Appendix M

Habitat Expansion for Spring-Run Chinook Salmon and Steelhead in the Lower Yuba River

Prepared for the HEA Steering Committee by Members of the Yuba Accord River Management Team

HABITAT EXPANSION FOR SPRING-RUN CHINOOK SALMON AND STEELHEAD IN THE LOWER YUBA RIVER

Prepared for the HEA Steering Committee

INTRODUCTION

Representatives of the Habitat Expansion Agreement (HEA) Steering Committee provided the Yuba Accord River Management Team (RMT) with an overview of the HEA project evaluation, selection and approval process. In response to the HEA Steering Committee's request for additional information regarding biological, physical and operational considerations pertinent to the lower Yuba River, the HEA Steering Committee and the Yuba Accord RMT held an informal technical workshop on October 6, 2009. Background information relevant to the lower Yuba River was provided to the HEA Steering Committee, and project-specific implementation considerations were discussed. HEA Steering Committee provided the RMT with a list of questions regarding habitat expansion issues on the lower Yuba River. Subsequent to the HEA Steering Committee and the Yuba Accord RMT informal technical workshop, the RMT conducted a field tour of the lower Yuba River on October 7, 2009 and reviewed and further discussed potential habitat expansion projects.

The RMT does not feel that it would be appropriate to provide comments as a group. Members of the RMT have different views and perspectives about some habitat restoration measures, and may choose to provide comments on behalf of their respective agencies. However, some of the members of the RMT did work together to draft comments for the HEA Steering Committee, and to provide some feedback on the questions posed. Those comments are incorporated into this document.

The Yuba Accord RMT membership includes Yuba County Water Agency (YCWA), California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), the South Yuba River Citizens League (SYRCL), the Bay Institute, Friends of the River, Trout Unlimited, PG&E, and Department of Water Resources (DWR), with the collaboration of the Pacific States Marine Fisheries Commission (PSMFC) and University of California at Davis (UC Davis). RMT responsibilities include providing input to real-time operational decisions, developing and implementing a Monitoring and Evaluation Program (M&E Program), and guiding the implementation of specific habitat restoration pilot projects. Using revenues generated by the water transfer program component of the Yuba Accord, YCWA is providing $6 million (about $550,000 annually) to implement the M&E

Program, and an additional $300,000 of funding dedicated to development and implementation of pilot restoration projects.

BACKGROUND

GOALS OF THE HABITAT EXPANSION AGREEMENT

The overall goal of the HEA is to expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon (and steelhead) in the Sacramento River Basin. The specific Habitat Expansion Threshold (HET) is to expand spawning, rearing and adult habitat sufficiently to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon for spawning in the Sacramento River Basin. The HET is focused on spring-run Chinook salmon as the priority species, because expansion of habitat for spring-run Chinook salmon typically accommodates steelhead as well.

LOWER YUBA RIVER POTENTIAL TO MEET IDENTIFIED HABITAT EXPANSION AGREEMENT GOALS AND THRESHOLDS

The lower Yuba River supports persistent populations of spring-run Chinook salmon and steelhead, and historically supported the largest, naturally-reproducing population of steelhead in the Central Valley (CDFG 1996). The lower Yuba River is among the last Central Valley floor tributaries supporting populations of naturally-spawning spring-run Chinook salmon and steelhead.

The lower Yuba River, extending approximately 24 miles from Englebright Dam downstream to the confluence with the Feather River near Marysville, is the largest river in the Central Valley not supported by a hatchery (**Figure 1**). The lower Yuba River has a high potential to meet the HEA goals and thresholds, and to meet the NMFS recovery objectives of supporting a viable independent population of spring-run Chinook salmon (and steelhead) primarily because: (1) the river continues to support persistent populations of spring-run Chinook salmon and steelhead; (2) flow and water temperature conditions under the Lower Yuba River Accord are suitable to support all life stage requirements; (3) the river does not have a hatchery on it; and (4) high habitat enhancement potential. These attributes are particularly important when considering long-term climate change (discussed below).

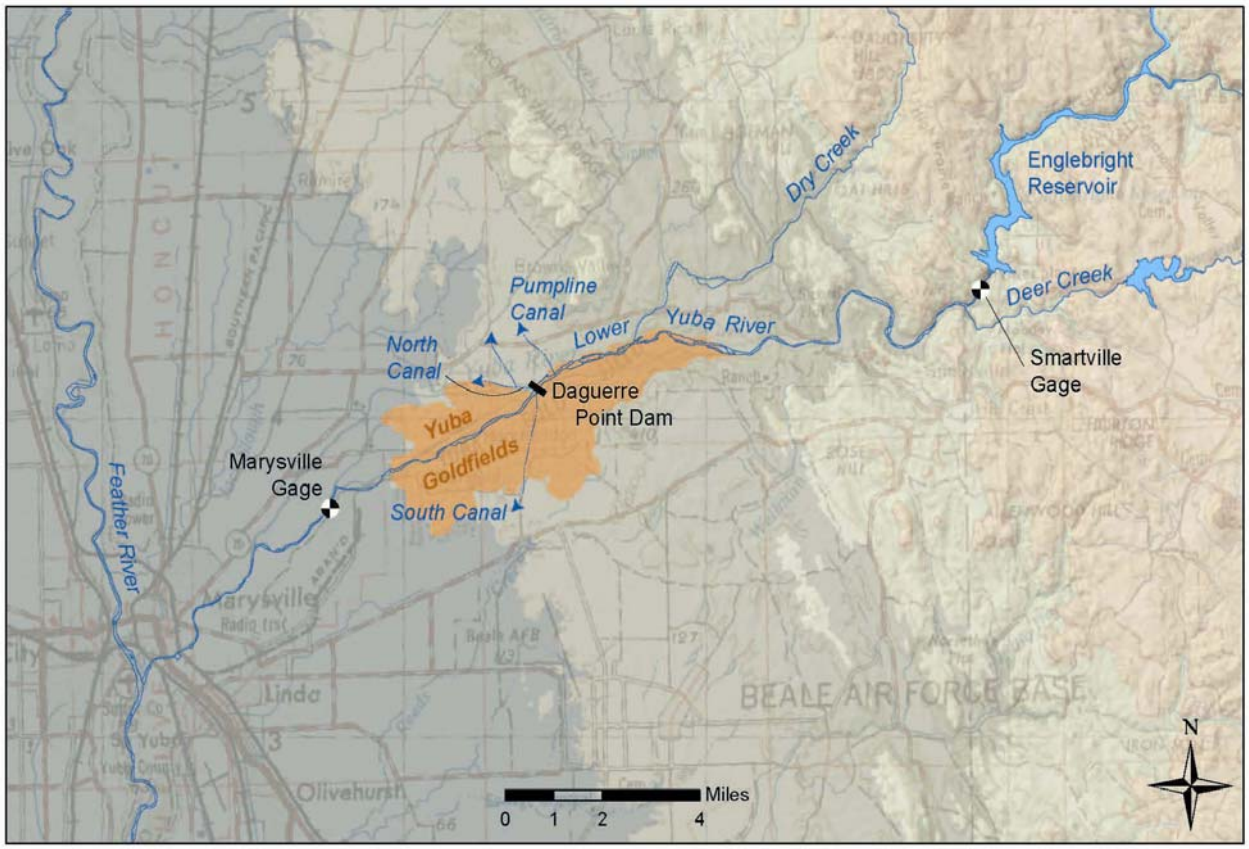


Figure 1. Lower Yuba River

The NMFS (2009) Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon, and the Distinct Population Segment of Central Valley Steelhead ("Draft Recovery Plan") recognizes the importance and potential to increase spring-run Chinook salmon and steelhead populations in the lower Yuba River. The Draft Recovery Plan established three priority levels to help guide recovery efforts for watersheds that are currently occupied, and are referred to as Core 1, 2, and 3 populations. Core 1 Populations are highest priority, have a known ability or potential to support viable populations, and have the capacity to respond to recovery actions (NMFS 2009). Spring-run Chinook salmon and steelhead in the lower Yuba River are Core 1 populations (NMFS 2009). Core 1 populations form the foundation of the recovery strategy, and should be the first focus of an overall recovery effort (NMFS 2009).

The Draft Recovery Plan states that "*…many of the processes and conditions that are necessary to support a viable independent population of spring-run Chinook salmon can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*".

After two one-year pilot programs in 2006 and 2007, on March 18, 2008 the State Water Resources Control Board (SWRCB) approved the consensus-based, comprehensive Yuba Accord to protect and enhance aquatic habitat in the lower Yuba River. The Yuba Accord will be in effect at least until 2016. Beyond 2016, it is anticipated that the Lower Yuba River Accord flow schedules will be the basis of new FERC license requirements for the lower Yuba River.

Presently, the lower Yuba River is one of the few Central Valley floor tributaries that consistently provides suitable water temperatures for salmonids throughout the year. In fact, water temperature evaluations conducted for the Yuba Accord EIR/EIS indicate that Yuba River water temperatures generally remain suitable for all life stages of spring-run Chinook salmon and steelhead. Water temperatures generally remain below 58°F year-round (including summer months) at Smartsville, and below 60°F year-round at Daguerre Point Dam (YCWA *et al.* 2007). At Marysville, water temperatures generally remain below 60°F from October through May, and below 65°F from June through September (YCWA *et al*. 2007).

Habitat Conditions

Major factors (not directly flow-related) continuing to influence the status of naturally-spawning spring-run Chinook salmon and steelhead in the Yuba River include: (1) blockage of historic spawning habitat resulting from the construction of the U.S. Corp of Engineers (Corps) Englebright Dam in 1941, which has implications for the spatial structure of the populations; (2) impaired adult upstream passage at the Corps Daguerre Point Dam; (3) unsuitable spawning conditions in the uppermost area (i.e., Englebright Dam to the Narrows) of the lower Yuba River; and (4) impaired juvenile downstream passage at Daguerre Point Dam. Additionally, other factors continue to influence juvenile spring-run Chinook salmon and steelhead habitat suitability including sparse and restricted amounts of riparian vegetation and associated instream object and overhanging object cover, limited aquatic habitat complexity and diversity, and altered natural river function and morphology in the lower Yuba River (CALFED and YCWA 2005).

The section of the lower Yuba River extending from Englebright Dam downstream through the Narrows (Englebright Dam Reach) is steep and contains a series of rapids, runs, and deep pools confined by a bedrock canyon (CALFED and YCWA 2005). Habitats classified as moderate gradient riffles are found only in this reach of the lower Yuba River (CALFED and YCWA 2005). Salmonid spawning gravels are scarce in the Englebright Dam Reach due to the truncation of gravel recruitment resulting from the construction of Englebright Dam and the high-energy hydraulic nature of this reach. Furthermore, the quantity and quality of salmonid spawning habitat in this reach has been significantly reduced by the deposition of large, consolidated rock fragments (i.e., “shot-rock”) downstream of Englebright Dam, resulting from dam construction and hillside landslides during major floods (Pasternack 2009). Additionally, local instream gravel mining has influenced potential spawning habitat in this reach.

Downstream of the Englebright Dam Reach, spawning gravels are abundant and generally of high quality throughout the lower Yuba River with the exception of the lowermost reach (Simpson Lane Reach) (YCWA *et al.* 2000).

Although montane hardwoods occupy much of the Englebright Dam Reach, the steep-walled canyons preclude riparian growth immediately adjacent to the river channel, thereby affecting aquatic habitat suitability (CALFED and YCWA 2005). In the vicinity of Daguerre Point Dam, the lower Yuba River is largely devoid of sufficient riparian vegetation commonly associated with highly suitable juvenile salmonid rearing habitat conditions (CALFED and YCWA 2005). The Yuba Goldfields area, comprised of approximately 11,000 acres of land adjoining the lower Yuba River near Daguerre Point Dam, is the result of intensive gold dredging in the late 1800s and early 1900s when up to 27 gold dredges simultaneously operated along the river and floodplain (Smith 1990). The Yuba Goldfields section near Daguerre Point Dam is largely devoid of streamside vegetation.

Shaded riverine aquatic (SRA) habitat generally occurs in the lower Yuba River as scattered, short strips of low-growing woody species (e.g., *Salix sp*.) adjacent to the shoreline (CALFED and YCWA 2005). The most extensive and continuous segments of SRA habitat occur along bars where recent channel migrations or avulsions have cut new channels through stands of riparian vegetation. Due to a lack of riparian vegetation throughout much of the lower Yuba River, coupled with Englebright Dam precluding the downstream transport of woody material, instream woody material also is limited in the lower Yuba River (CALFED and YCWA 2005).

In recent years, another factor influencing the status of naturally-spawning spring-run Chinook salmon and steelhead in the lower Yuba River included flow fluctuations (YCWA *et al.* 2007; CALFED and YCWA 2005). However, since the issuance of the SWRCB Yuba Accord Decision, a full-flow bypass structure has been installed on the Narrows II hydropower facility which will essentially eliminate the potential for flow fluctuations to occur in the lower Yuba River associated with maintenance and operation of the Narrows II facility.

MONITORING AND EVALUATION

Anadromous salmonid management in California's Central Valley suffers from the lack of sufficiently-funded, comprehensive, and sustained monitoring programs. The lower Yuba River is unique among Central Valley Rivers in that an ongoing monitoring and evaluation program, based on quantified expressions of the viable salmonid population (VSP) concept, provides the opportunity to develop and evaluate the implementation of habitat expansion projects.

The Yuba Accord includes a Fisheries Agreement, under which YCWA cooperatively manages the flows of the lower Yuba River according to certain specified criteria, and provides $550,000 of annual funding for monitoring and evaluation of fish populations (including spring-run Chinook salmon and steelhead), aquatic habitat conditions, and fish-habitat interactions through

the year 2016. Additionally, extensive in-kind contributions from YCWA and CDFG, plus solicitation of grant funding when available, further extend the monitoring and evaluation budget.

The Yuba Accord River Management Fund is administered by the RMT, which has developed and is implementing the Yuba Accord M & E Program. Because of the complexity associated with the multiple considerations for monitoring and evaluation efforts within the lower Yuba River, the M&E Program framework is designed to evaluate whether implementation of the Yuba Accord maintains fish in good condition, and promotes viable salmonid populations in the lower Yuba River.

McElhany *et al.* (2000) developed the "Viable Salmonid Population" (VSP) concept to facilitate establishment of Evolutionarily Significant Unit (ESU)-level delisting goals and to assist in recovery planning by identifying key parameters related to population viability. As presented in Good *et al.* (2007), criteria for viable salmonid populations (VSP) are based upon measures of population parameters that reasonably predict extinction risk and reflect processes important to populations: (1) abundance; (2) productivity; (3) diversity; and (4) spatial structure (McElhany *et al.* 2000). Abundance is critical, because small populations are generally at greater risk of extinction than large populations. Stage-specific or lifetime productivity (i.e., population growth rate) provides information on important demographic processes. Abundance and productivity data are used to asses the status of populations of threatened and endangered ESUs (Good *et al.* 2005). Genotypic and phenotypic diversity are important in that they allow species to use a wide array of environments, respond to short-term changes in the environment, and survive long-term environmental change. Spatial structure reflects how abundance is distributed among available or potentially available habitats and how it can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change.

In the M&E Program, performance indicators associated with each of the VSP parameters (Abundance, Productivity, Diversity and Spatial Structure) and analytical steps ("analytics") to address each of these performance indicators are provided separately for the adult and juvenile lifestages of the anadromous salmonids, including spring-run Chinook salmon and steelhead, in the lower Yuba River. Completed, ongoing, or planned M&E Program activities include the following:

- Flow and Water Temperature Monitoring
- Morphological Unit & Mesohabitat Classification
- Substrate and Cover Classification and Mapping
- Topographic Mapping
- Development of a Digital Elevation Model of the entire 24 miles of the lower Yuba River
- Development of a 2-D Hydraulic Model
- Acoustic Tracking of Phenotypic Spring-run Chinook Salmon

- Genetic Analysis of Spring-run and Fall-run Chinook Salmon
- Chinook Salmon Escapement (Carcass) Surveys
- Adult Salmonid Biological Sampling (otoliths, scales, tissue, CWT)
- VAKI Riverwatcher System Monitoring of Fish Passage at Corps' Daguerre Point Dam
- Angler Surveys
- Redd (and Superimposition) Surveys
- Juvenile Outmigration Rotary Screw Trapping
- Juvenile Habitat Utilization Snorkel Surveys

Information obtained through the Yuba Accord M&E Program provides a basis to develop and consider habitat expansion projects in the lower Yuba River, within the context of the HET and expanded habitat utilization. Additionally, the Yuba Accord M&E Program will serve as a baseline for the future evaluation of habitat expansion projects in the lower Yuba River and, if lower Yuba River habitat expansion projects are implemented in a timely fashion, the Yuba Accord M&E Program could directly evaluate population response, as well as serve as a baseline.

LOWER YUBA RIVER HABITAT EXPANSION CONSIDERATIONS

The intent of the HEA is to create "permanent" solutions to problems, or at least to provide benefits through the term of a typical Federal Energy Regulatory Commission license (i.e., up to 50 years). Where possible, projects should address the root cause of current habitat constraints rather than dealing with their symptoms or surface expression, and should consider the potential effects of climate change.

CLIMATE CHANGE AND HABITAT EXPANSION SUSTAINABILITY

The scientific, political, and public priorities associated with long-term climate change are evolving toward determining its ecosystem impacts, and developing strategies for adapting to those impacts.

Studies suggest that up to 40 percent of Pacific Northwest salmon populations may be lost by 2050 (Battin *et al.* 2007). In California and the Pacific Northwest, most wild salmon populations are extinct or imperiled in 56 percent of their historical range (Francis and Mantua 2003). Studies also suggest that about one-third of the current habitat for salmon and other coldwater fish will no longer be suitable for them by the end of this century as key temperature thresholds are exceeded (Thomas *et al.* 2009). Because climate change impacts on salmon and steelhead habitat is projected to be negative, climate change is expected to hinder efforts to recover depleted

populations of Chinook salmon and steelhead (Thomas *et al.* 2009). Climate change also could be reasonably expected to affect the sustainability of habitat expansion projects in the Central Valley.

In California, there have been observed changes in air temperatures, annual precipitation, runoff, and sea levels over the past century (Anderson *et al.* 2008). Regional-scale climate models for California are in broad agreement that temperatures in the future will warm significantly, total precipitation may decline, and snowfall will decline significantly (Lindley *et al.* 2007). Literature suggests that by 2100, mean summer temperatures in the Central Valley may increase by 2 to 8°C, precipitation will likely shift to more rain and less snow, with significant declines in total precipitation possible, and hydrographs will likely change, especially in the southern Sierra Nevada mountains. Thus, climate change poses an additional risk to the survival of salmonids in the Central Valley.

Long-term climate change considerations emphasize the importance of implementing habitat expansion projects in locations where they would be expected to be sustainable. The lower Yuba River has a high potential to sustain spring-run Chinook salmon and steelhead populations, primarily because of suitable flows and the consistent flow of cold water.

The lower Yuba River is expected to provide the most suitable water temperature conditions for anadromous salmonids, of all Central Valley floor rivers, in consideration of long-term climate change because of specific physical and hydrologic factors. New Bullards Bar Reservoir is a deep, steep-sloped reservoir with ample coldwater pool reserves. Throughout the period of operations of New Bullards Bar Reservoir (1969 through present), which encompasses the most extreme critically dry year on record (1977), the coldwater pool in New Bullards Bar Reservoir has not been depleted. Since 1993, coldwater pool availability in New Bullards Bar Reservoir has been sufficient to accommodate year-round utilization of the lower river outlets at the direction provided by CDFG in order to provide cold water to the lower Yuba River.

RECOVERY ACTIONS AND HABITAT EXPANSION PROJECTS

The conceptual recovery scenarios for spring-run Chinook salmon and steelhead in the Draft Recovery Plan include: (1) securing extant populations by implementing key habitat restoration actions, particularly in the near term; and (2) establishing additional viable independent populations.

In order to secure viable independent populations of spring-run Chinook salmon and steelhead in the lower Yuba River, the Draft Recovery Plan identified several key near-term and long-term habitat restoration actions, including the following:

- Continue implementation of the Yuba Accord flow schedules to provide suitable habitat (flow and water temperature) conditions for all life stages
- Implement a spawning habitat rehabilitation program in the uppermost area (i.e., Englebright Dam to the Narrows) of the lower Yuba River
- Improve riparian habitats for juvenile salmonid rearing
- Create and restore side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas
- Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing
- Improve adult and juvenile salmonid passage at Daguerre Point Dam

According to HEA Evaluation Criterion (b), a number of projects might need to be concentrated in a single watershed to result in sufficient environmental change to meet the HET.

The HEA Steering Committee considered several individual habitat expansion actions in combination for the lower Yuba River. The HEA Steering Committee considered integration of these actions because they believed that the actions potentially benefited each other. The following actions are being considered by the HEA Steering Committee for the lower Yuba River:

- Spawning habitat rehabilitation of the Englebright Dam Reach, including Deer Creek
- Side channel, floodplain and riparian habitat restoration
- Operation of a segregation weir in the 6-mile reach between the Highway 20 Bridge and Englebright Dam
- Fish passage improvements at Daguerre Point Dam

Total funding availability, engineering feasibility, operations and maintenance, and action sustainability may require consideration of the priority of specific actions within the suite of potential actions for the lower Yuba River, and consideration of each action's ability to achieve biological benefit and accomplishment of the goals of the HEA. For example, two of the four actions directly address the overall goal of the HEA, which is to expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead in the Sacramento River Basin: (1) spawning habitat rehabilitation of the Englebright Dam Reach; and (2) side channel, floodplain and riparian habitat restoration.

The two remaining actions do not directly address the overall goal of the HEA: (3) operation of a segregation weir in the 6-mile reach between the Highway 20 Bridge and Englebright Dam; and (4) fish passage improvements at Daguerre Point Dam.

- Design, construction, operation and maintenance of a segregation weir does not, unto itself, expand habitat. Rather, the stated intent is to accomplish geographic distinction and

thereby reduce the potential for genetic introgression between fall-run Chinook salmon and spring-run Chinook salmon.

- Although improved fish passage at Daguerre Point Dam would help to facilitate access to available upstream habitat, it would not expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead.

Spawning Habitat Rehabilitation of the Englebright Dam Reach, Including Deer Creek

Englebright Dam was constructed by the Corps in 1941 on the lower Yuba River to trap hydraulic mining debris resulting from the gold rush in California. The dam has been blocking the natural recruitment of spawning gravels in the Englebright Dam Reach, extending approximately 0.8 miles downstream from Englebright Dam to the confluence with Deer Creek, for over 65 years. In many areas of this reach, the spawning gravels are completely absent and have been replaced by a bedrock substrate. Spring-run Chinook salmon have been observed to migrate and hold in this area of river, but spawning success has been largely impacted by a lack of suitable spawning habitat.

The Englebright Dam Reach spawning habitat rehabilitation component is highly feasible, based upon a 5-year (2003-2008) comprehensive investigation conducted to ascertain the linkages between hydrology, geomorphology, and ecology (Pasternack 2009), and a 2007 pilot gravel injection study. Pasternack (2009) highly recommended that spawning habitat rehabilitation in this reach be designed using the Spawning Habitat Integrated Rehabilitation Approach (SHIRA) that is in use on the Feather, American, Trinity, and Mokelumne Rivers. For details, see the website at http://shira.lawr.ucdavis.edu. Using SHIRA would ensure that a project of this magnitude would immediately yield spawning habitat, as has been thoroughly documented on the Mokelumne and Trinity rivers.

There are three shot-rock deposits in the Englebright Dam Reach. First, an extremely coarse and thin veneer occurs at the upper end of the reach on river right. Second, angular cobble forming a bar is located just upstream of the USGS Gaging Station rapid that impacts the gaging station every time there is a flood. Third, a mixture of angular gravel, cobbles, and boulders is located upstream of the junction with Deer Creek on river right. This deposit is called Sinoro Bar. Thus, there are two big deposits on river right and one small deposit on river left (Pasternack 2009).

To yield high quality Chinook spawning habitat in the Englebright Dam Reach, Pasternack (2009) stated that a spawning habitat rehabilitation project must accomplish two things. First, it must remove the massive amount of shot-rock off of Sinoro Bar, returning that entire point bar to the elevation of the water's surface at approximately 800 cfs. Second, it must place suitable spawning gravel into the river, substantially filling in the present channel and changing site-

specific hydraulic characteristics to new suitable patterns. Shot-rock removal, localized grading, and gravel injection will improve spawning habitat by restoring natural channel morphological units, restoring natural channel form and unit types synonymous with spawning habitat values (i.e. pool, riffle, bank structure, LWD retention, etc.), and restoring natural spawning substrate absent in this reach. Once spawning habitat rehabilitation is performed in this reach, it would be possible to sustain the project using gravel injection at the upper portion of this reach (e.g., downstream from the Narrows II Powerhouse).

Wheaton *et al.* (2004) further described how spawning habitat rehabilitation is segregated into three categories: (1) gravel augmentation; (2) hydraulic structure placement; and (3) spawning bed enhancement. Gravel augmentation (also known as gravel injection, infusion or replenishment) involves dumping clean spawning gravels into piles along the edges of a river (usually just downstream of a dam). For this approach to yield usable spawning habitat, practitioners must assume that high flows occur in the near future, that augmented gravels entrain during high flows, and that gravels do not fill mining holes or pools but instead deposit as bars or riffles. Hydraulic structure placement entails placement of large woody debris (LWD), boulder clusters, v-dams or similar structures to alter hydrodynamics in such a way that spawning gravels are deposited in the vicinity of the structures (Brookes *et al*. 1996 in Wheaton *et al.* 2004). The technique relies on an adequate supply of gravel from upstream and an active bedload transport regime to deliver it. Such structures may also be intended to provide refugia, cover and add habitat heterogeneity (Van-Zyll-De-Jong *et al*. 1997 in Wheaton *et al.* 2004). Spawning bed enhancement is the direct modification of the bed to provide immediate spawning habitat (e.g., riffle construction, bed ripping and riffle cleansing). Although bed enhancement may quickly provide usable spawning habitat, limited project lifespan may result without adequate consideration of geomorphic processes or regular gravel replenishment (Kondolf 2000b in Wheaton *et al.* 2004). In summary, spawning habitat rehabilitation projects are typically reach-scale restoration activities sometimes, but not necessarily, nested within a larger, long-term, basin-scale management plan (e.g., McBain and Trush 1997 in Wheaton *et al.* 2004).

Spawning habitat rehabilitation in the Englebright Dam Reach is expected to expand available spawning habitat primarily for spring-run Chinook salmon, because suitable flow and water temperature regimes already exist. A pilot gravel injection project was successfully completed in the Englebright Dam Reach during November 2007. Approximately 361 cubic yards of spawning gravels were injected below the Narrows II Powerhouse. Aerial redd surveys conducted during 2008 and snorkel surveys conducted during 2009 identified spring-run Chinook salmon utilizing small, localized pockets of gravel created by this pilot project. However, additional gravels, as well as hydraulic structure placement and spawning bed enhancement, are needed to fully rehabilitate this reach. Thus, the Englebright Dam Reach spawning habitat rehabilitation project is specifically comprised of shot-rock removal from Sinoro Bar, hydraulic structure placement and spawning bed enhancement of Sinoro Bar, gravel

injection downstream of Narrows II Powerhouse for recruitment to Sinoro Bar, and possible direct placement of gravel on Sinoro Bar itself (**Figure 2**).

Figure 2. The Sinoro Bar site for spawning habitat rehabilitation.

Spawning habitat rehabilitation in the Englebright Dam Reach of the lower Yuba River could provide additional spawning habitat to achieve the specific HET to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon spawning annually. A realistic approach to estimate the number of spring-run Chinook salmon that would be expected to utilize the habitat expansion resulting from the Englebright Dam Reach spawning habitat rehabilitation project is based on observations of actual SHIRA sites. The most data from SHIRA rehabilitation sites in the Central Valley is available from the Mokelumne River. For those SHIRA sites, 2005 redd surveys resulted in a calculation of 1 Chinook salmon redd per $17m^2$. For the Sinoro Bar project, an approximate area estimate of 40,500 m^2 could be expected to result in establishment of 2,382 spring-run Chinook salmon redds. Assuming 2 spring-run Chinook salmon adults per redd, the result would be 4,764 adult spring-run Chinook salmon.

Gravel augmentation in lower Deer Creek has been included as a potential component of the project. Spawning habitat rehabilitation in lower Deer Creek may have substantial benefit for steelhead. However, concerns persist regarding the efficacy of gravel augmentation in Deer Creek due to: (1) flow patterns associated with releases from Lake Wildwood; (2) the presence of a significant falls located approximately 500 feet upstream of the mouth of Deer Creek which

is likely impassable during drier years, although steelhead have been found above the falls during wetter years with high runoff (CDFG 1991); and, particularly (3) extant water temperatures during the spring-run Chinook salmon spawning period.

Side Channel, Floodplain, and Riparian Habitat Restoration

As previously mentioned, several factors continue to influence juvenile spring-run Chinook salmon and steelhead rearing habitat suitability: (1) including sparse and restricted amounts of riparian vegetation and associated instream object and overhanging object cover; (2) limited aquatic habitat complexity and diversity; and (3) altered natural river function and morphology in the lower Yuba River. SRA habitat generally occurs in the lower Yuba River as scattered, short strips, with the most extensive and continuous segments of SRA habitat occurring along bars where recent channel migrations or avulsions have cut new channels through stands of riparian vegetation.

The juvenile salmonid rearing habitat expansion actions directly address the overall goal of the HEA, which is to expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead. Moreover, these actions are consistent with several key near-term and long-term habitat restoration actions identified in the Draft Recovery Plan for the lower Yuba River, including: (1) the creation and restoration of side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas; (2) improvement of riparian habitats for juvenile salmonid rearing; and (3) implementation of projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing.

Several ongoing activities addressing habitat enhancement opportunities in the lower Yuba River have recently been funded by the RMT, Anadromous Fish Restoration Program (AFRP), and PG&E. These activities include conducting studies and obtaining fluvial/geomorphological information necessary to guide habitat enhancement actions, and also include the conduct of pilot habitat enhancement projects in the lower Yuba River. The RMT M&E Program has completed or soon will have available invaluable information to guide specific spring-run Chinook salmon (and steelhead) juvenile rearing habitat enhancement actions. In addition to habitat utilization, specific physical habitat capabilities, which will be generally available (including to the HEA Steering Committee), to guide habitat enhancement actions include:

- Morphological Unit & Mesohabitat Classification
- Substrate and Cover Classification and Mapping
- Topographic Mapping
- Development of a Digital Elevation Model of the entire 24 miles of the lower Yuba River
- Development of a 2-D Hydraulic Model

In addition, SYRCL has been funded by the AFRP to conduct a pilot project, taking advantage of a conservation easement on Western Aggregates land, directed towards enhancing juvenile salmonid rearing habitat. The pilot project is considering creation of new functional floodplain habitat, off-channel rearing habitat (backwaters and side-channels), installation of large wood structure and enhancement of riparian vegetation. At present, a pre-project assessment is being conducted to inform opportunities for juvenile salmonid habitat enhancements in a 3.5-mile study reach from Parks Bar to Hammon Bar on the lower Yuba River. The pre-project assessment is addressing the geomorphic, hydrologic, and biotic factors influencing: (1) available floodplain habitat; (2) creation and maintenance of marginal and off-channel rearing habitat; and (3) riparian recruitment, growth, and survival in the project area. Current work includes a public outreach component to inform nearby landowners, concerned stakeholders, and watershed groups about the proposed pilot project. Information obtained through this pilot project also will inform future habitat enhancement actions in the lower Yuba River.

Members of the RMT conducted a field tour of the lower Yuba River on October 7, 2009, and among other activities reviewed and further discussed potential spring-run Chinook salmon (and steelhead) juvenile rearing habitat expansion projects. Some of the RMT representatives believe that the most beneficial and cost-effective type of juvenile rearing habitat expansion projects, and those that would yield the most immediate benefits, would be the creation of new side-channel habitats associated with existing stands of riparian vegetation not hydraulically connected to the river channel. Specifically, the benefit of new side-channel habitats would: (1) increase and maintain existing riparian vegetation; (2) provide instream object and overhanging object cover; (3) provide new SRA, and associated allochthonous food sources for rearing juveniles; (4) increase aquatic habitat complexity and diversity; (5) provide habitats more consistent with those previously available in the upper watershed; and (6) provide predator escape cover, and overall increased survival of juvenile spring-run Chinook salmon and steelhead.

On October 13, 2009 a small group of RMT members met to further identify and refine potential juvenile salmonid rearing habitat expansion actions for the lower Yuba River. Following a thorough discussion regarding project effectiveness within a fluvial geomorphological perspective, this stakeholder group identified nine habitat enhancement actions/locations to provide rearing habitat for juvenile spring-run Chinook salmon and steelhead. Essentially, the group reviewed locations along the lower Yuba River where residual riparian vegetation indicated that the river channel had previously existed. In several of these locations, the hydraulically disconnected river channel could be re-connected fairly easily, thus developing additional secondary (side-channel) habitat. Based on work conducted in the lower Yuba River by Professor Greg Pasternack (UC Davis) and the RMT, the group determined that these side-channel habitat locations are viable for re-construction.

From upstream to downstream in the lower Yuba River, they have been identified as follows:

Upstream of Daguerre Point Dam

The lower Yuba River extends approximately 12.6 miles from Englebright Dam to Daguerre Point Dam. The following juvenile salmonid rearing habitat enhancement action sites are located within this section of the lower Yuba River.

Site 1 (**Figure 3**) "Upper Gilt Edge" – Enhance the structural complexity of the left bank of the main river channel. Line the left bank of the main channel with boulder/wood structures, and enhance an ephemeral backwater with boulder/wood structures to maintain aquatic habitat.

Site 2 (**Figure 4**) "First Island" – Create a side channel in an existing swale within a stand of relatively dense riparian vegetation. Enhance the structural complexity of the left bank of the main river channel by placement of large wood material. Approximate length 1,500 ft, potential area 30,000 ft^2 (0.7 ac at 20 ft width, 60,000 ft^2 (1.4 ac) at 40 ft width.

Site 3 (**Figure 5**) "North Silica Bar" (bar opposite of Silica Bar side channel) – Create a side channel in an existing swale within a stand of relatively dense riparian vegetation which presently includes willows and cottonwoods. Approximate length 4,600 ft, potential area 92,000 ft^2 (2.1 ac at 20 ft width, 189,000 ft^2 (4.3 ac) at 40 ft width.

Site 4 (included in Figure 5) "Silica Bar" – Create a side channel in an existing swale within a stand of diverse, mature, native riparian vegetation. Approximate length 2,000 ft, potential area 40,000 ft^2 (0.9 ac at 20 ft width, 80,000 ft^2 (1.9 ac) at 40 ft width.

Site 5 (**Figure 6**) "Hammon Bar" – Create a side-channel, within a stand of riparian vegetation, extending from the bar on the southern bank of the main-channel into the current backwater area. Boulder structures for hydraulic maintenance may be placed at the inflow section. At the outflow section, wood/boulder structures may be placed, and riparian vegetation may be planted. Approximate length 1,250 ft, potential area 25,000 ft^2 (0.6 ac at 20 ft width, 50,000 ft^2 (1.1 ac) at 40 ft width.

Site 6 (**Figure 7**) "South Bar above Daguerre Point Dam" – Create a side channel, within a stand of riparian vegetation, along the toe of the training wall, extending from the upper portion of the site to the existing downstream backwater area. Boulders for hydraulic maintenance may be placed at the inflow. Approximate length 2,400 ft, potential area 48,000 ft^2 (1.1 ac at 20 ft width, 96,000 ft^2 (2.2 ac) at 40 ft width.

Downstream of Daguerre Point Dam

The lower Yuba River extends approximately 11.4 miles from Daguerre Point Dam to the confluence with the lower Feather River. The following juvenile salmonid rearing habitat enhancement action sites are located within this section of the lower Yuba River.

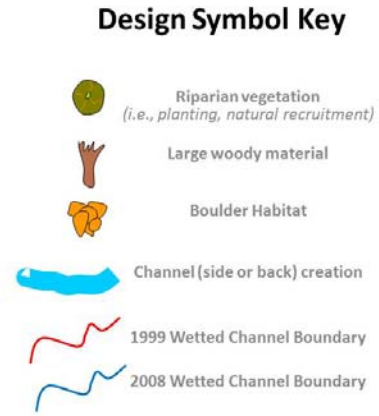
Site 7 (**Figure 8**) "Waterway 13" – Create a side-channel, within a stand of riparian vegetation, extending from the main-channel into the current backwater area. Boulder structures for hydraulic maintenance may be placed at the inflow section. This site would be expected to receive flow augmentation from the Yuba Goldfields return flow. Approximate length 2,800 ft, potential area 56,000 ft^2 (1.3 ac at 20 ft width, 112,000 ft^2 (2.6 ac) at 40 ft width.

Site 8 (**Figure 9**) "Narrow Bar" – Create a side-channel north of the main channel following a historic channel path. Existing riparian vegetation would border the created side-channel. Boulders for hydraulic maintenance may be placed at the inflow. Approximate length 2,900 ft, potential area 58,000 ft^2 (1.3 ac at 20 ft width, 116,000 ft^2 (2.7 ac) at 40 ft width.

Site 9 (**Figure 10**) "Goldfields Terminus" – Create a side-channel, within a stand of riparian vegetation, extending into a current backwater habitat located at the downstream corner of the Goldfields. Boulder structures for hydraulic maintenance may be placed at the inflow section. Approximate length 5,000 ft, potential area 100,000 ft^2 (2.3 ac at 20 ft width, 200,000 ft^2 (4.6 ac) at 40 ft width.

Figures 3 – 10 identify the locations of the potential sites for habitat enhancement. Design plans would be informed by the information and processes listed above. The precise location of side-channels as well as the placement of structural elements and riparian plantings would be informed by a variety of analyses including hydraulic modeling. As evidenced by existing riparian vegetation or topography in Figures 3 - 10, many of these potential side channels follow previous alignments of the river, or were side channels. Additional geomorphic analysis will be necessary to fully understand the processes that originally formed these channels and subsequently moved the river to a different location. However, these features were selected based on the premise that: (a) side channels can be re-established relatively easily using moderate terra-forming, boulder placement, and other techniques; and (b) that the features will have more than a short-term persistence in the river once constructed.

The Design Symbol Key (below) is utilized in the following figures.



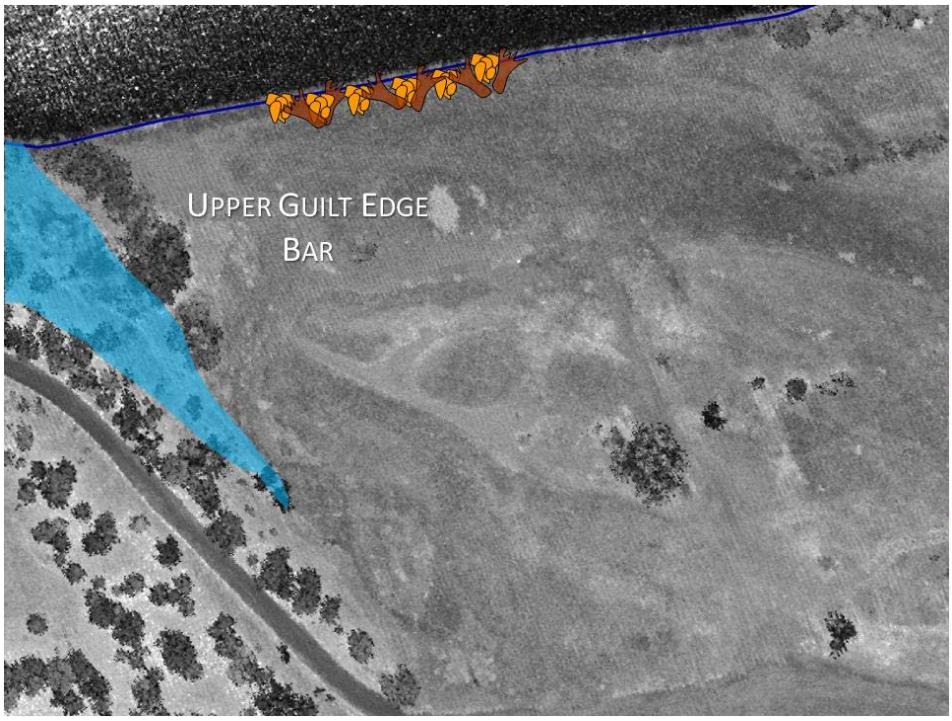


Figure 3. The Upper Guilt Edge Bar site for juvenile rearing habitat enhancement.

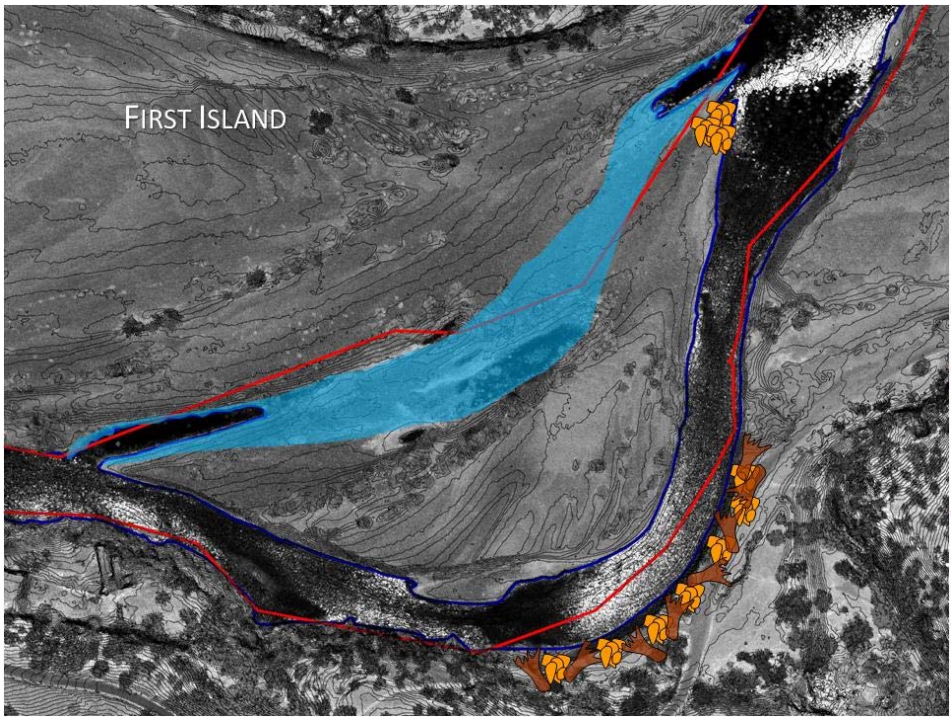


Figure 4. The First Island site for juvenile rearing habitat enhancement.

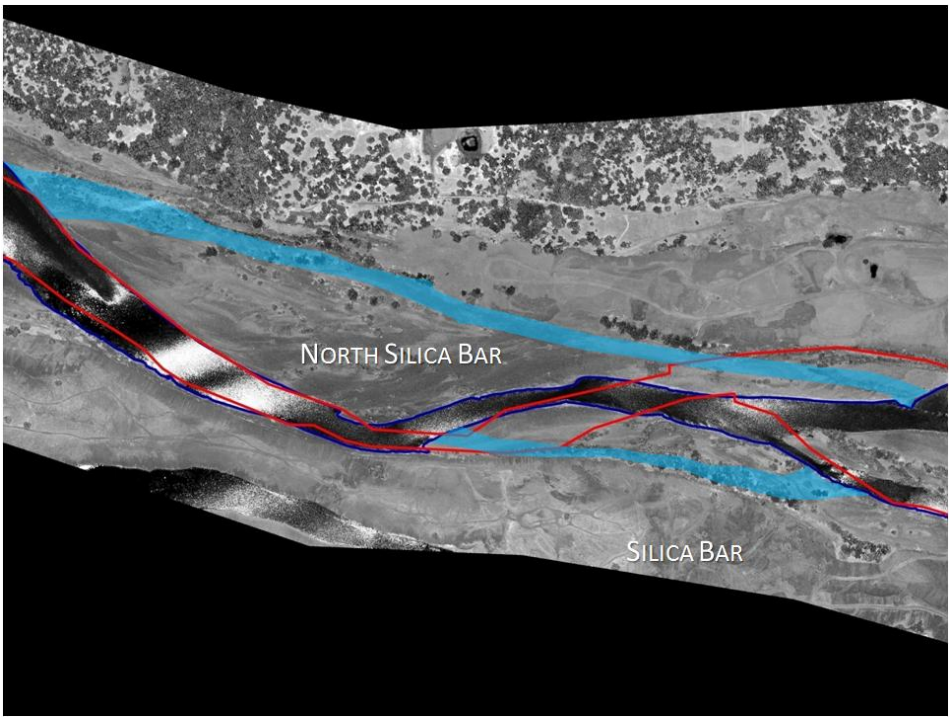


Figure 5. The North Silica Bar and Silica Bar sites for juvenile rearing habitat enhancement.

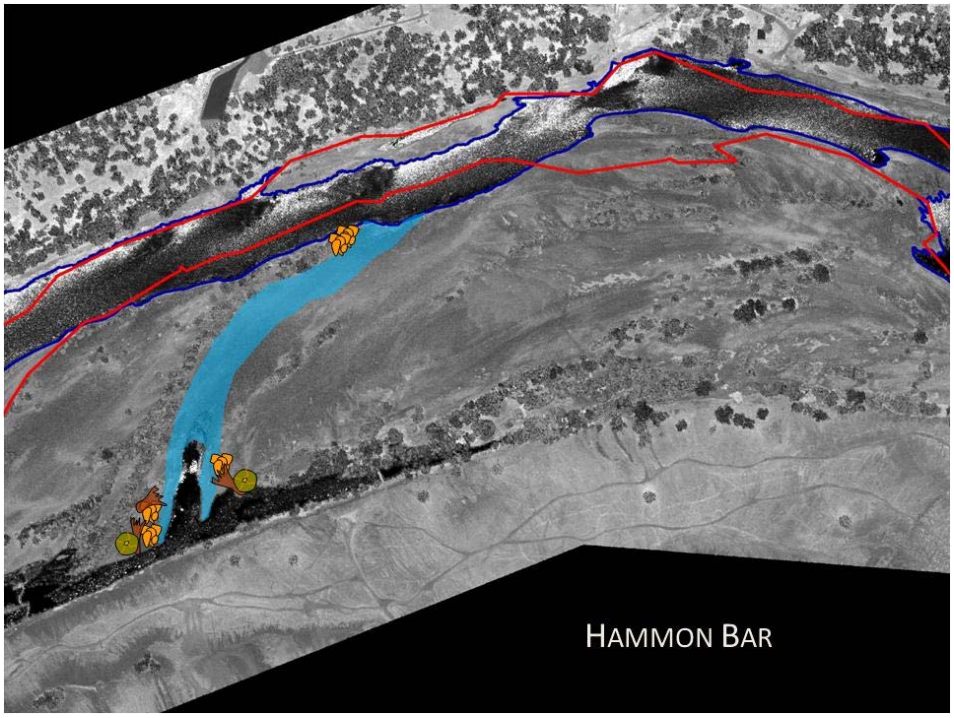


Figure 6. The Hammon Bar site for juvenile rearing habitat enhancement.

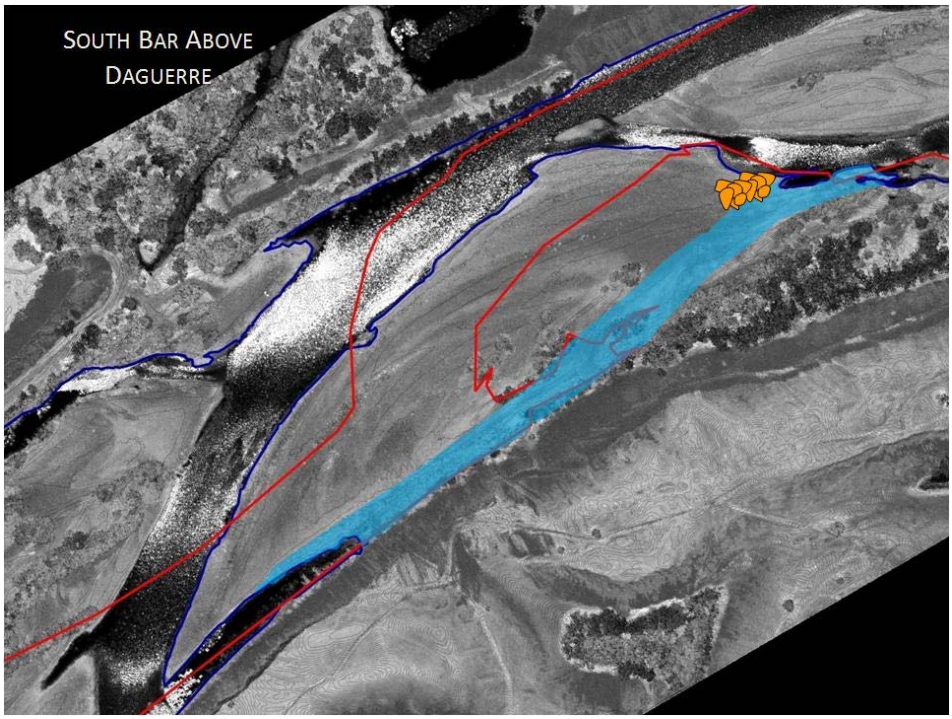


Figure 7. The South Bar above Daguerre Point Dam site for juvenile rearing enhancement.

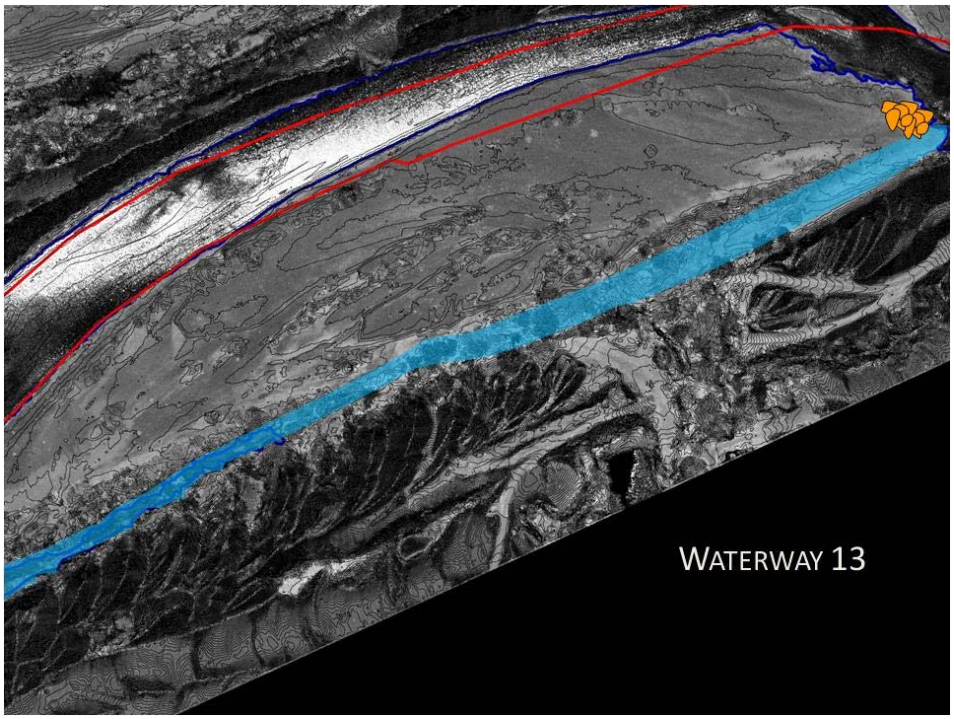


Figure 8. The Waterway 13 site for juvenile rearing habitat enhancement.

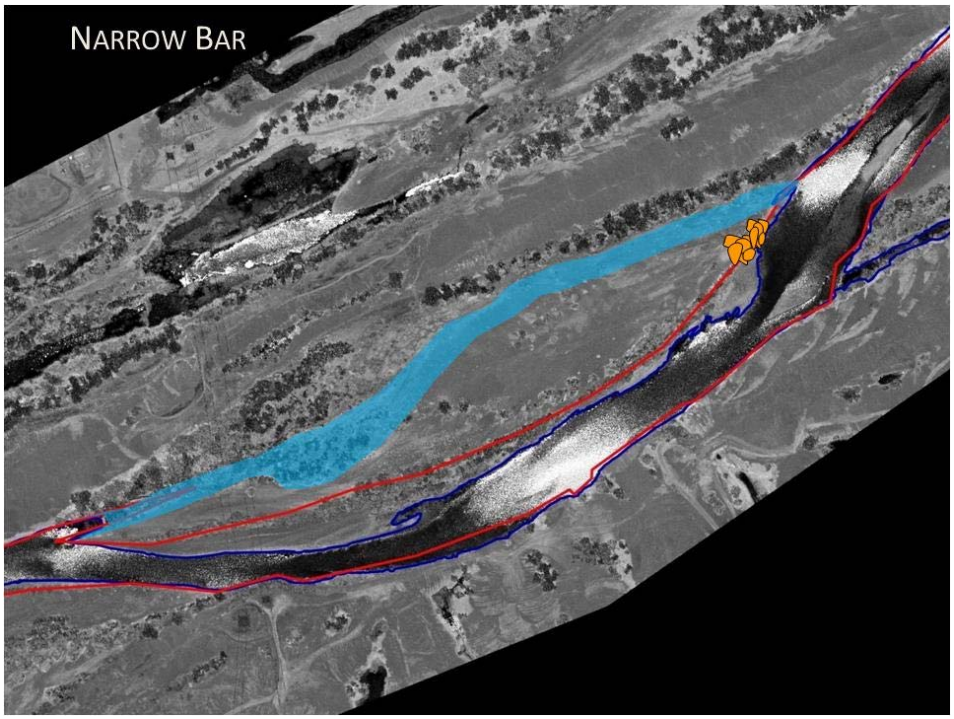


Figure 9. The Narrow Bar site for juvenile rearing habitat enhancement.

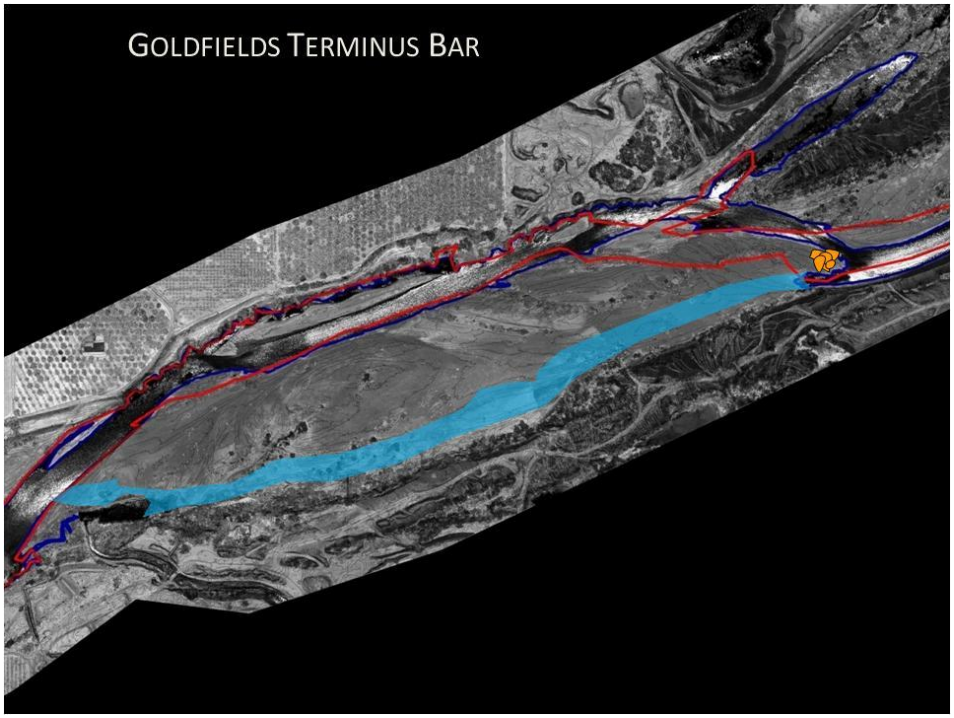


Figure 10. The Goldfields Terminus Bar site for juvenile rearing habitat enhancement.

Segregation Weir

The intent of the segregation weir component is to achieve "…*favorable spatial separation from other populations or runs to maintain genetic diversity by minimizing interbreeding…"* A priority within the HEA is the segregation of habitat for spring-run and fall-run Chinook salmon. In the Central Valley, introgression of fall- and spring-run Chinook salmon has been identified as a potential factor limiting spring-run Chinook salmon. In many cases, this is due to the concurrent spawning of hatchery-produced fall-run Chinook salmon in areas where spawning of spring-run Chinook salmon occurs.

Unlike many rivers in the Central Valley, there is no hatchery on the lower Yuba River. However, some straying does occur in the lower Yuba River, most likely from the Feather River Hatchery. However, straying of fish into the lower Yuba River can be addressed by a number of actions including replacing off-site releases with volitional releases from the hatchery, allowing all fish that attempt to return to the hatchery to do so, and reducing the amount of fish released (see CDFG and NMFS (2001), for a review of hatchery issues). Currently, best management practices and a hatchery genetics management plan continue to be developed and implemented at the Feather River Hatchery.

Further, to address the problem of introgression of fall- and spring-run Chinook salmon, the HEA criterion indicate that projects that encourage the separation of fall- and spring-run Chinook salmon will be considered favorable. Separation may be achieved either through physical barriers or through the development of habitat conditions that favor spring-run Chinook salmon over fall-run Chinook salmon. Clearly, the intent is to achieve separation of fall-run and spring-run Chinook salmon to minimize/avoid genetic introgression.

The biologic premise behind the concept of "separation" is the intent to achieve reproductive isolation. Reproductive isolation has a spatial and/or temporal component that, in a natural system, can be accomplished through behavioral manifestation achieving spatial and/or temporal segregation. In the lower Yuba River, to some extent spatial and temporal segregation of Chinook salmon spawning presently occurs. Previously conducted reconnaissance-level redd surveys, carcass surveys, and the more intensive 2008 pilot redd survey demonstrate that the majority of redds constructed during September to early October (phenotypically consistent with spring-run Chinook salmon spawning timing) were observed in the uppermost portion of the survey area (i.e., upstream of the Highway 20 Bridge). Preliminary data obtained from early season redd surveys conducted from August 31 through October 1, 2009 demonstrate that of the total 714 redds constructed during this period throughout the lower Yuba River, 520 (73%) were constructed upstream of the Highway 20 Bridge. By contrast, redds constructed later in the season (phenotypically consistent with fall-run Chinook salmon spawning timing) were primarily observed further downstream in the lower Yuba River. Preliminary 2009 data demonstrate of the

1,598 redds constructed since October 1 through October 29, 2009, 952 (60%) were constructed downstream of the Highway 20 Bridge.

Seasonal flow releases and suitable spring-run Chinook salmon water temperatures are currently being provided by implementation of the Yuba Accord, which enhances the spawning of phenotypically characterized spring-run Chinook salmon. Additional monitoring (acoustic tracking, spawning surveys, genetic analysis) is ongoing, and will provide additional information regarding the current extent of reproductive isolation between spring-run and fall-run Chinook salmon in the lower Yuba River. The need for, benefits of, and specific operational considerations for the segregation weir component of the project are presently uncertain, and can be more completely evaluated following results from ongoing studies by the Yuba Accord RMT. A genetic analysis of phenotypic spring-run Chinook salmon collected in the lower Yuba River is in progress. The results of this study will help identify the amount of introgression among spring-run and fall-run Chinook salmon, and source populations for phenotypic spring-run Chinook salmon that currently exist in the lower Yuba River. Ongoing monitoring conducted as part of the Yuba Accord M&E Program will provide additional information regarding specific timing and specific locations of adult immigration, holding, and spawning of Chinook salmon in the lower Yuba River. This additional information will be useful to evaluate the need for, and potential location of a segregation weir in the future. In addition, evaluation of the technical feasibility and full costs associated with implementation of a segregation weir in the lower Yuba River remains to be conducted. At a minimum, careful consideration of the feasibility and full costs of construction of a hard-mounted fish barrier (including in-river construction techniques and impacts), the costs of developing and securing access for construction and operations, the challenges of operations and cleaning, and the risk and potential for damage by high or flood flows will need to be undertaken prior to a final decision on this potential project.

The segregation weir is not supported at this time.

Daguerre Point Dam Passage Improvement

Upstream passage at the Corps Daguerre Point Dam can be impeded for migrating adult spring-run Chinook salmon and steelhead due to the inadequacies of the fish ladders. Adult salmonid passage is impeded when rain or snowmelt runoff produces high flow conditions at the dam, which coincides with flow conditions under which spring-run Chinook salmon and steelhead generally migrate upstream to their spawning areas. The Corps' policy is to close the ladders when water elevation reaches 130 feet, and to keep them closed until the water recedes to an elevation of 127 feet. Because spring-run Chinook salmon and steelhead upstream migration occurs during the potentially high-flow periods during winter and spring, this policy can affect their upstream migration. Throughout winter and spring when flows are high, adult spring-run Chinook salmon and steelhead can experience difficulty in finding the entrance to the ladders because of the relatively low percentage of attraction flows exiting the ladders compared to the

massive sheet-flow coming over the rest of the dam. The angle of the orifices and proximity to the plunge pool also increase the difficulty for fish to find the entrances to the ladders. Other design deficiencies which have been identified include periodic obstruction of the ladders by woody material, operating criteria that require closure of the ladders at high flows, and the proximity and orientation of the ladder entrances to the spillway (CDFG 1991; USFWS 1994 in NMFS 2007).

Upstream passage at the Corps Daguerre Point Dam can also be impeded when sediment builds up near the upstream exit of the fish ladders. Geofluvial action has, in the past, caused gravel to build up on the upstream side of the dam where it can impede flows into the ladders, thereby reducing the ability of fish to climb the ladders and reducing the attraction flow exiting the base of the ladders. In addition, the gravel bars have built up to the point where they reduce access to the main channel for fish that have exited at the top of the ladders and are attempting to continue their upstream migration. The Corps has initiated a long-term sediment management program to address this problem, and it is expected that this issue will be alleviated through continued diligent implementation of this program.

Adult Chinook salmon have been observed congregating in the plunge pool below the dam and leaping at the face of the dam, indicating that migrating adults may not readily find the entrances to the fish ladders. A simple time delay is not the only consequence of spring-run Chinook salmon being unable to pass Daguerre Point Dam. When adult Chinook salmon enter fresh water they cease eating and must rely solely on the finite supply of energy which they have stored in their bodies to last them through their entire migration, holding, and spawning activities. In their efforts to pass Daguerre Point Dam, particularly if these efforts continue for several days or even weeks, they consume a greater amount of these energy stores than if there had been no obstacle in their path. This may leave the fish in a weakened state before spawning which may subject them to a greater chance of disease, especially if they have to hold over the summer prior to spawning (e.g., spring-run Chinook salmon). Other biological consequences of blockage or passage delay include changes in spawning distribution (Hallock 1987), increased adult pre-spawning mortality (Reclamation 1985 in NMFS 2007), and decreased egg viability (Vogel *et al.* 1988), all of which may result in the reduction in abundance and productivity of this species.

Juvenile salmonids can also be adversely affected by Daguerre Point Dam on their downstream migration. Juveniles can experience injury or direct mortality by being carried over the face of the dam by sheet flow and encountering the dam face or the downstream base of the dam. Also, there is an elevated risk of predation created when juveniles plunge over the dam into the pool below. The large plunge pool at the base of the dam creates an area for predatory fish which may seasonally congregate below Daguerre Point Dam. The deep pool provides ambush habitat for predators in an area where juvenile salmonids can be disoriented or injured as they plunge over the face of the dam into the turbulent waters at the base, making them vulnerable to

predation. High levels of predation over long periods of time can reduce juvenile numbers and weaken their contribution to year class strength and recruitment.

The potential to improve both adult upstream and juvenile downstream passage at Daguerre Point Dam has been the subject of previous studies, including: (1) Daguerre Point Dam Fish Passage Improvement Project Alternative Concepts Evaluation (DWR and Corps 2003 in NMFS 2007); (2) Daguerre Point Dam Fish Passage Improvement Project 2002 Fisheries Studies – Analysis of Potential Benefits to Salmon and Steelhead from Improved Fish Passage at Daguerre Point Dam (DWR and Corps 2003a in NMFS 2007); and (3) Daguerre Point Dam Fish Passage Improvement 2002 Water Resources Studies (DWR and Corps 2003b in NMFS 2007). In November 2007 NMFS issued a Biological Opinion (NMFS 2007) on the operation of Corps facilities on the Yuba River, including Daguerre Point Dam and passage-related issues. Passage at Daguerre Point Dam is the subject of ongoing considerations. Although much evaluation and analysis has already been completed, a final preferred alternative has not yet been identified to alleviate passage impediment issues at Daguerre Point Dam.

SELECTION AND APPROVAL CRITERIA CONSIDERATIONS

CONTRIBUTION TO ACHIEVING THE HABITAT EXPANSION THRESHOLD

> *As previously mentioned, the specific Habitat Expansion Threshold (HET) is to expand spawning, rearing and adult habitat sufficiently to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon for spawning in the Sacramento River Basin. The Habitat Expansion Threshold is focused on spring-run Chinook salmon as the priority species, as expansion of habitat for spring-run Chinook salmon typically accommodates steelhead as well.*

Preliminary estimates indicate that spawning habitat rehabilitation in the Englebright Dam Reach of the lower Yuba River could provide additional spawning habitat for 4,764 spring-run Chinook salmon, and thereby achieve the specific HET to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon spawning annually. The benefit of new side-channel habitats would: (1) increase and maintain existing riparian vegetation; (2) provide instream object and overhanging object cover; (3) provide new SRA, and associated allochthonous food sources for rearing juveniles; (4) increase aquatic habitat complexity and diversity; (5) provide habitats more consistent with those previously available in the upper watershed; and (6) provide predator escape cover, and overall increased survival of juvenile spring-run Chinook salmon and steelhead – all of which would thereby contribute to increased annual spawning run abundance. Based on preliminary estimates of area (scaled from Figures 4 – 11 herein), additional aquatic rearing habitat could be 10 to 21 acres; additional riparian habitat could be an additional 10 to 21 acres.

As previously mentioned, a segregation weir does not, unto itself, expand habitat and directly contribute to achieving the goals of the HET. Rather, the stated intent is to accomplish geographic distinction (and reproductive isolation) and thereby reduce the potential for genetic introgression between fall-run and spring-run Chinook salmon. Similarly, although improved fish passage at the Corps Daguerre Point Dam would help to facilitate access to available upstream habitat, it would not expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead.

MOST COST-EFFECTIVE COMPARED TO OTHER POTENTIAL HABITAT EXPANSION ACTIONS

For each Viable Action, a rough estimate of its cost and contribution to the HET will be determined. Each Viable Action then will be ranked in terms of its cost effectiveness (i.e., the cost of the action versus its contribution to the HET). Refer to the discussion of favorable cost effectiveness in Evaluation Criterion (d).

Based upon the economic feasibility (below) it is possible that the proposed habitat enhancement actions in the lower Yuba River can be implemented within extant funding limitations, and would achieve or exceed the specific HET goal of establishing a self-sustaining, viable population, representing a net increase of 2,000 to 3,000 spring-run Chinook salmon spawning annually in the Central Valley. Although uncertainty remains regarding the feasibility and cost, particularly associated with the segregation weir, and the consideration that Daguerre Point Dam fish passage improvements may be required to be implemented through other processes, the Englebright Dam Reach spawning habitat rehabilitation component would be extremely cost-effective, and the juvenile salmonid rearing habitat enhancement actions would have synergistic benefit and augment resulting habitat expansion through enhanced spring-run Chinook salmon and steelhead juvenile production.

FEASIBILITY (ACTION[S] CAN REASONABLY BE ACCOMPLISHED)

As stated in Evaluation Criterion (a), actions/projects must have a high likelihood of success (i.e., they must be highly feasible). The term "feasibility" is being interpreted broadly to include the concepts described for four Evaluation Criteria: (a) technical feasibility, (d) economic feasibility, (i) favorable political and local support, and (l) consistency with other resource uses.

The feasibility varies among the suite of actions being considered by the HEA Steering Committee.

The Englebright Dam Reach spawning habitat rehabilitation component is highly feasible, based upon a 5-year (2003-2008) comprehensive investigation conducted to ascertain the linkages between hydrology, geomorphology, and ecology (Pasternack 2009), and a 2007 pilot gravel injection study. Pasternack (2009) highly recommended that such a project be designed using the Spawning Habitat Integrated Rehabilitation Approach (SHIRA) that is in use on the Feather, American, Trinity, and Mokelumne Rivers. For details, see the website at http://shira.lawr.ucdavis.edu. Using SHIRA would ensure that a project of this magnitude would immediately yield spawning habitat, as has been documented thoroughly on the Mokelumne and Trinity Rivers. We have not prepared a cost estimate for the Englebright Dam Reach spawning habitat rehabilitation action. However, in response to the HEA questionnaire, the stated cost of this action was approximately $3 million, although it is uncertain whether this stated cost includes all project-related requirements.

Prior to the RMT's field tour of potential juvenile salmonid rearing habitat enhancement projects and further identification and refinement of specific actions, the response to the HEA questionnaire stated that the cost of this action was $2 million, although it is uncertain whether this stated cost includes all project-related requirements. We have not prepared a cost estimate for the juvenile salmonid habitat enhancement actions. However, review of Appendix E in the Draft Recovery Plan suggests that "channel restoration" pertinent to Central Valley rivers ranges in cost from $1.2 million to $8.7 million per mile, and USFWS reports that for AFRP habitat enhancement/development actions, cost estimates of $1.0 to $1.5 million per mile were derived. The HEA Steering Committee would likely need to develop their own cost estimates.

The suite of actions considered by the HEA Steering Committee also may include a segregation weir located approximately 6 miles below Englebright Dam to provide spawning segregation of spring-run Chinook salmon from fall-run Chinook salmon. The need for, benefits of, and specific operational considerations for the segregation weir component of the project are presently uncertain, and can be more completely evaluated following results from ongoing studies by the Yuba Accord RMT involving tagging, tracking, redd mapping and genetic analysis. Although resistance board segregation weirs are versatile and have been used in other locations, evaluation of the technical feasibility and full costs associated with implementation in the lower Yuba River have not been conducted. We have not prepared a cost estimate for the segregation weir action. However, in response to the HEA questionnaire, it was suggested that based on a preliminary, reconnaissance-level review, a resistance board weir would cost approximately $220,000 for installation and $52,000 annually for weir operation and monitoring, although it is likely that this stated cost does not include all project-related requirements. At a minimum, careful consideration of the full costs of construction of a hard-mounted fish barrier, the costs of developing and securing access for construction and operations, the cost associated with operations and cleaning, and the costs associated with maintenance and the potential for damage

by high or flood flows will need to be undertaken prior to a final decision on this potential project.

Potential alternatives associated with fish passage improvements at the Corps Daguerre Point Dam continue to be part of ongoing investigations. According to the NMFS 2007 Biological Opinion (BO), the Corps shall develop and implement a plan to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam. Moreover, the NMFS BO requires that the Corps shall complete the feasibility study and PED phases of the ongoing fish passage improvement project, as described in the Corps biological assessment for the proposed project, within five years of the issuance of the BO. It further requires that the Corps shall commence implementation of the preferred alternative to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam, developed through the feasibility study and PED process, within ten years of the issuance of the BO. Therefore, it may be appropriate to assume that associated costs would be the Corps responsibility, and not necessarily be an appropriate consideration pursuant to the HEA eligibility criteria.

TIMING (EXPECTED TO BE IMPLEMENTED WITHIN A REASONABLE PERIOD OF TIME)

> *As noted in Evaluation Criterion (h), factors important to the success of a project include not only the length of time to implement the project but also the length of time to realize benefits. Thus, the HEP will favor "shovel-ready" projects that can be implemented in a reasonable period of time (e.g., less than approximately 5 years). The more favorable projects will be those that need minimal additional public process, particularly related to permitting, zoning, or land use issues. In addition, projects that benefit spring-run Chinook within a relatively short period of time (e.g., approximately 10 years or less) will be favored.*

The Englebright Dam Reach spawning habitat rehabilitation project is essentially "shovel ready". A 5-year (2003-2008) comprehensive investigation has been conducted to ascertain the linkages between hydrology, geomorphology, and ecology (Pasternack 2009), and a 2007 pilot gravel injection study has been implemented. Located in a remote rural area, this project requires minimal additional public process, particularly related to permitting, zoning, or land use issues. The project could be implemented once final design, plans and specifications are completed, and appropriate permits are obtained (potentially less than one year). By using the SHIRA approach that is in use on the Feather, American, Trinity, and Mokelumne rivers, a project of this magnitude would immediately yield spawning habitat, as has been thoroughly documented on the Mokelumne and Trinity rivers.

It is anticipated that the proposed juvenile salmonid rearing habitat enhancement actions would be designed, access and permits obtained, and selected actions implemented consistent with the approval and implementation schedule established for the HEA implementation process. Given the tools in development and work currently underway (e.g., mapping of entire lower Yuba, 2D hydraulic model of the lower Yuba River, pilot restoration project design), it seems likely that a preliminary design and permitting analysis could be completed within 1 year. Permitting, landowner access and other issues could be resolved within 1 to 2 years, depending on complexities. Construction could be accomplished in one to two seasons.

As previously discussed, the need for, benefits of, and specific operational considerations for the segregation weir component of the project are presently uncertain. Evaluation of the technical feasibility associated with implementation in the lower Yuba River has not been conducted. It is uncertain when evaluation of the infrastructure integrity and operations and management practices, access logistics, a feasibility study, and obtaining appropriate permits would occur.

The NMFS 2007 BO requires that the Corps shall complete the feasibility study and PED phases of the ongoing Daguerre Point Dam fish passage improvement project within five years of the issuance of the BO. It further requires that the Corps shall commence implementation of the preferred alternative to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam, developed through the feasibility study and PED process, within ten years of the issuance of the BO. However, in consideration that the NMFS 2007 BO is the subject of a legal challenge pending in the United States District Court for the Eastern District of California, specific timing is presently uncertain.

RELATIONSHIP TO OTHER PARTIES

> *Actions identified in other venues are eligible for consideration provided that what is implemented under the HEA results in an expansion of habitat over any existing requirements and commitments. As stated in Evaluation Criterion (n), projects required as part of other proceedings… will not be favored and may be considered ineligible.*

Although the cessation of spawning gravel recruitment from areas upstream of the Corps Englebright Dam may be directly attributable to the presence of the dam, some of the shot-rock on Sinoro Bar results from high flows and landslides, and the geomorphic structure also has been influenced by local instream gravel mining. Research conducted by Professor Greg Pasternack (UC Davis) provides substantial evidence that the downstream section of the Englebright Dam Reach (including Sinoro Bar) is primarily impacted by historic hydraulic gold mining and modern mechanized placer mining conducted since 1960 (Pasternack 2009). Thus, the Englebright Dam Reach spawning habitat rehabilitation project addresses physical habitat conditions distinct from those directly associated with construction of the Corps Englebright

Dam. The Englebright Dam Reach spawning habitat rehabilitation project proposed for HEA consideration includes shot-rock removal, localized grading and contouring, placement of hydraulic roughness elements, and initial gravel placement.

Although the Corps is required to implement a long-term gravel augmentation program by the NMFS 2007 BO, such a program would provide minimal benefits to spring-run Chinook salmon and steelhead until the channel is rehabilitated from instream gravel mining and deposition of shot-rock. After initial spawning habitat rehabilitation and the provision of gravel associated with the Englebright Dam Reach spawning habitat rehabilitation project, it is suggested that ongoing gravel supply would then be maintained as per requirements of the Corps in the NMFS 2007 BO, or whatever requirements emanate from the legal challenge pending in the United States District court for the Eastern District of California. That ongoing process injects additional uncertainty regarding the timing of the Corps participation in this project. It has been estimated that ongoing annual maintenance of the spawning habitat could be accomplished through the injection of approximately 10,000 cubic yards of gravel per year (Pasternack 2009).

The juvenile salmonid rearing habitat enhancement project is not required under other venues, and would be appropriate for funding under the HEA. As stated in SYRCL's response to the questionnaire for this project, funding partners could include the Corps, Western Aggregates, PG&E, BLM, USFWS AFRP and project partners could include the Corps and SYRCL. It is presently undetermined what parties would be responsible for continued maintenance of the juvenile salmonid rearing habitat enhancement project. However, considering that construction of Englebright Dam by the Corps has resulted in the reduced functionality of juvenile salmonid rearing habitat in the lower Yuba River, it may be appropriate to consider the Corps as the primary responsible party for continued maintenance. Although the Corps is required to implement by 2012 a program of large wood supply to the lower Yuba River by the NMFS 2007 BO (legal challenge pending), that requirement does not include the proposed juvenile salmonid rearing habitat enhancement project.

The Yuba Accord RMT subcommittee does not specifically recommend the segregation weir project for the lower Yuba River at this time. However, as the HEA Steering Committee continues to consider numerous specific projects, it is noted that, as stated in SYRCL's response to the questionnaire for this project, funding partners could include PG&E (per the Narrows Mitigation Fund) and the USFWS AFRP, and project partners could include the Corps.

Potential alternatives associated with fish passage improvements at Daguerre Point Dam continue to be part of ongoing investigations. According to the NMFS 2007 BO, the Corps shall develop and implement a plan to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam. Moreover, the NMFS BO requires that the Corps shall complete the feasibility study and PED phases of the ongoing fish passage

improvement project, as described in the Corps biological assessment for the proposed project, within five years of the issuance of the biological opinion. It further requires that the Corps shall commence implementation of the preferred alternative to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam, developed through the feasibility study and PED process, within ten years of the issuance of the biological opinion. Although the NMFS 2007 BO is the subject of a legal challenge pending in the United States District Court for the Eastern District of California, it is anticipated that fish passage improvements at Daguerre Point Dam will remain the Corps' responsibility.

SUPPORTS ESTABLISHING A GEOGRAPHICALLY SEPARATE, SELF-SUSTAINING POPULATION OF SPRING-RUN

As discussed in Evaluation Criterion (g), the proposed projects should support development of a viable population of spring-run Chinook salmon within the Sacramento River Basin, in addition to those that already exist in Mill, Deer, and Butte Creeks.

A priority within the HEA is the development of a new, geographically separate, self-sustaining population of spring-run Chinook salmon (see Section 4.2.3[c] of the HEA). NMFS has identified presently viable spring-run Chinook populations in Mill, Deer and Butte Creeks (Lindley *et al.* 2007). NMFS Approval Criteria (items a–f contained in Section 4.2.3 of the HEA) includes the development of a viable population of spring-run Chinook salmon within the Sacramento River Basin, in addition to those that already exist in Mill, Deer and Butte Creeks.

NMFS Approval Criteria (item 4.2.3[c] of the HEA) further states that, in addition to being geographically separate, the proposed actions need to provide habitat that is of sufficient quantity (e.g., watershed size of 500 km^2 or greater as a guideline) and quality, and sufficiently separate to support a self-sustaining population of spring-run Chinook salmon. The Yuba River Watershed drains 1,339 square miles of the western slope of the Sierra Nevada and includes portions of Sierra, Placer, Yuba, and Nevada counties (YCWA *et al.* 2007).

Implementation of the Englebright Dam Reach spawning habitat rehabilitation project and the juvenile salmonid rearing habitat enhancement project, and associated establishment of a viable spring-run Chinook salmon population in the lower Yuba River (in addition to presently viable spring-run Chinook salmon populations in Mill, Deer and Butte creeks), may satisfy the criteria of:

- *Favorable spatial separation from other spawning streams to minimize population impacts of a stream-specific adverse event (geographic distribution is favored over centralization)*

- *Supports establishing a geographically separate, self-sustaining population of Spring-Run*

SUPPORTS SEGREGATING SPRING-RUN HABITAT FROM CENTRAL VALLEY FALL-RUN CHINOOK SALMON

> *As discussed in Evaluation Criterion (f), the proposed projects should support segregation of spring-run and fall-run Chinook salmon populations. Segregating the two runs can involve creating a segregation barrier, increasing instream flow, or enhancing habitat for spring-run over fall-run Chinook.*

As previously discussed, separation may be achieved either through physical barriers or through the development of habitat conditions that favor spring-run Chinook salmon over fall-run Chinook salmon. Clearly, the intent is to achieve separation of fall-run and spring-run Chinook salmon to minimize/avoid genetic introgression, to be accomplished by reproductive isolation.

As previously mentioned, to some extent spatial and temporal segregation presently occurs in the lower Yuba River. Previously conducted reconnaissance-level redd surveys, carcass surveys, and the more intensive 2008 pilot redd survey demonstrate that the majority of redds constructed during September to early October (phenotypically consistent with spring-run Chinook salmon spawning timing) were observed in the uppermost portion of the survey area (i.e., upstream of the Highway 20 Bridge). Preliminary data obtained from early season redd surveys conducted from August 31 through October 1, 2009 demonstrate that of the total 714 redds constructed during this period throughout the lower Yuba River, 520 (73%) were constructed upstream of the Highway 20 Bridge. By contrast, redds constructed later in the season (phenotypically consistent with fall-run Chinook salmon spawning timing) were primarily observed further downstream in the lower Yuba River. Preliminary 2009 data demonstrate of the 1,598 redds constructed since October 1 through October 29, 2009, 952 (60%) were constructed downstream of the Highway 20 Bridge.

HEA STEERING COMMITTEE OUTSTANDING QUESTIONS AND ISSUES

At the RMT meeting held on September 23, 2009, the HEA Steering Committee provided the RMT with a list of questions regarding habitat expansion project in the lower Yuba River.

BIOLOGICAL

1.0 What is the potential contribution for each component of the proposed project to the Habitat Expansion Threshold?

As previously discussed, preliminary estimates indicate that spawning habitat rehabilitation in the Englebright Dam Reach of the lower Yuba River could provide additional spawning habitat for up to 4,764 spring-run Chinook salmon, and thereby achieve the specific HET to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon spawning annually. The juvenile salmonid rearing habitat enhancement project and resultant increased habitat complexity (e.g., create/restore backwater and side-channel habitat, physical structure, SRA, riparian vegetation, and instream object and overhanging cover) would provide for increased growth, protection from predators, and overall increased survival of juvenile spring-run Chinook salmon and steelhead, and thereby contribute to increased annual spawning run abundance. Preliminary estimates indicate that up to 22,450 lineal feet (4.25 miles), or 10 to 21 acres of in-river rearing habitat could be created, with an additional 10 to 20 acres of riparian habitat.

As also previously discussed, a segregation weir does not, unto itself, expand habitat and directly contribute to achieving the goals of the HET. Rather, the stated intent is to accomplish geographic distinction and thereby reduce the potential for genetic introgression between fall-run Chinook salmon and spring-run Chinook salmon. Similarly, although improved fish passage at the Corps Daguerre Point Dam would help to facilitate access to available upstream habitat, it would not expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead.

2.0 How would juvenile habitat enhancement and fish passage improvements translate into numbers of fish?

Explicit quantification of the "numbers of fish" associated with these two project components cannot be estimated at this time. Although estimates of benefit were provided to the HEA Steering Committee of the Englebright Dam Reach spawning habitat restoration action *via* the initial questionnaires, which have been refined in this document, the RMT is presently not prepared to provide additional quantitative estimation until the results of RMT studies currently underway are available. It is expected that results obtained through the Yuba Accord M&E Program will provide information allowing development of annual instream production estimates, relating the numbers of juveniles produced and emigrating from the lower Yuba River annually to the number of spawners. However, as previously mentioned, resultant increased habitat complexity (see above) would provide for increased growth, protection from predators, and overall increased survival of juvenile spring-run Chinook salmon and steelhead.

Also, as previously discussed, fish passage improvements at the Corps Daguerre Point Dam could be expected to reduce occurrence of disease in upstream migrating adults, provide additional opportunities for upstream spawning distribution, reduce adult pre-spawning mortality, and increase egg viability, all of which may result in the reduction in abundance and productivity of spring-run Chinook salmon and steelhead. Fish passage improvements at Daguerre Point Dam also could be expected to reduce juvenile salmonid injury, direct mortality and predation rates, and thereby potentially increase juvenile numbers and their contribution to year class strength and recruitment. Improving rearing habitat and fish passage is expected to work in concert with the improvements to spawning habitat in the Englebright Dam Reach.

3.0 Are there fish passage issues at Daguerre Point Dam?

[See the previous discussion of Daguerre Point Dam passage improvement considerations.]

4.0 Where is the best location to place a segregation weir on the Lower Yuba River?

In practical terms, there are a limited number of locations that would be most suitable for installation and maintenance of a segregation weir in the lower Yuba River. Evaluation of the technical feasibility (including potential site locations) associated with implementation of a segregation weir in the lower Yuba River remains to be conducted. At a minimum, careful consideration of the feasibility and full costs of construction of a hard-mounted fish barrier (including in-river construction techniques and impacts), the costs of developing and securing access for construction and operations, the challenges of operations and cleaning, and the risk and potential for damage by high or flood flows will need to be undertaken prior to a final decision on this potential project. If future implementation of a segregation weir in the lower Yuba River is considered, then additional monitoring (acoustic tracking, spawning surveys, genetic analysis) being conducted by the Yuba Accord RMT will provide additional information regarding the specific locational and operational considerations for the segregation weir project.

5.0 Where are phenotypic spring-run Chinook salmon spawning, above or below the proposed location of the segregation weir?

[See the previous discussions regarding spatial and temporal distribution of Chinook salmon spawning, and issues surrounding the segregation weir project.]

PROJECT RELATED

1.0 What are the resource agencies positions on the segregation weir?

[Response to this question requires direct consultation with resource agencies]

2.0 Are the Narrows gravel augmentation and Daguerre Point Dam fish passage improvement actions the responsibility of the Corps under the biological opinions?

As previously described, although the cessation of spawning gravel recruitment from areas upstream of the Corps Englebright Dam may be directly attributable to the presence of the dam, some of the shot-rock on Sinoro Bar results from high flows and landslides, and the geomorphic structure also has been influenced by local instream gravel mining. The Englebright Dam Reach spawning habitat rehabilitation project proposed for HEA consideration includes shot-rock removal, localized grading and contouring, placement of hydraulic roughness elements, and initial gravel placement.

Although the Corps is required to implement a long-term gravel augmentation program by the NMFS 2007 BO, such a program would provide minimal benefits to spring-run Chinook salmon and steelhead until the channel is rehabilitated from instream gravel mining and deposition of shot-rock. After initial spawning habitat rehabilitation and the provision of gravel associated with the Englebright Dam Reach spawning habitat rehabilitation project, it is suggested that ongoing gravel supply would then be maintained as per requirements of the Corps in the NMFS 2007 BO, or whatever requirements emanate from the legal challenge pending in the United States District court for the Eastern District of California. It has been estimated that ongoing annual maintenance of the spawning habitat could be accomplished through the injection of approximately 10,000 cubic yards of gravel per year (Pasternack 2009).

Potential alternatives associated with fish passage improvements at Daguerre Point Dam continue to be part of ongoing investigations. According to the NMFS 2007 BO, the Corps shall develop and implement a plan to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam. Although the NMFS 2007 BO is the subject of a legal challenge pending in the United States District Court for the Eastern District of California, it is anticipated that fish passage improvements at Daguerre Point Dam will remain the Corps' responsibility.

3.0 Are there accurate cost estimates for the individual project components including permitting, construction, and long term operation and maintenance costs?

We have not prepared cost estimates for proposed habitat enhancement projects in the lower Yuba River. Additional cost information is provided under the previous discussion regarding feasibility, which includes economic feasibility.

4.0 Are there potential funding partners for operation and maintenance activities?

Anticipated potential funding partners were preliminarily identified in the questionnaire responses for each of the considered habitat expansion project for the lower Yuba River, and

were discussed above under the section titled "Relationship to Other Parties". Potential funding partners suggested in the responses to the questionnaires have not necessarily confirmed their participation or approval of identified habitat expansion projects in the lower Yuba River.

For summary purposes, information regarding potential funding partners for each of the four considered projects in the lower Yuba River is presented below.

After initial spawning habitat rehabilitation and the provision of gravel associated with the Englebright Dam Reach spawning habitat rehabilitation project, ongoing gravel supply would then be maintained as per requirements of the Corps in the NMFS 2007 BO, or subsequent requirements pending the outcome of the legal challenge being considered by the United States District Court of the Eastern District of California.

As stated in SYRCL questionnaire response, funding partners for juvenile salmonid rearing habitat enhancement project could potentially include the Corps, Western Aggregates, PG&E, BLM, USFWS AFRP, and project partners could potentially include the Corps and SYRCL. As previously discussed, potential funding partners suggested in the responses to the questionnaires have not necessarily confirmed their participation or approval of identified habitat expansion projects in the lower Yuba River. Moreover, it is likely that all of the potential funding partners have funding limits or constraints for a project of the necessary scope and magnitude.

It is presently undetermined what parties would be responsible for continued maintenance of the juvenile salmonid rearing habitat enhancement project.

As stated in SYRCL's response to the questionnaire for the segregation weir project, funding partners could potentially include PG&E and the USFWS AFRP, and project partners could potentially include the Corps. As part of the NMFS 2007 BO, the Corps shall maintain the current fish passage facilities, including fish ladder clearing and sediment management, at Daguerre Point Dam until it develops and implements a plan to improve passage at Daguerre Point Dam. Although the NMFS 2007 BO is the subject of a legal challenge pending in the United States District Court for the Eastern District of California, it is anticipated that fish passage improvements, including ongoing maintenance activities at Daguerre Point Dam will remain the Corps' responsibility.

5.0 Who would own, operate, and maintain a segregation weir?

It is presently undetermined what parties would be responsible for the segregation weir. As discussed above, SYRCL's questionnaire response stated that potential funding partners for segregation weir implementation could potentially include PG&E and the USFWS AFRP, and project partners involved with ongoing operation and maintenance activities could potentially include the Corps.

REFERENCES

Anderson, J., F. Chung, M. Anderson, L. Brekke, D. Easton, M. Ejeta, R. Peterson, and R. Snyder. 2008. Progress on Incorporating Climate Change into Management of California's Water Resources. Climatic Change (2008) 87 (Suppl 1):S91–S108. DOI 10.1007/s10584-007-9353-1.

Battin, J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki. 2007. Projected Impacts of Climate Change on Salmon Habitat Restoration. Proceedings of the National Academy of Sciences, 104(16), 6720-6725.

CALFED and YCWA. 2005. Draft Implementation Plan for Lower Yuba River Anadromous Fish Habitat Restoration: Multi-Agency Plan to Direct Near-Term Implementation of Prioritized Restoration and Enhancement Actions and Studies to Achieve Long-Term Ecosystem and Watershed Management Goals. Prepared by Lower Yuba River Fisheries Technical Working Group. Funded by CALFED and Yuba County Water Agency. October 2005.

CDFG. 1991. Lower Yuba River Fisheries Management Plan. The Resources Agency, CDFG, Stream Evaluation Report No. 91-1. February 1991.

CDFG. 1996. Steelhead Restoration and Management Plan for California. Prepared by D. McEwan and T. Jackson. Inland Fisheries Division, Sacramento, CA.

CDFG and NMFS. 2001. Final Report on Anadromous Salmonid Fish Hatcheries in California. California Department of Fish and Game and National Marine and Fisheries Service Southwest Region. NMFS Southwest Regional Office, Long Beach, CA.

Francis, R. C. and N. J. Mantua. 2003. Climatic Influences on Salmon Populations in the Northeast Pacific. In: Assessing Extinction Risk for West Coast Salmon [MacCall, A.D. and T.C. Wainwright (eds.)]. NOAA technical memo NMFS-NWFSC-56. National Marine Fisheries Service, [Washington, DC], pp. 37-67. Fisheries Research Institute. Joint Institute for the Study of the Atmosphere and Oceans. University of Washington. Seattle WA. URL = http://cses.washington.edu/db/pdf/Francis_Mantua_ClimateInfluences23.pdf

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66.

Hallock, R.J., W.F. Van Woert, and L. Shapavalov. 1961. An Evaluation of Stocking Hatcher-reared Steelhead Rainbow Trout (Salmo guirdneri gairdneri) in the Sacrametno River System. California Fish and Game Fish Bulletin 114, 73 p.

Intergovernmental Panel on Climate Change (IPCC). 2007. Summary for Policymakers: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, pp 18.

Lindley, S.T., Schick, R.S., Mora, E., Adams, P.B., Anderson, J.J., Greene, S., Hanson, C., May, B.P., McEwan, D.R., MacFarlane, R.B., Swanson, C., and Williams, J.G. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science. February 2007.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer. NOAA Tech. Memo. NMFS-NWFSC-42, 156 pp.

National Marine Fisheries Service (NMFS). 2007. Biological Opinion on the Operation of Englebright and Daguerre Point Dam on the Yuba River, California. File Number 151422-SWR-2006-SA00071:MET (PCTS # 2007/01232). November 21, 2007.

NMFS. 2009. Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. Available online at: http://swr.nmfs.noaa.gov/recovery/centralvalleyplan.htm

Oreskes, N. 2004. The Scientific Consensus on Climate Change. Science 306:1686.

Pasternack, Greg. 2009. 2009 SHIRA-Based River Analysis and Field-Based Manipulative Sediment Transport Experiments to Balance Habitat and Geomorphic Goals on the Lower Yuba River. Final Report. U.C. Davis Cooperative Ecosystems Studies Unit.

Smith, J.G. 1990. Fishery Investigations in the Yuba River Goldfields Area Near Daguerre Point Dam on the Yuba River in 1989. U.S. Fish and Wildlife Service Report No. AFF1-FAO-90-9. Fisheries Assistance Office, Red Bluff, CA, pg. 15.

Thomas R. Karl, J. M. Melillo, and T. C. Peterson (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press. 2009. Available online at: http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf

Vogel, D.A., K.R. Marine, and J.G. Smith. 1988. Fish Passage Action Program for Red Bluff Diversion Dam. Final Report. U.S. Fish and Wildlife Service Report No. FR1-FAO-88-19.

Wheaton, J. M., Pasternack, G. B., and Merz, J. E. 2004. Spawning Habitat Rehabilitation - 1. Conceptual Approach & Methods. International Journal of River Basin Management 2:1:3-20.

Yuba County Water Agency (YCWA), SWRI and JSA. 2000. Draft Environmental Evaluation Report. Yuba River Development Project (FERC No. 2246). Submitted to the Federal Energy Regulatory Commission. December 2000.

YCWA, DWR and Reclamation. 2007. Draft Environmental Impact Report/ Environmental Impact Statement for the Proposed Lower Yuba River Accord. Prepared by HDR|Surface Water Resources, Inc., June 2007.