IDENTIFICATION OF THE INSTREAM FLOW REQUIREMENTS FOR ANADROMOUS FISH IN THE STREAMS WITHIN THE CENTRAL VALLEY OF CALIFORNIA

Annual Progress Report
Fiscal Year 2002

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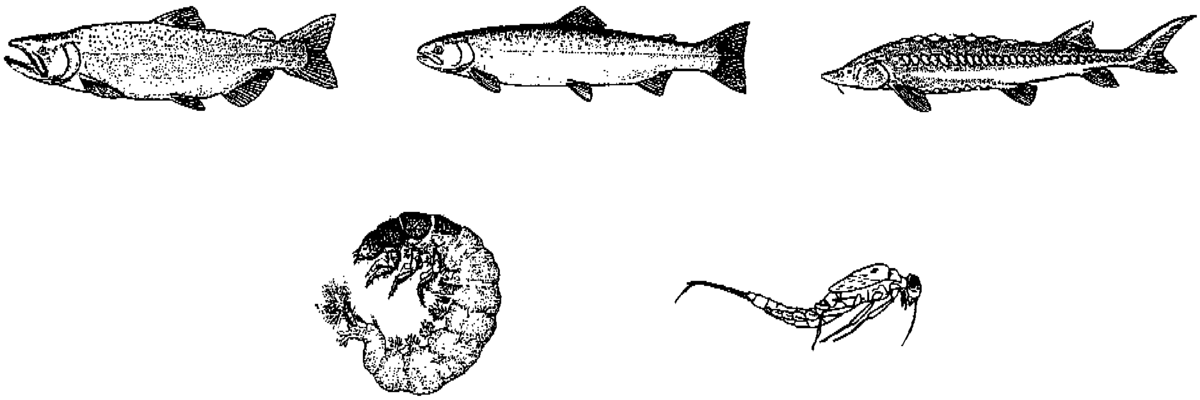

PREFACE

The following is the first annual progress report prepared as part of the Central Valley Project Improvement Act Instream Flow Investigations, a 6-year effort which began in October, 2001[1]. Title 34, Section 3406(b)(1)(B) of the Central Valley Project Improvement Act, P.L. 102-575, requires the Secretary of the Interior to determine instream flow needs for anadromous fish for all Central Valley Project controlled streams and rivers, based on recommendations of the U.S. Fish and Wildlife Service (Service) after consultation with the California Department of Fish and Game (CDFG). The purpose of this investigation is to provide reliable scientific information to the Service's Central Valley Project Improvement Act Program to be used to develop such recommendations for Central Valley streams and rivers.

The fieldwork described herein was conducted by Ed Ballard, Mark Gard, Bill Pelle, Rick Williams, Terry Adelsbach, Susan Hill, Jennifer Bain, and Debbie Giglio.

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[1] This program is a continuation of a 7-year effort, also titled the Central Valley Project Improvement Act Instream Flow Investigations, which ran from Febrary 1995 through September 2001.

INTRODUCTION

In response to substantial declines in anadromous fish populations, the Central Valley Project Improvement Act requires the doubling of the natural production of anadromous fish stocks, including the four races of chinook salmon (fall, late-fall, winter, and spring), steelhead trout, and white and green sturgeon. In June 2001, the USFWS, Sacramento Fish and Wildlife Office, Energy Planning and Instream Flow Branch prepared a study proposal to use the Service's Instream Flow Incremental Methodology (IFIM) to identify the instream flow requirements for anadromous fish in selected streams within the Central Valley of California. The proposal included completing instream flow studies on the Sacramento and Lower American Rivers and Butte Creek which had begun under the previous 7-year effort, and conducting instream flow studies on other rivers, with the Yuba River selected as the next river for studies.

The Sacramento River study was planned to be a seven-year effort originally scheduled to be concluded in September, 2001. Specific goals of the study are to determine the relationship between streamflow and physical habitat availability for all life stages of chinook salmon (fall-, late-fall-, winter-runs) and to determine the relationship between streamflow and redd dewatering and juvenile stranding. The study components include: 1) compilation and review of existing information; 2) consultation with other agencies and biologists; 3) field reconnaissance; 4) development of habitat suitability criteria (HSC); 5) study site selection and transect placement; 6) hydraulic and structural data collection; 7) construction and calibration of reliable hydraulic simulation models; 8) construction of habitat models to predict physical habitat availability over a range of river discharges; and 9) preparation of draft and final reports. The first five study components were completed by September 2001. The FY 2002 Scope of Work (SOW) identified study tasks to be undertaken. These included: hydraulic and structural data collection (study component 6), construction of hydraulic models (study component 7), construction of habitat models (study component 8) and preparation of draft and final reports (study component 9).

The Lower American River study was a one-year effort which culminated in a March 27, 1996, report detailing the methods and results of this effort. This report was submitted to CDFG for enclosure in their final report on the lower American River. Subsequently, questions arose as to which of the chinook salmon spawning HSC criteria used in the March 27, 1996, report would be transferable to the Lower American River. As a result, additional field work was conducted in FY 1997, culminating in a supplemental report submitted to CDFG on February 11, 1997. As a result of substantial changes in the Lower American River study sites from the January 1997 storms, a second round of habitat data collection and modeling was begun in April 1998. Data collection for this effort was completed in February 1999 and a final report on the Physical Habitat Simulation (PHABSIM) portion of the study was completed on September 29, 2000. A final report on the 2-D modeling portion of the study is scheduled to be completed by September 2003.

The Butte Creek study is a two-year effort which started with collection of spring-run chinook salmon spawning habitat suitability criteria during September 1999. In May 2000, fieldwork was begun to determine the relationship between habitat availability (spawning) and streamflow for spring-run chinook salmon. This fieldwork included study site selection, transect placement and hydraulic and structural data collection. This data collection was completed in May 2001. Collection of spring-run chinook salmon spawning habitat suitability criteria was completed in September 2000. A draft report on the study is scheduled to be completed by December 2003.

The Yuba River study is a four year effort, the goals of which are to determine the relationship between streamflow and physical habitat availability for all life stages of chinook salmon (fall and spring-runs) and steelhead/rainbow trout and to identify flows at which redd dewatering and juvenile stranding conditions occur. The study started with the location and counting of spring-run chinook salmon redds during September 2001 and the collection of fall-run chinook salmon spawning habitat suitability criteria during November-December 2001. Steelhead/rainbow trout spawning criteria data collection was conducted in February and April 2002. In January 2002, fieldwork was begun to determine the relationship between habitat availability (spawning) and streamflow for spring-run and fall-run chinook salmon and steelhead/rainbow trout. This fieldwork included study site selection, transect placement, and hydraulic and structural data collection.

The following sections summarize project activities between October, 2001 and September, 2002.

SACRAMENTO RIVER

Hydraulic and Structural Data Collection

Juvenile chinook salmon stranding areas

In FY 2000 and 2001, 108 sites were located between Keswick Reservoir and Battle Creek where stranding flows for juvenile chinook salmon will be identified. Stage-discharge data collection for juvenile chinook salmon stranding sites was completed in FY 2001. In FY 2002, we completed stranding area data collection for the stranding sites with the collection of data at one remaining site. For smaller sites, such as this site, we have determined the area by measuring the length and two to six widths of the stranding site, using an electronic distance meter; the area is calculated by multiplying the length times the average width. The areas of larger sites have been measured on aerial photos using a planimeter.

Chinook salmon spawning habitat

Hydraulic and structural data collection on the six fall-run chinook salmon spawning sites (Mudball Riffle, Osborne Riffle, Blackberry Riffle, Jellys Ferry, Upper Bend Riffle, and Five Fingers Riffle) between Battle Creek and Deer Creek, which began in August 1999, was completed in October 2001. As discussed in the FY 1999 progress report, these sites will be modeled using two-dimensional hydraulic and habitat modeling. The 2-D model uses as inputs the bed topography and substrate of a site, and the water surface elevation at the bottom of the site, to predict the amount of habitat present in the site. A PHABSIM transect at the bottom of the site (outflow transect) is used to provide the water surface elevations used by the 2-D model, while the water surface elevations predicted by a PHABSIM transect at the top of the site (inflow transect) are used to calibrate the 2-D model. The data collected at the inflow and outflow transects include: 1) water surface elevations (WSELs), measured to the nearest .01 foot at a minimum of three significantly different stream discharges using standard surveying techniques (differential leveling); 2) wetted streambed elevations determined by subtracting the measured depth from the surveyed WSEL at a measured flow; 3) dry ground elevations to points above bankfull discharge surveyed to the nearest 0.1 foot; 4) mean water column velocities measured at a mid-to-high-range flow at the points where bed elevations were taken; and 5) substrate and cover classification at these same locations and also where dry ground elevations were surveyed. Data collected between the transects include: 1) bed elevation; 2) northing and easting (horizontal location); 3) cover; and 4) substrate. These parameters are collected at enough points to characterize the bed topography, substrate and cover of the site.

In FY 2002, the collection of low flow WSELs (approximately 5,000 cfs) at Five Fingers completed the collection of WSELs at all six sites. Dry bed elevations were collected at Osborne and Five Fingers, completing dry bed elevation data collection at all six sites.

Substrate and cover data collection at all six sites was completed in October 2002 with the collection of this data for Five Fingers. Underwater video equipment and an electronic distance meter were used to determine the substrate and cover (Tables 1 and 2) along the deeper portions of the transects, with the shallow and dry portions determined visually. The underwater video equipment consists of two cameras mounted on a 75 pound bomb at angles of 45 and 90 degrees. The 75 pound bomb is raised and lowered from our boat using a winch. Two monitors on the boat provide the views from the cameras. A grid on the 90 degree camera monitor calibrated at one foot above the bottom is used to measure the substrate and cover.

Discharge measurements were needed at transects with split channels (Mudball XS 2, Bend XS 2) and for Five Fingers XS 2, to develop relationships between total flow and the flow in each split channel. Discharges for the remaining transects will be determined from gage data. In FY 2002, measurements of discharges for these transects were completed with the collection of low-flow (approximately 5,000 cfs) discharge measurements for Mudball XS 2 and Five Fingers XS 2.

Table 1
Substrate Descriptors and Codes

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

We have used two techniques to collect the data between the top and bottom transects: 1) for areas that were dry or shallow (less than three feet), bed elevation and horizontal location of individual points were obtained with a total station, while the cover and substrate were visually assessed at each point; and 2) in portions of the site with depths greater than three feet, the ADCP was used in concert with the total station to obtain bed elevation and horizontal location. Specifically, the ADCP was run across the channel at 50 to 150-foot intervals, with the initial and final horizontal location of each run measured by the total station. The WSEL of each ADCP run was measured with the level before starting the run. The WSEL of each run was then used together with the depths from the ADCP to determine the bed elevation of each point along the run. Velocities at each point measured by the ADCP will be used to validate the 2-D model. The total station was used to relocate initial and final location of each run. Buoys were placed at these locations for use during the collection of the deep substrate and cover data. The underwater video and electronic distance meter were then used to determine the substrate and cover along each run, so that substrate and cover values could be assigned to each point of the run.

Table 2
Cover Coding System

Cover Category	Cover Code[2]
no cover	0
cobble	1
boulder	2
fine woody vegetation (< 1" diameter)	3
branches	4
log (> 1' diameter)	5
overhead cover (< 2' from water surface)	7
undercut bank	8
aquatic vegetation	9
rip-rap	10

To validate the velocities predicted by the 2-D model for shallow areas within a site, depth, velocities, substrate and cover measurements were collected along the right and left banks within each site by wading with a wading rod equipped with a Marsh-McBirney[R] model 2000 or a Price AA velocity meter. The horizontal locations and bed elevations were determined by taking a total station shot on a prism held at each point where depth and velocity were measured. A minimum of 25 representative points were measured along the length of each side of the river per site.

Collection of both the dry/shallow bed elevation/substrate/cover data and the deep bed elevation data was completed in FY 2000, while the collection of shallow validation velocity data and deep substrate and cover data was completed in FY 2001.

For biological validation of the 2-D models for Osborne, Blackberry Island and Five Fingers sites, the locations of fall-run redds in or near these sites on October 24, 2001 were mapped using GPS, and the substrate and percent embeddedness of each redd recorded. In addition, GPS coordinates of the head and tail pins of the transects for all six sites were recorded, so that the results of the 2-D modeling could be input into GIS.

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[2] In addition to these cover codes, we have been using the composite cover codes 3/7, 4/7, 5/7 and 9/7; for example, 4/7 would be branches plus overhead cover.

Hydraulic Model Construction and Calibration

Juvenile chinook salmon stranding areas

Stranding flows have been determined for 88 of the 108 stranding sites. Stranding areas have been determined for 102 of the 108 stranding sites. The stranding flows and areas for the remaining sites will be determined in FY 2003, and a final report on juvenile chinook salmon stranding sites will be completed by September 2003.

Chinook salmon spawning habitat

All data for the six fall-run chinook salmon spawning sites between Battle Creek and Deer Creek has been compiled and checked. Construction and calibration of 2-D hydraulic models of these sites will be conducted in FY 2003. A draft report on the PHABSIM analysis of the fall, late-fall and winter-run chinook salmon spawning sites between Keswick Dam and Battle Creek was completed in September 2001, has completed peer review, and a final report should be completed by September 2002. A draft report on 2-D modeling for spawning between Battle Creek and Deer Creek should be completed by September 2003.

Juvenile chinook salmon rearing habitat

The topographic data for the 2-D model (contained in bed files) is first processed using the R2D_Bed software, where breaklines are added to produce a smooth bed topography. The resulting dataset is then converted into a computational mesh using the R2D_Mesh software, with mesh elements sized to reduce the error in bed elevations resulting from the mesh-generating process to 0.1 feet where possible, given the computational constraints on the number of nodes. The resulting mesh is used in River2D to simulate depths and velocities at the flows to be simulated.

The PHABSIM transect at the bottom of each site is calibrated to provide the WSEL's at the bottom of the site used by River2D. The PHABSIM transect at the top of the site is calibrated to provide the water surface elevations used to calibrate the River2D model. The initial bed roughnesses used by River2D are based on the observed substrate sizes and cover types. A multiplier is applied to the resulting bed roughnesses, with the value of the multiplier adjusted so that the WSEL's generated by River2D at the top of the site match the WSEL's predicted by the PHABSIM transect at the top of the site[3]. The River2D model is run at the flows at which the validation dataset was collected, with the output used in GIS to determine the difference between simulated and measured velocities, depths, bed elevations, substrate and cover.

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[3] This is the primary technique used to calibrate the River2D model.

All of the data for the rearing sites between Keswick Dam and Battle Creek have been compiled and checked. PHABSIM data decks have been created and hydraulic calibration has been completed for the upstream and downstream transects for all of the rearing sites between Keswick Dam and Battle Creek. Bed files and computational meshes for the 2-D modeling program have been completed for all of the rearing sites between Keswick Dam and Battle Creek. Calibration of the two-dimensional hydraulic models has been completed for 14 of the 17 rearing sites. Production runs for all of the simulation flows have been completed for 13 of the 17 rearing sites. A draft report on the 2-D analysis of the fall, late-fall and winter-run chinook salmon rearing sites between Keswick Reservoir and Battle Creek will be completed in FY 2003.

Habitat Suitability Criteria (HSC) Development

Spawning

Methods

Collection of fall-run spawning HSC data and development of depth, velocity and substrate HSC were completed in FY 2000. Details on criteria and methods are given in U.S. Fish and Wildlife Service 2002. Collection of late-fall and winter-run chinook salmon spawning HSC data and development of depth, velocity and substrate HSC were completed in FY 2001. Details on criteria and methods are given in U.S. Fish and Wildlife Service 2002.

Rearing

Data collection for fry and juvenile rearing criteria was completed in FY 2001. Work on developing fry and juvenile rearing criteria began toward the end of FY 2002 and should be completed by December 2002. Progress on developing criteria in FY 2002 was delayed by the time required to acquire statistical software.

Macroinvertebrate Criteria

We are developing a second set of juvenile chinook salmon HSC - one based on food supply rather than physical habitat. Specifically, we are developing HSC for macroinvertebrate biomass and diversity. The criteria we develop will be run on the juvenile rearing site habitat models to predict the relationship between flow and habitat area for macroinvertebrate biomass and diversity. We completed our sampling for macroinvertebrate criteria in FY 2001, with a total of 75 macroinvertebrate samples (twenty-two in riffles, twenty in runs, thirteen in pools and twenty in glides). Having completed our sampling, we are now working on sorting, identifying and enumerating the samples. To date, we have completed initial processing of 25 out of 75 samples, separating macroinvertebrates from detritus. These samples are ready to have their biomass measured. We will then determine the relative biomass and diversity represented by each sample. HSC will be developed for macroinvertebrate production and diversity as determined by depth, velocity, and substrate size based on the relative biomass and diversity determined for the samples. Given the stratification of the sampling by depth, velocity and substrate, the 75 samples collected should be sufficient to generate habitat suitability criteria. Lack of sufficient personnel and funding precluded completing this work in FY 2002. We hope to obtain sufficient funding to allow completion of this work in FY 2003.

LOWER AMERICAN RIVER

As a result of the 115,000 cfs flood releases made into the lower American River in January of 1997, considerable morphological changes have occurred in many areas of the river including some of our previous study sites. Consequently, CDFG requested that we collect additional hydraulic and structural data, and develop new spawning habitat models for fall-run chinook salmon on the lower American River.

We decided to run both PHABSIM and the 2-D habitat modeling program used by the USGS office in Fort Collins, Colorado, to allow for additional comparisons of the 2-D model to PHABSIM. The 2-D model uses as inputs the bed topography and substrate of a site, and the water surface elevation at the bottom of the site, to predict the amount of habitat present in the site. We are in the process of running the 2-D model for each of the five study sites described in the FY 1998 annual report. The downstream-most PHABSIM transect was used as the bottom of the site, to provide WSELs as an input to the 2-D model. The upstream-most PHABSIM transect was used as the top of the site. To calibrate the 2-D model, bed roughnesses were adjusted until the WSEL at the top of the site matched the WSEL predicted by PHABSIM.

Hydraulic Model Construction and Calibration

All of the data for the five lower American River spawning sites have been compiled and checked. PHABSIM data decks have been created and hydraulic calibration has been completed for the lower American River spawning site transects. A final report on the PHABSIM portion of the lower American River study was completed in September 2000. Bed files and computational meshes for the 2-D modeling program have been completed for all of the lower American River spawning sites. Production runs have been completed for all of the sites. A draft report on the 2-D modeling portion of the lower American River study was completed in February 2002, has completed peer review and a final report should be completed by September 2003.

BUTTE CREEK

The 2-D habitat modeling program described for the Lower American River study is being used for Butte Creek. Data collection for Butte Creek was completed in FY 2001; see the 2001 annual report for more details on data collection methods and results. We are in the process of completing 2-D modeling for the seven study sites described in the FY 2001 annual report.

Hydraulic Model Construction and Calibration

All data for the spawning habitat sites have been compiled and checked, and PHABSIM data decks, hydraulic calibration and final 2-D modeling files for the seven sites were completed for all sites in FY 2002. The downstream PHABSIM transect was used as the bottom of the site, to provide WSEL's as an input to the 2-D model. The upstream PHABSIM transect was used as the top of the site. To calibrate the 2-D model, bed roughnesses were adjusted until the WSEL at the top of the site matched the WSEL predicted by PHABSIM. Production runs have been completed for six of the sites; we are still in the process of completing the production runs for the remaining site. A final report on the 2-D modeling portion of the Butte Creek study will be completed by the end of FY 2003.

Habitat Suitability Criteria (HSC) Development

Spawning

Data collection for spring-run chinook salmon spawning HSC was completed in FY 2001. Spring-run chinook salmon spawning HSC should be completed by December 2002.

YUBA RIVER

Habitat Suitability Criteria (HSC) Development

Spawning

Methods

Due to the fact that the study was not approved until late September, we were unable to collect habitat suitability criteria data for spawning spring-run chinook salmon in 2001. We collected spring-run chinook salmon spawning criteria data on September 16-19, 2002 and September 23-26, 2002. We sampled the Yuba River above Daguerra Dam from below the Narrows to Daguerra Dam, and sampled the Yuba River below Daguerra Dam from Daguerra Dam to Hallwood Road, collecting habitat suitability data (depth, velocity and substrate) and counting the number of redds in each distinct spawning area. The location of each redd was marked with a GPS unit. We also sampled all five of our study sites above Daguerra Dam and two of our study sites (Upper Daguerra and Lower Daguerra) below Daguerra Dam. The location of each redd found in our study sites was determined with a total station. We sampled shallow areas by wading, and sampled deep areas within our study sites visually using an inflatable kayak; water visibility was sufficient to sample all areas in our study sites by visual observation above the water surface. We also recorded the percent redd superimposition and periodically recorded water temperature. Flows in the river upstream of Daguerra Dam from the beginning of spring-run spawning (September 1) until data collection for this portion of the river was completed on September 26, 2002 fluctuated between 600-721 cfs. Flows in the river downstream of Daguerra Dam from the beginning of spring-run spawning until data collection for this portion of the river were completed on September 26 fluctuated between 442-528 cfs. The unstable nature of the flows in both portions of the river resulted in some uncertainty that the measured depths and velocities were the same as those present at the time of redd construction.

We collected habitat suitability criteria data for fall-run chinook salmon on November 13–16, 2001 and November 19, 2001. We sampled the Yuba River above Daguerra Dam from the U.C. Sierra Research Station up to the downstream end of the Narrows, and from Sycamore Ranch Campground downstream approximately one mile. We also sampled below Daguerra Dam from immediately below Daguerra Dam downstream approximately one mile, and from Walnut Road to approximately one-half mile below Hallwood Road, collecting habitat suitability data (depth, velocity and substrate) and counting the number of redds in each distinct spawning area. Only shallow areas were sampled for redds due to low flows preventing the use of our boat. The upstream and downstream end of each spawning area was marked with a GPS unit. We also recorded the percent redd superimposition and periodically recorded water temperature. Flows in the river upstream of Daguerra Dam from the beginning of fall-run spawning (October 1) until data collection for this portion of the river was completed on November 19, 2001 fluctuated between 581-797 cfs. Flows in the river downstream of Daguerra Dam from the beginning of fall-run spawning until data collection for this portion of the river were completed on November 16 fluctuated between 391-545 cfs. The unstable nature of the flows in both portions of the river resulted in some uncertainty that the measured depths and velocities were the same as those present at the time of redd construction. We plan to collect additional habitat suitability criteria for fall-run chinook salmon spawning above and below Daguerra Dam in November-December 2002, with particular effort to be spent on looking for deep redds[4].

We collected habitat suitability criteria data for steelhead/rainbow trout on February 5-7, 2002, February 26, 2002, April 9-11, 2002, and April 23, 2002. With the exception of February 6 and April 23, when the river was surveyed from downstream of the Highway 20 bridge down to Daguerra Dam, all data collection was conducted between the downstream end of the Narrows and one mile

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[4] We have recently borrowed a boat from our Red Bluff Office which we should be able to use to sample deep areas for redds even at low flows.

below the Highway 20 bridge. Due to time constraints, no surveys were conducted downstream of Daguerra Dam. The steelhead/rainbow spawning criteria data collected consisted of habitat suitability data (depth, velocity and substrate), redd widths and lengths, and a count of the number of redds in each distinct spawning area. The location of each redd was marked with a GPS unit. We also recorded the percent redd superimposition and periodically recorded water temperature. In most cases, observed redds were in water depths shallow enough to enable measurement by hand. However, 9 redds were observed in deep water on April 11, 2002 between the downstream end of the Narrows and U.C. Sierra Research Station. Flows fluctuated between 1214-1986 cfs during the one month period prior to the February 5-7, 2002 data collection, resulting in some uncertainty that the measured depths and velocities were the same as those present at the time of redd construction. During the one month period leading up to the February 26, 2002 data collection, flows were relatively steady, fluctuating between 1434-1513 cfs, with the exception of 3 consecutive days when flows increased up to 1888-2789 cfs. During the one month period leading up to the April 9-11 and April 23, 2002 data collection, flows were again relatively steady, fluctuating between 1977-2015 cfs. The relatively stable nature of the flows during these latter data collection periods suggests that the measured depths and velocities were the same as those present at the time of redd construction. We plan to continue collecting steelhead/rainbow trout spawning habitat suitability criteria data above and below Daguerra Dam in February-April 2003; depending on the number of redds found in 2003, data collection may have to continue in 2004 to obtain a minimum of 150 observations.

For habitat suitability criteria data collection, all of the active redds (those not covered with periphyton growth) which could be distinguished were measured. Data were collected from an area adjacent to the redd which was judged to have a similar depth and velocity as was present at the redd location prior to redd construction. This location was generally about two to four feet upstream of the pit of the redd; however it was sometimes necessary to make measurements at a 45 degree angle upstream, to the side, or behind the pit. The data were almost always collected within six feet of the pit of the redd. Depth was recorded to the nearest 0.1 ft and average water column velocity was recorded to the nearest 0.01 ft/s. Substrate was visually assessed for the dominant particle size range (i.e., range of 1-2") at three locations: 1) in front of the pit; 2) on the sides of the pit; and 3) in the tailspill. Substrate embeddedness data were not collected because the substrate adjacent to all of the redds sampled was predominantly unembedded. The substrate coding system used is shown in Table 1.

Location of steelhead/rainbow trout redds in deep water was accomplished by boat using underwater video. When searching for redds in deep water using underwater video, a series of parallel runs with the boat upstream within a mesohabitat unit was performed. After locating a redd in deep water, substrate size was measured using underwater video directly over the redds. Depth and water velocity was measured over the redds using the ADCP. The location of all redds (both in shallow and deep water) was recorded with a Global Positioning System (GPS) unit, so that we could ensure that redds were not measured twice.

Results

We collected habitat suitability criteria for 164 spring-run chinook salmon redds above Daguerra Dam (between Daguerra Dam and the downstream end of the Narrows) and for 4 spring-run chinook salmon redds below Daguerra Dam (between Daguerra Dam and Hallwood Road).

We collected habitat suitability criteria for 192 fall-run chinook salmon redds above Daguerra Dam (between Daguerra Dam and the downstream end of the Narrows) and for 313 fall-run chinook salmon redds below Daguerra Dam (between Daguerra Dam and approximately one-half mile downstream of Hallwood Road).

Habitat suitability criteria were collected for 47 steelhead/rainbow trout redds and one late-fall-run chinook salmon redd above Daguerra Dam (between Daguerra Dam and the downstream end of the Narrows). Due to the difficulty in distinguishing between steelhead trout and endemic rainbow trout, it was impossible to verify whether the redds were constructed by steelhead trout. Based on data collected by CDFG on fall-run chinook salmon and steelhead redds in the Lower American River, we have developed the following criteria to distinguish steelhead/rainbow trout redds from chinook salmon redds: Steelhead/rainbow trout redds have a length less than 5.1 feet and a width less than 4.5 feet, while chinook salmon redds have a length greater than 5.1 feet or a width greater than 4.5 feet. These criteria correctly classified 96% of 129 chinook salmon redds and 53% of 28 steelhead redds from the Lower American River. Since our goal is to avoid classifying chinook salmon redds as steelhead redds, we feel that the above criteria are sufficiently accurate for purposes of collecting steelhead/rainbow trout spawning criteria, particularly since there appear to be relatively few late-fall-run chinook salmon in the Yuba River.

Field Reconnaissance and Study Site Selection

Spawning

Field reconnaissance in FY 2002 investigated potential study sites where two-dimensional (2-D) habitat modeling will be undertaken for fall-run chinook salmon, spring-run chinook salmon, and steelhead/rainbow trout spawning. Some of these sites may also be used for habitat modeling of fall-run chinook salmon, spring-run chinook salmon, and steelhead/rainbow trout fry and juvenile rearing. The following section describes the methods employed and the results of FY 2002 reconnaissance and study site selection efforts for this species.

We began preliminary work of determining spring-run chinook spawning locations on September 21, 2001. This work consisted of floating downstream from U.C. Sierra Research Station to Daguerra Dam and recording with GPS the locations and approximate numbers of redds observed. This data was collected in order to facilitate the selection of study sites based on heaviest spawning use. We collected the same data for fall-run redds in November and December 2001 for fall-run redds between the downstream end of the Narrows and Simpson Lane Bridge. For fall-run redds, we also recorded the percent redd superimposition and periodically recorded water temperature.

The above observations made in 2001 for spawning spring-run and fall-run chinook salmon were combined in a GIS analysis with data collected in 2000 on fall-run chinook salmon and steelhead/rainbow trout spawning by Jones and Stokes Consulting biologists. Study sites selected were those that received heaviest use by spring-run and fall-run chinook salmon and steelhead/rainbow trout.

Considering time and manpower constraints, ten study sites were selected for modeling spring-run and fall-run chinook salmon and steelhead/rainbow trout habitat (Table 3). Five sites are located between the Narrows and Daguerra Dam and the remaining five are located downstream of Daguerra Dam between Daguerra Dam and Plantz Road. As described previously, these ten sites are among those which received the heaviest use by spawning spring-run and fall-run chinook salmon and steelhead/rainbow trout. For the sites selected for modeling, the landowners along both riverbanks were identified and temporary entry permits were sent, accompanied by a cover letter, to acquire permission for entry onto their property during the course of the study.

Transect Placement (study site setup)

Spawning

The modeling of spring-run and fall-run chinook salmon and steelhead/rainbow trout spawning will be accomplished using two-dimensional modeling. Study sites were established March-June 2002. The study site boundaries (top and bottom) were selected to coincide with the top and bottom of the boundaries of the heavy spawning use areas[5]. The location of these boundaries was established during site setup by navigating to the points marked with the GPS unit during our redd counts in September and November-December 2001 along with referencing mapped locations of fall-run salmon and steelhead/rainbow trout redds recorded by Jones and Stokes Consulting biologists.

For each study site, a transect was placed at the top and bottom of the site. The bottom transect will be modeled with PHABSIM to provide water surface elevations as an input to the 2-D model. The upstream transect will be used in calibrating the 2-D model - bed roughnesses are adjusted until the water surface elevation at the top of the site matches the water surface elevation predicted by PHABSIM. Transect pins (headpins and tailpins) were marked on each river bank above the

[5] In some cases, the top of the site was moved upstream and/or the bottom of the site was moved downstream to a location that was better suited to being a boundary for the 2-D model (a relatively unvarying WSEL and parallel flow across the transect).

Table 3
Sites Selected for Modeling Spring-run, Fall Run Chinook Salmon
and Steelhead/Rainbow Trout Spawning

		Number of Redds			
Site Name	Reach	Fall-Run 2000	Fall-Run 2001	Spring-Run 2001	ST/RBT 2000
U.C. Sierra	Above Daguerra	76	>100	108	>1
Timbuctoo	Above Daguerra	50	78	25	>8
Highway 20	Above Daguerra	20	>85	15	>9
Island	Above Daguerra	15	34	30	>1
Hammond	Above Daguerra	40	39	9	0
Upper Daguerra	Below Daguerra	41	>75	---	---
Lower Daguerra	Below Daguerra	29	95	---	---
Pyramids	Below Daguerra	36	51	---	---
Hallwood	Below Daguerra	16	40	---	---
Plantz	Below Daguerra	10	30	---	---

10,000 cfs water surface level using rebar driven into the ground and/or lag bolts placed in tree trunks. Survey flagging was used to mark the locations of each pin. Horizontal benchmarks were established at each site for total station placement when collecting bed topography data. The precise northing and easting coordinates and vertical elevations of two horizontal benchmarks were established for each site by the U.S. Bureau of Reclamation using dual frequency survey-grade differential GPS. The elevations of these benchmarks was tied into the vertical benchmarks on our sites using differential leveling. Collection of site bed topography data relative to these values will be used primarily to enable the incorporation of bed topography data collected for the Yuba River by the U.S. Army Corps of Engineers using LIDAR technology and boat traces. This incorporated data will allow greater refinement of the bed topography for each study site. This approach will also enable establishing the location and orientation of the sites and their bed elevations and water surface elevations relative to data that is concurrently being collected by other entities. This will facilitate the sharing and comparison of data for the various studies being conducted on the Yuba River.

Hydraulic Model Construction and Calibration

Spawning

Hydraulic and structural data collection began in March 2002. The data collected at the inflow and outflow transects include: 1) WSELs, measured to the nearest .01 foot at a minimum of three significantly different stream discharges using standard surveying techniques (differential leveling); 2) wetted streambed elevations determined by subtracting the measured depth from the surveyed WSEL at a measured flow; 3) dry ground elevations to points above bankfull discharge surveyed to the nearest 0.1 foot; 4) mean water column velocities measured at a mid-to-high-range flow at the points where bed elevations were taken; and 5) substrate and cover classification at these same locations (Tables 1 and 2) and also where dry ground elevations were surveyed. Data collected between the transects include: 1) bed elevation; 2) northing and easting (horizontal location); 3) cover; and 4) substrate. These parameters are collected at enough points to characterize the bed topography, substrate and cover of the site.

We have used two techniques to collect the data between the top and bottom transects: 1) for areas that were dry or shallow (less than three feet), bed elevation and horizontal location of individual points are obtained with a total station, while the cover and substrate are visually assessed at each point; and 2) in portions of the site with depths greater than three feet, the ADCP is used in concert with the total station to obtain bed elevation and horizontal location. Specifically, the ADCP is run across the channel at 50 to 150-foot intervals, with the initial and final horizontal location of each run measured by the total station. The WSEL of each ADCP run is measured with the level before starting the run. The WSEL of each run is then used together with the depths from the ADCP to determine the bed elevation of each point along the run. Velocities at each point measured by the ADCP will be used to validate the 2-D model. To validate the velocities predicted by the 2-D model for shallow areas within a site, depth, velocities, substrate and cover measurements will be collected along the right and left banks within each site by wading with a wading rod equipped with a Marsh-McBirney[R] model 2000 or a Price AA velocity meter. The horizontal locations and bed elevations will be determined by taking a total station shot on a prism held at each point where depth and velocity were measured. A minimum of 25 representative points will be measured along the length of each side of the river per site.

Water surface elevations have been measured at flows of 1867-2007 cfs and 909 cfs for U.C. Sierra, Timbuctoo, Highway 20, Island, and Hammond sites (above Daguerra Dam). Water surface elevations have also been measured at a flows of 2586 cfs for Upper Daguerra and Lower Daguerra sites, and a flows of 1263-1448 cfs and 697 cfs for Upper Daguerra, Lower Daguerra, Pyramids, Hallwood, and Plantz sites (below Daguerra Dam). Water surface elevations will be collected at lower flows for all sites in the fall of 2002. Water surface elevations will be collected at the highest flow available for all sites during the course of the study. Discharge measurements for the above WSELs have been made on all sites except Hallwood and Plantz[6]. Velocity sets were collected for the transects at U.C. Sierra, Timbuctoo, Highway 20, Island, Hammond, Upper Daguerra, Lower Daguerra, and Pyramids sites at flows of 1263-2586 cfs. Depth and velocity measurements were made using a boat-mounted ADCP and by wading with a wading rod equipped with a Marsh-McBirney[R] model 2000 or a Price AA velocity meter.

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[6] We will be using the Marysville gage (USGS No. 11421000) flow for the discharge fore these two sites.

A tape or an electronic distance meter were used to measure stations along the transects. Substrate and cover along the transects were determined visually. Dry bed elevations along the transects have been collected for U.C. Sierra (XS 2 only), Highway 20, Island, Hammond, Upper Daguerra, Lower Daguerra (XS 2 only), and Pyramids sites. Substrate and cover data along the transects have been collected for U.C. Sierra, Timbuctoo, Highway 20, Island and Hammond sites. Vertical benchmarks have been tied together for all sites except Plantz.

We have collected the data between the top and bottom transects by obtaining the bed elevation and horizontal location of individual points with a total station, while the cover and substrate are visually assessed at each point. Through the end of FY 2002, bed topography data were collected for Upper Daguerra and Island sites and for part of Hammond site. Bed elevations, substrate and cover data for portions of the sites over 3 feet in depth have been collected using the ADCP and total station for Highway 20, Island, Hammond, Upper Daguerra, Lower Daguerra, and Pyramids sites. This work has also been mostly completed for U.C. Sierra and Timbuctoo sites. Most of the area of the sites has been shallow enough that the underwater video has not been needed to collect substrate and cover data; instead the substrate and cover data has been directly visually determined. Shallow validation velocity data collection for the ten study sites will be conducted during FY 2003. We anticipate completing the hydraulic and structural data collection for all ten spawning study sites in FY 2003.

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