQ 1-1 and AQ 1-2. The proposed number and general locations of the study sites within these geomorphic reaches are also shown in Table AQ 1-1 and Map AQ 1-1. The specific locations and lengths of the study sites will be selected in the field with concurrence from the Aquatic TWG (Table AQ 1-2). Prior to study site selection in the field, PCWA will summarize the geomorphic and hydrological data and work with the Aquatic TWG to finalize the delineation of geomorphic/hydrologic reaches. PCWA will also summarize the aquatic habitat characterization data and study site access data and work with the Aquatic TWG to make a preliminary recommendation of study site locations. A field trip will be scheduled in the late summer of

2007 with the Aquatic TWG to select study sites and specific habitat units and transects to model (Table AQ 1-2) (also see Study Site Modeling below).

Coordination of Study Site Selection

Study site selection will be coordinated with the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP to include FYLF habitat, where appropriate, within the study sites. In addition, if unique locations (e.g., breeding sites) are identified by the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP and the Aquatic TWG, then they will be modeled as part of the AQ 1 – Instream Flow TSP.

Selection of study sites will also be coordinated with the AQ 10 – Riparian Resources TSP and the AQ 9 – Geomorphology TSP to provide hydrodynamics modeling data for these studies within the general instream flow study sites. In addition, the AQ 1 – Instream Flow TSP will coordinate with the AQ 10 – Riparian Resources TSP to provide hydrodynamics modeling input during the selection of several riparian comparison study sites located upstream of selected Project diversions and in reference reaches (Table AQ 1-1 and Map AQ 1-1).

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/hydrologic reach. The weighting will be based on the percentage of each mesohabitat within the geomorphic/hydrologic reach.

The sampling effort within each study site will be coordinated and determined in collaboration with the Aquatic TWG. The goal is to obtain a relatively accurate representation of the habitat versus flow relationship for each geomorphic/hydrologic reach. Some geomorphic/hydrologic river reaches, however, have greater (or lesser) importance in relation to the amount of habitat they provide (e.g., length of the reach or quality of the habitat) or the potential the Project has to modify habitat; therefore, the sampling effort will be adjusted as appropriate. In addition, there is some difficulty determining *a priori* the sampling effort (number and type of habitat units sampled) necessary to provide accurate habitat versus flow relationships.

In general, it is proposed that within a study site mesohabitat types will be sampled approximately in proportion to their abundance. Adjustments to the proportional sampling may be made based on the importance or variability of particular mesohabitat types. Typically, 10 mesohabitat units within a geomorphic reach will be sampled (modeled). This provides enough sampling to replicate each major mesohabitat type (e.g., two mesohabitat samples of each type) and provides for additional sampling in abundant and/or important mesohabitat types (e.g., 3 or more mesohabitat samples of abundant and/or important types). Each major mesohabitat type (greater than approximately 5-10% of the geomorphic/hydrologic reach) will be modeled. Rare mesohabitat types (<5%) that provide unique or important habitat (e.g., spawning, passage) will be modeled if they exist in the study site. In particular, patches of spawning gravel may be important habitat features to sample in the Project study sites. Mesohabitat types (e.g., cascades) that do not contain significant habitat for the primary target species or rare mesohabitat types (<5%) that do not have unique habitat importance will not be modeled.

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/hydrologic reach. Results from the 2005-

2006 Aquatic Habitat Characterization Study (PCWA 2007) will be used to compare (e.g., average length, width, depth, and substrate) mesohabitat types in the geomorphic reach 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 habitat units will be completed in the field in collaboration with the Aquatic TWG. PCWA does not recommend random sampling of mesohabitat units because unrepresentative results could occur.

For one-dimensional modeling, typically three cross-sections will be visually placed in the mesohabitat units to best represent the habitat over a range of flows. Fewer cross-sections may be placed in simple mesohabitat units with little variability or where the cross-sections are being placed to sample a variety of mesohabitat units of a particular type and not necessarily to fully characterize particular mesohabitat units. In some cases, additional cross-sections may be placed in highly variable mesohabitat units, if appropriate. Concurrence regarding cross-section placement within mesohabitat units will be obtained from the Aquatic TWG. The study sites where one-dimensional modeling is currently proposed and the approximate number of mesohabitat units to be sampled is shown in Table AQ 1-1.

The proposed sampling effort at three specific study sites is lower (6 mesohabitat units) compared to the effort at other sites due to the flow patterns, diversion operations, and reach length (Table AQ 1-1). 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 periods when the diversions are not operating. As a result, habitat modeling is primarily limited to quantifying habitat in winter and spring when diversion may occur. In addition, the natural summer/fall flows are very low (e.g., <1 cfs), which limits habitat availability.

Overall, for the 10 one-dimensional modeling sites identified in Table AQ 1-1 (not including the riparian comparison sites) the target total number of modeling cross-sections is 210 or less. This is an average 24 cross-sections for each of the seven typical sites and 14 cross-sections for each of the three reduced sampling effort sites. The final number of cross-sections and mesohabitat samples at each sampling site will be determined in the field with the Aquatic TWG.

Two-dimensional modeling will be targeted for application at the study sites in the peaking reach (Table AQ 1-1), 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, improved representation of complex flow patterns, and efficient integration of various habitat analyses (fish, amphibians, macroinvertebrates, riparian vegetation, sediment transport). Also, two-dimensional modeling is capable of representing how habitat moves spatially with changes in flow, which is important when flow changes rapidly (e.g., peaking). However, to efficiently collect large amounts of topography for two-dimensional modeling on a large river, good site access and good survey grade Global Positioning System (GPS) coverage typically 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 collaboration with the Aquatic TWG when the study sites are selected. Because the mesohabitat units are very long in the peaking reach (larger river), the number of mesohabitat units sampled may need to be reduced (i.e., less than the 10 mesohabitat units proposed for one-dimensional modeling sites in the smaller river locations). A reasonable length of river to model at each site in the peaking reach is 0.5 to 1.0 miles.

Two additional study sites, one each in the Middle Fork American and Rubicon rivers upstream of Ralston Afterbay, will likely have some 2-D modeling at amphibian breeding locations (see

AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP). Any two-dimensional habitat modeling completed in the bypass or peaking reaches as part of the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP will be included in the fish habitat modeling as appropriate.

Hydrodynamics Modeling

PHABSIM (e.g., Milhouse et al. 1989) or equivalent one-dimensional hydraulics modeling procedures, as appropriate for the study site and specific objectives for the site, will be used for modeling water surface elevations and velocities across each cross-section. These procedures include stage-discharge regressions, Manning's equations, backwater step models (e.g., WSP, HecRas), and IFG4. Two-dimensional models, where used, will include River2D (Steffler and Blackburn 2001), 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 (1-D) or three-dimensional (2-D) 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 calibration 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 calibration discharges. The discharges will span the range of flows of interest (Table AQ 1-1). The calibration flows will be determined by the Aquatic and Recreation TWGs once the hydrology has been compiled.
- Empirical velocity data will be collected across each cross-section (15-20 locations) at the high calibration discharge (or middle calibration discharge if determined by the Aquatic TWG to be the most appropriate discharge). In the peaking reach, if cross-section modeling is done, velocity data will be collected at the high discharge (e.g., 700 – 1,000 cfs) and at the middle calibration discharge. Table AQ 1-1 shows the target calibration discharges and the discharges where velocity will be measured. 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 Instream Flow Incremental Methodology (IFIM) approach (Bovee et al. 1998). Where appropriate, the habitat modeling will include an additional bioenergetics based habitat analysis (e.g., Guensch et al. 2001, Hayes et al. 2000) (see AQ – 5 Bioenergetics TSP). 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 (1-D) or in polygons (2-D) 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 flow 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 potential habitat limiting factors and time periods.
- Coordinate with the AQ 12 – Special-Status Amphibian and Aquatic Reptile TSP to identify outputs from the instream flow modeling that will assist in analyzing the relationship between instream flow and FYLF habitat.
- Coordinate with the AQ 10 – Riparian Resources TSP 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.
- Potential collection of species observations at 2-D modeling sites for the purpose of habitat modeling validation will be determined in coordination with the Aquatic TWG following selection of the study sites in the field and following a review of the 2007 fish population and amphibian sampling results at the sites.

<u>Methods Specific to the Peaking Reach</u>

- 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 three to six key locations throughout the peaking reach to develop a flow fluctuation travel-time/flow attenuation monitoring and modeling relationship. In the summer, monitor a series of flow fluctuations in the peaking reach that includes flow fluctuations from approximately 200 to 1,000 cfs.
- Select the instream flow modeling sites in the peaking reach (Table AQ 1-1) to include representative habitat of fish, benthic macroinvertebrate, amphibian, and riparian resources that is sensitive to flow fluctuations. For example, select sites that have fry rearing habitat, potential fish stranding locations, amphibian breeding habitat, and benthic macroinvertebrate habitat.
- Model fish, special-status amphibian, benthic macroinvertebrate, and riparian habitat to address within-day flow fluctuations that result from hydropower peaking. 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 or during some other stranding

sensitive time period determined in consultation with the Aquatic TWG, quantify stranding of aquatic species in sensitive habitats along 1,000 m of stream. If possible, this reach of stream will overlap with one of the instream flow study sites. This is a screening level stranding evaluation and will be used to identify the type (e.g., riffle, run, pool) and character (e.g., slope, dominant substrate, etc.) of habitats where stranding potentially may be occurring under the current flow regime. Results will be used in conjunction with the instream flow modeling stranding analysis to identify the potential level of stranding that may be occurring within the peaking reach.

Additional Study Elements

The following describes two additional study elements included in the instream flow study.

PCWA will collect presence/absence algae samples at each instream flow study site to identify if *Didymosphenia geminate* is present. Algae abundance will also be assessed visually and photos will be taken to document the typical abundance of algae at each instream flow study site during late summer.

The relationship between flow in the Middle Fork American River and flow entering the Horseshoe Bar area will be characterized using one-dimensional hydraulic modeling, if possible. Horseshoe Bar is an oxbow bend in the Middle Fork American River that is bypassed during low to moderate flows by a tunnel (Tunnel Chute) constructed by miners in the late 1800s. The relationship between flow in the Middle Fork American River and Horseshoe Bar will be evaluated by adding one or more instream flow cross-sections at the entrance to Horseshoe Bar and on the Middle Fork American River. These will be used to hydraulically estimate the flow versus stage relationship in the Middle Fork American River and the corresponding stage versus flow relationship in Horseshoe Bar.

If a long duration high flow event occurs during the spring of 2008 or the winter/spring of 2008-2009 that is large enough to cause flow to enter Horseshoe Bar, and a crew can be mobilized, the water surface elevations at the cross-sections will be surveyed (if the survey can be accomplished safely) to calibrate the hydraulic model. If the flow cannot be safely surveyed, the water surface elevations will be visually estimated and an appropriate Manning's n value will be used in the hydraulics model to estimate the flow relationship between the Middle Fork American River and Horseshoe Bar.

SCHEDULE:

Date	Activity
June 2007	Select calibration flows in consultation with the Aquatic and Recreation TWGs
July and August 2007	Select instream flow modeling site selection, installation of pressure transducers in the peaking reach
November 2007 through February 2008	Consult with the Aquatic TWG regarding: habitat suitability criteria, periodicity charts, and habitat modeling methods
March through October 2008	Conduct field surveys (topography, water surface elevations, velocities, substrate/cover data collection)
November 2008 through June 2009	Analyze data and prepare draft report
June 2009	Distribute draft report to the Aquatic TWG
July through September 2009	Aquatic TWG 90 day review and comment period
October through December 2009	Resolve comments and prepare final report
January 2010	Distribute final report to the Aquatic TWG and Plenary

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TABLES

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

Study Reaches/Sites	Bypass Reaches	Peaking Reach	Reach Upstream of Project Facilities	Site Name	Approximate Number of Mesohabitat Units to Sample [1]	Approximate Discharges for Model Calibration (cfs)[2] (V = Velocity data collection)				Modeling Methods
						Aquatic Habitat Modeling			Riparian /Geomorphic Modeling	
						Base	Med	High		
Duncan Creek										
Duncan Creek upstream of Diversion			●	IF D9.0	1-3	NA	NA	NA	Based on availability of spring high flows (HF)	Develop stage-discharge relationship for riparian vegetation comparisons
Duncan Creek below Diversion	●			IF D6.3/ D8.3	10	4-8	16[V]	44	HF[7]	1D
Middle Fork American River Upstream of Middle Fork Interbay										
Middle Fork American River upstream of French Meadows Reservoir			●	IF MF51.8	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons (potential)
Middle Fork American River below French Meadows Reservoir	●			IF MF44.7	10	4-8	48[V]	187	HF[7]	1D
Middle Fork American River Immediately above Middle Fork Interbay[5]	●			IF MF36.2	TBD	4-8	48[V]	187	HF[7]	1D
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay										
Middle Fork American River between Middle Fork Interbay and Ralston Afterbay	●			IF MF26.2	10	12-23	100[V]	374[8]	HF[7]	1D (some 2D for Amphibian habitat)

Table AQ 1-1. Instream Flow Study Reaches and Modeling Methods (continued).

Study Reaches/Sites	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Site Name	Approximate Number of Mesohabitat Units to Sample[1]	Approximate Discharges for Model Calibration (cfs)[2] (V = Velocity data collection)				Modeling Methods
						Aquatic Habitat Modeling			Riparian/ Geomorphic Modeling	
						Base	Med	High		
Middle Fork American River Downstream of Ralston Afterbay										
Middle Fork American River below Ralston Afterbay		●		IF MF14.1	10[3] or 0.5-1 mile[4]	75	368[v]	1000	HF[7]	2D/1D
Middle Fork American River above North Fork American River confluence		●		IF MF4.8	10[3] or 0.5-1 mile[4]	75	368[v]	1000	HF[7]	2D/1D
Rubicon River										
Rubicon River above Hell Hole Reservoir			●	IF R36.2	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons (potential)
Rubicon River below Hell Hole Reservoir	●			IF R25.7	10	10-20	80[v,9]	315[9]	HF[7]	1D
Rubicon River Near Ellicott Bridge	●			IF R20.9	10	10-20[6]	80[v,6]	315[6]	HF[7]	1D
Rubicon River Near Ralston Afterbay	●			IF R3.5	10	10-20[6]	80[v,6]	315[6]	HF[7]	1D (some 2D for Amphibian habitat)

Table AQ 1-1. Instream Flow Study Reaches and Modeling Methods (continued).

Study Reaches/Sites	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Site Name	Approximate Number of Mesohabitat Units to Sample [1]	Approximate Discharges for Model Calibration (cfs) [2] (V = Velocity data collection)				Modeling Methods
						Aquatic Habitat Modeling			Riparian/ Geomorphic Modeling	
						Base	Med	High		
North Fork Long Canyon Creek										
North Fork Long Canyon Creek upstream of Diversion			●	IF NFLC3.8	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons (potential)
North Fork Long Canyon Creek below Diversion	●			IF NFLC1.9	6	2	5[v]	11	HF[7]	1D
South Fork Long Canyon Creek										
South Fork Long Canyon Creek upstream of Diversion			●	IF SFLC4.2	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons
South Fork Long Canyon Creek below Diversion	●			IF SFLC2.3	6	2.5-5	10[v]	21	HF[7]	1D
Long Canyon Creek										
Long Canyon Creek below North and South Fork Long Canyon Creek	●			IF LC9.0	6	4.5-7	15[v]	47.5	HF[7]	1D

Table AQ 1-1. Instream Flow Study Reaches and Modeling Methods (continued).

Study Reaches/Sites	Bypass Reaches	Peaking Reach	Reaches Upstream of Project Facilities	Site Name	Approximate Number of Mesohabitat Units to Sample[1]	Approximate Discharges for Model Calibration (cfs)[2] (V = Velocity data collection)				Modeling Methods
						Aquatic Habitat Modeling			Riparian/ Geomorphic Modeling	
						Base	Med	High		
Other Tributaries										
North Fork Middle Fork American River			●	IF NFMF2.3	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons
North Fork American River			●	IF NF31.3	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons
North Fork American River			●	IF NF35.7	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for amphibian breeding habitat.
North Fork American River			●	IF NF53.7	1-3	NA	NA	NA	HF[7]	Develop stage-discharge relationship for riparian vegetation comparisons. Limited access at high flows.

[1]Number of habitat units to model in some reaches may be reduced due to circumstances in the particular reach. See text for details.
[2]The target discharges were developed in consultation with the Aquatic and Recreation TWG. The discharges are approximate (or target releases) and the exact discharge may vary depending on circumstances during the release period (e.g., ability to accurately release flows, weather, etc.). The intent of the target discharges is to provide water surface elevations and a velocity data set to calibrate the hydraulic models. If flows during field data collection greatly deviate from the target discharges identified here, the Aquatic TWG will be notified and a decision will be made if additional data is required to calibrate the hydraulic models. A detailed table used by the Aquatic TWG to develop the flows is included in Appendix A.
[3]The number of mesohabitat units sampled may need to be reduced in this reach because habitat units are very long.
[4]If two-dimensional modeling is determined to be the most appropriate method in the reach, up to one mile (0.5 – 1.0 miles) of habitat will be modeled.
[5]The accessible section of stream in this section of river is short in length and may not be representative.
[6]Hell Hole release plus natural accretion, approximate target flows are 10-20, 104, and 370 cfs
[7]Based on availability of spring high flows.
[8]The canyon is narrow in this reach and 374 cfs may be too high to safely work in the channel. A flow release will be made as close to 374 cfs as can be safely worked.
[9]The facilities below Hell Hole Reservoir are limited in their release capabilities. The medium flow may need to be reduced to approximately 65 cfs. The highest flow may depend on the availability of spill events. The Aquatic TWG will be informed regarding the flows that can be released and consulted regarding hydraulic model development options

Table AQ 1-2. Instream Flow Study Detailed Site Information.[1]

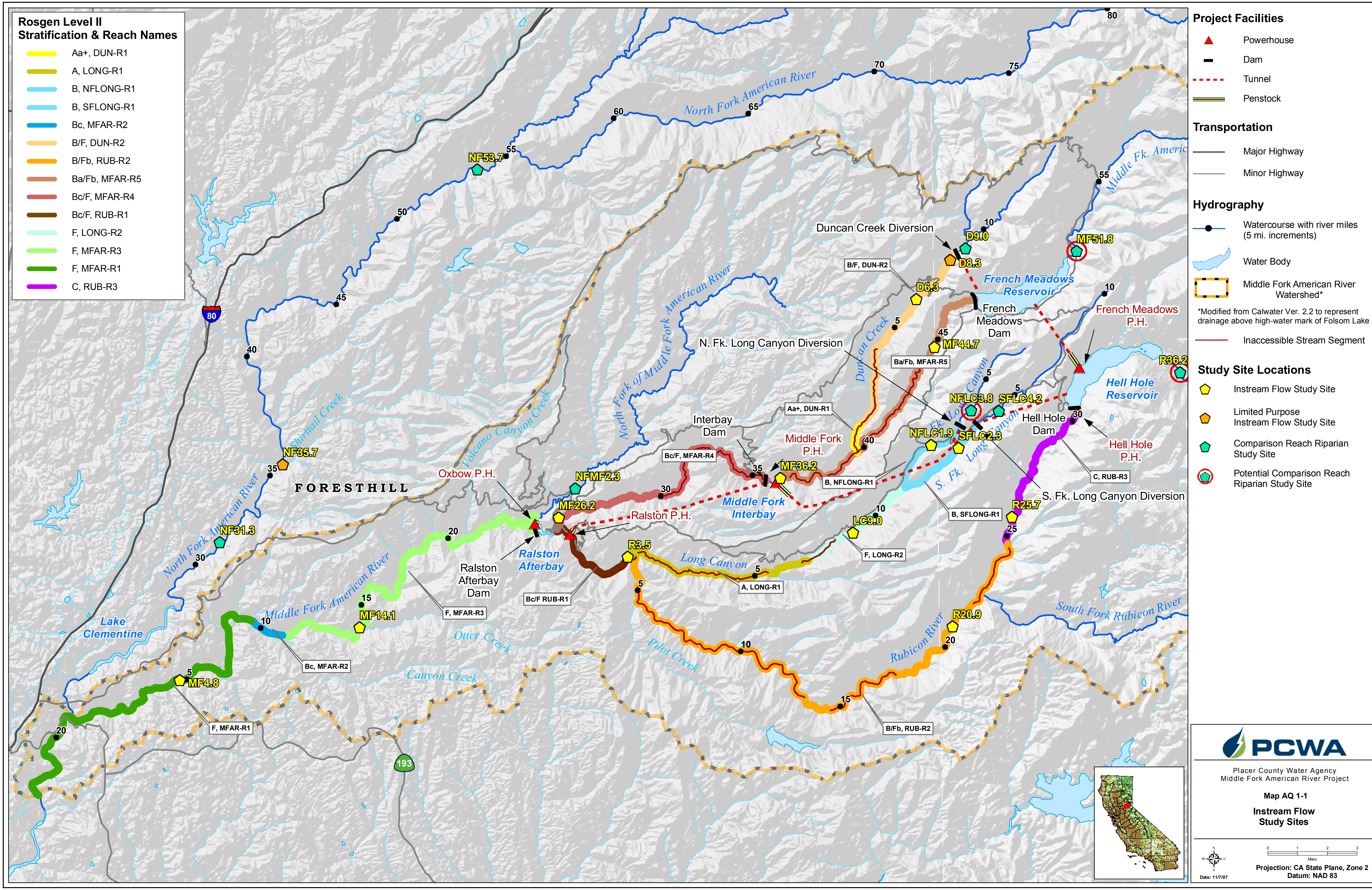
Site Name	Geomorphic Reach[2]	River Mile Location of Site	UTM-Coords at Beginning of Site (Downstream River Mile) (Zone 10N, NAD83)	Number of						Comments
				Mesohabitats (Cross-sections)					Special Purpose Cross-sections	
				Total	HGR	LGR	RUN	POOL		
Duncan Creek										
IF D9.0	Abv Diversion	9.0 - 9.2	718174, 4335012	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only
IF D6.3	DUN-R2	6.1 - 6.5	715520, 4332094	10 (22)	2 (4)	2 (2)	2 (4)	4 (12)	0	Instream Flow, Geomorphic, and Riparian Site
IF D8.3	DUN-R2	8.0 - 8.5	717228, 4334321	3 (3)	n/a	n/a	n/a	n/a	3	Limited Purpose Site 3 Geomorphic Cross-sections Only
Middle Fork American River Upstream of Middle Fork Interbay										
IF MF51.8	Abv Reservoir	Not a suitable comparison reach								Riparian Site (potential)
IF MF44.7	MFAR-R5	44.7 - 45.1	716554, 4329824	8 (19)	2 (3)	1 (1)	2 (3)	3 (12)	0	Instream Flow, Geomorphic, and Riparian Site
IFMF36.2[3]	MFAR-R5	36.0-36.2	708184, 4322341	11 (17)	3 (4)	1 (1)	3 (3)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay										
IF MF26.2	MFAR-R4	25.9 - 26.4	696388, 4320083	9 (23)[4] 2[8] (20)	2 (4)	2 (2)	2 (7)[4] 1 (20)	3 (10)[4] 1[8] (20)	0	Instream Flow, Geomorphic, and Riparian Site (2D Amphibian Site)
Middle Fork American River Downstream of Ralston Afterbay										
IF MF14.1[5]	MFAR-R3	13.8 – 14.5	685560, 4313771	10 (2D)[5]	1 (2D)[5]	3 (2D)[5]	2 (2D)[5]	4 (2D)[5]	0	Instream Flow, Geomorphic, and Riparian Site
IF MF4.8[5]	MFAR-R1	4.1 – 4.8	675208, 4310856	11 (2D)[5]	0[5]	3 (2D)[5]	4 (2D)[5]	4 (2D)[5]	0	Instream Flow, Geomorphic, and Riparian Site
Rubicon River										
IF R36.2	Abv Reservoir	Not a suitable comparison reach								Riparian Site (potential)
IF R25.7	RUB-R3	25.1 - 26.2	720666, 4319717	11 (26)	2 (4)	3 (4)	3 (6)	3 (11)	1	Instream Flow, Geomorphic, and Riparian Site
IF R20.9	RUB-R2	20.2 - 21.0	717255, 4314092	13 (22)	3 (5)[7]	1 (1)	5 (5)	4 (11)	0	Instream Flow, Geomorphic, and Riparian Site

Table AQ 1-2. Instream Flow Study Detailed Site Information.[1]

Site Name	Geomorphic Reach[2]	River Mile Location of Site	UTM-Coords at Beginning of Site (Downstream River Mile) (Zone 10N, NAD83)	Number of						Comments
				Mesohabitats (Cross-sections)					Special Purpose Cross-sections	
				Total	HGR	LGR	RUN	POOL		
IF R3.5	RUB-R1	2.6 - 3.7	697150, 4319188	11 (22)[6] 2[8] (20)	2 (3)	2 (3)	3 (5)	3 (11)[6] 2[8] (20)	0	Instream Flow, Geomorphic, and Riparian Site (2D Amphibian Site)
North Fork Long Canyon Creek										
IF NFLC3.8	Abv Diversion	Not a suitable comparison reach								Riparian Site (potential)
IF NFLC1.9	NFLONG-R1	1.7 - 2.1	716314, 4324314	12 (18)	2 (3)	3 (3)	3 (3)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
South Fork Long Canyon Creek										
IF SFLC4.2	Abv Diversion	4.6 - 4.9	720388, 4326694	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only
IF SFLC2.3	SFLONG-R1	2.2 - 2.6	717821, 4324192	11 (19)	2 (2)	2 (3)	3 (5)	4 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Long Canyon Creek										
IF LC9.0	LONG-R2	8.7 - 9.2	712229, 4319403	8 (18)	1 (2)	2 (4)	2 (3)	3 (9)	0	Instream Flow, Geomorphic, and Riparian Site
Other Tributaries (North Fork American River and North Fork of the Middle Fork American River)										
IF NFMF~~1.7~~2.3	Other Trib.	3.1 - 2.4	697380, 4321935	3 (4)	n/a	n/a	n/a	n/a	4	Riparian and Amphibian Site
IF NF31.3	Other Trib.	30.5 – 31.8	677360, 4317941	4 (4)	n/a	n/a	n/a	n/a	4	Riparian Site Only
IF NF35.7	Other Trib.	35.6 - 36.0	681311, 4322809	2 (2)	n/a	n/a	n/a	n/a	2	Amphibian Site Stage Only
IF NF53.7	Other Trib.	53.1 - 53.3	691215, 4338605	3 (3)	n/a	n/a	n/a	n/a	3	Riparian Site Only (Limited Access at High Flows)

[1]Table to be completed in the field and in coordination with the Aquatic TWG. Study sites and modeling cross-sections were selected in the field in coordination with the Aquatic TWG in August and October 2007. Detailed information regarding mesohabitats and cross-sections is available in the PCWA Instream Flow Field Site Visit Data Packet (PCWA 2007b).
[2]See Map AQ 1-2 for reach descriptions.
[3]The accessible section of stream in this section of river is short in length and may not be representative.
[4]Three of the pool and three of the run cross-sections will be replaced with 2D modeling for amphibian breeding habitat.
[5]Site selected for 2D modeling. No cross-sections are required for 2D modeling.
[6]Three of the pool cross-sections will be replaced with 2D modeling for amphibian breeding habitat.
[7]One cross-section comes from a run mesohabitat.
[8]2D Modeling sites will in some cases extend downstream into portions of other mesohabitat units.

MAPS


Rosgen Level II
Stratification & Reach Names
Aa+, DUN-R1
A, LONG-R1
B, NFLONG-R1
B, SFLONG-R1
Bc, MFAR-R2
B/F, DUN-R2
B/Fb, RUB-R2
Ba/Fb, MFAR-R5
Bc/F, MFAR-R4
Bc/F, RUB-R1
F, LONG-R2
F, MFAR-R3
F, MFAR-R1
C, RUB-R3
Project Facilities
Powerhouse
Dam
Tunnel
Penstock
Transportation
Major Highway
Minor Highway
Hydrography
Watercourse with river miles
(5 mi. increments)
Water Body
Middle Fork American River
Watershed*
*Modified from Calwater Ver. 2.2 to represent
drainage above high-water mark of Folsom Lake
Inaccessible Stream Segment
Study Site Locations
Instream Flow Study Site
Limited Purpose
Instream Flow Study Site
Comparison Reach Riparian
Study Site
Potential Comparison Reach
Riparian Study Site
North Fork American River
North Fork of Middle Fork American River
Middle Fork American River
Middle Fk. American
South Fork Rubicon River
Rubicon River
Duncan Creek
Long Canyon
S. Fk. Long Canyon
Volcano Canyon Creek
Shirttail Creek
Otter Creek
Canyon Creek
Pilot Creek
FORESTHILL
Lake
Clementine
French Meadows
Reservoir
Hell Hole
Reservoir
Middle Fork
Interbay
Ralston
Afterbay
Duncan Creek Diversion
N. Fk. Long Canyon Diversion
S. Fk. Long Canyon Diversion
French
Meadows
Dam
French Meadows
P.H.
Hell Hole
Dam
Hell Hole
P.H.
Interbay
Dam
Middle Fork
P.H.
Oxbow P.H.
Ralston P.H.
Ralston
Afterbay
Dam
NF53.7
NF35.7
NF31.3
NFMF2.3
MF26.2
MF36.2
MF44.7
MF51.8
MF14.1
MF4.8
D9.0
D8.3
D6.3
NFLC3.8
SFLC4.2
NFLC1.9
SFLC2.3
LC9.0
R3.5
R25.7
R20.9
R36.2
80
193
PCWA
Placer County Water Agency
Middle Fork American River Project
Map AQ 1-1
Instream Flow
Study Sites
Projection: CA State Plane, Zone 2
Datum: NAD 83
Date: 11/7/07
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APPENDIX AQ 1-A

Target Instream Flow Modeling Calibration Flows Working Table

Appendix AQ 1-A. Target Instream Flow Modeling Calibration Flows Working Table.

Facility/ Location	License Requirement[1]	1975 - 2003 Hydrology (cfs)		Target Calibration Flow/Release[3, 4, 8]	Approximate Duration (days)	Approximate Timing in 2008	Frog Breeding Considerations During Flow Releases	Comments
		Min, Avg, Max, 30% of Avg	% Exceedance 90, 80, 50, 20, 10, 40% of 10					
Duncan Creek Diversion Dam	**Dry: 4 cfs or natural Wet: 8 cfs or natural**	**Imp : 0.1, 13.0, 2560, 3.9 UnImp : 0.1, 38.6, 2800, 11.6**	**0.7, 1.1, 5.9, 13, 16, 6.4 0.8, 1.2, 8.2, 55, 110, 44.0**	**4-8, 16[5], 44**	**1, 2, 1**	**Sp, Sp, Sp**	**Likely Not**	---
French Meadows Dam	**Dry: 4 cfs Wet: 8 cfs**	**Imp : 2.6, 19.4, 3430, 5.8 UnImp : 0.2, 165.3, 10373, 49.6**	**5.5, 7.7, 9.6, 11, 14, 5.6 4.5, 9.3, 46.4, 248, 467, 187.0**	**4-8, 48[5], 187**	**1, 2, 1**	**Su, Sp/Early Su, Sp**	**Likely Not**	---
Middle Fork Interbay	**Dry: 12 cfs or natural Wet: 23 cfs or natural**	**Imp : 4.8, 67.9, 7600, 20.4 UnImp : 2.8, 344.4, 17359, 103.3**	**13.0, 18.0, 24.0, 46, 85, 34.1 15.3, 23.6, 98.4, 552, 935, 374.1**	**12-23, 100[5], 374[9]**	**1, 2, 1**	**Su, Sp/Early Su, Sp**	**May/Early June**	---
Below Oxbow Powerhouse	**All Times: 75 cfs bl. NF of MF Confluence**	**Imp : 41.0, 1123.7, 64500, 337.1 UnImp[2]: 15.4, 1244.5, 88473, 373.4 UnImp : 17.1, 1481.6, 87662, 444.5**	**119.0, 277.0, 743.0, 1510, 2310, 924.0 76.6, 116.3, 362.8, 1971, 3229, 1291.4 81.2, 124.0, 466.6, 2428, 3863, 1545.0**	**75, 368[5], 1000[5,6]**	**2, 4, 2**	**Su, Su, Su**	**Likely Not, Typical Summer Operations Are Within The Range Of Target Flow Releases**	---
Hell Hole Dam	**Dry: 10 cfs June 1 – Oct 14 6 cfs Oct 15 – May 31 Wet: 20 cfs May 15 – Dec 14 10 cfs Dec 15 – May 14**	**Imp : 0.3, 39.4, 17100, 11.8 UnImp[2]: 0.1, 278.9, 22985, 83.7 UnImp : 0.1, 405.7, 25762, 121.7**	**10.0, 12.0, 20.0, 23, 26, 10.4 5.1, 11.3, 75.1, 416, 789, 315.4 9.1, 19.6, 120.4, 596, 1174, 469.6**	**10-20, 80[5,10], 315[10]**	**3, 6 (** may be able to reduce), 3**	**Su, Sp/Early Su, Sp**	**May/Early June**	---
Rubicon Bl South Fork	**None**	**Imp : 8.3, 117.4, 27544, 35.2 UnImp[2]: 3.7, 356.9, 34973, 107.1 UnImp : 3.0, 599.1, 36353, 179.7**	**26.0, 32.3, 47.1, 106, 193, 77.3 19.2, 29.4, 101.3, 533, 924, 369.5 19.1, 35.4, 178.7, 933, 1667, 666.8**	**10-20*, 80*, 315* (*Hell Hole release plus natural accretion, approx. target 10-20, 104, 370)**	**** same days as above**	**Su, Sp/Early Su, Sp**	**May/Early June**	---
South Fork Long Canyon Diversion Dam	**Dry: 2.5 cfs or natural Wet: 5 cfs or natural**	**Imp : 0.0, 8.7, 1304, 2.6 UnImp : 0.0, 18.4, 1304, 5.5**	**0.4, 0.7, 3.4, 6, 10, 4.2 0.4, 0.7, 4.4, 30, 52, 20.7**	**2.5-5[7], 10[5], 21**	**1, 2, 1**	**Sp, Sp, Sp**	**Presently Unknown**	---
North Fork Long Canyon Diversion Dam	**All Times: 2 cfs or natural**	**Imp : 0.0, 5.1, 742, 1.5 UnImp : 0.0, 9.8, 742, 2.9**	**0.3, 0.4, 2.0, 4, 8, 3.2 0.3, 0.4, 2.4, 15, 27, 11.0**	**2[7], 5[5], 11**	**1, 2, 1**	**Sp, Sp, Sp**	**Presently Unknown**	---
Long Canyon Creek	**None**	**Imp : 0.1, 29.3, 3424, 8.8 UnImp : 0.1, 43.8, 3424, 13.1**	**1.2, 1.8, 8.3, 29, 64, 25.6 1.2, 1.8, 10.6, 65, 119, 47.5**	**4.5-7[7], 15[5], 47.5 (NF and SF releases above plus natural accretion)**	**1, 2, 1 (** same days as NF and SF above)**	**Sp, Sp, Sp**	**Presently Unknown**	---

[1]CDWR current year forecast of unimpeded run-off of the American River to Folsom Reservoir: Dry <1,000,000 a/f, Wet > 1,000,000 a/f.

[2]UnImp* = Unimpaired flows without PCWA Project, but impaired by SMUD.

[3]The lowest flow is the existing minimum flow. The medium flow is the higher of (A) the 2X the highest existing minimum flow or (B) the average of the 50% exceedance flow and the 30% of average flow (typically the latter). The highest flow is 40% of the 10% exceedance flow (allows modeling up to the 10% exceedance flow). Some exceptions exist to these rules. Below the Oxbow Powerhouse the maximum flow is set at 1000 cfs as this is the maximum flow that can be released through the powerhouse. In the North and South Forks of Long Canyon the medium flow target was set higher, between the minimum and high flows, to facilitate hydraulic modeling.

[4]These are target flows identified by the Aquatic TWG based on current information. The target flows may need to be modified if for instance the Recreation studies indicate that a flow outside the range of flows that can be modeled by the target flows needs to be evaluated.

[5]These flows are proposed for velocity data collection and will need to be maintained for several days during daylight hours. The other flows can be measured quickly and require shorter duration releases.

[6]An additional water surface elevation measurement near 2000 cfs will be measured if possible during spring runoff.

[7]An additional water surface elevation measurement lower than the minimum flow, will be obtained if possible, to facilitate low flow modeling.

[8]The target discharges were developed in consultation with the Aquatic and Recreation TWG. The discharges are approximate (or target releases) and the exact discharge may vary depending on circumstances during the release period (e.g., ability to accurately release flows, weather, etc.). The intent of the target discharges is to provide water surface elevations and a velocity data set to calibrate the hydraulic models. If flows during field data collection greatly deviate from the target discharges identified here, the Aquatic TWG will be notified and a decision will be made if additional data is required to calibrate the hydraulic models.

[9]The canyon is narrow in this reach and 374 cfs may be too high to safely work in the channel. A flow release will be made as close to 374 cfs as can be safely worked.

[10]The facilities below Hell Hole Reservoir are limited in their release capabilities. The medium flow may need to be reduced to approximately 65 cfs. The highest flow may depend on the availability of spill events. The Aquatic TWG will be informed regarding the flows that can be released and consulted regarding hydraulic model development options.

