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

Annual Progress Report
Fiscal Year 2011

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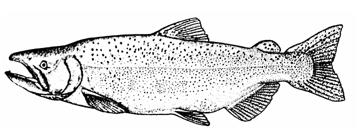
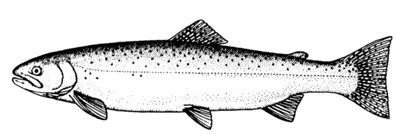
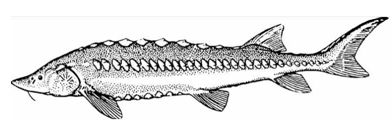

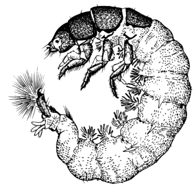
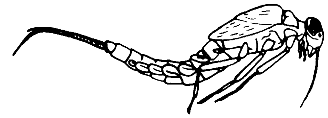

EXHIBIT BKS-259

Available at https://www.fws.gov/lodi/instream-flow/instream_flow_reports.htm

PREFACE

The following is the Tenth Annual Progress Report, Identification of the Instream Flow Requirements for Anadromous Fish in the Streams within the Central Valley of California and Fisheries Investigations, prepared as part of the Central Valley Project Improvement Act (CVPIA) Instream Flow and Fisheries Investigations, an 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 Department 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 purposes of this investigation are: 1) to provide 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; and 2) to provide scientific information to other CVPIA programs to use in assessing fisheries restoration actions. The purpose of this report is to provide an update on the Monitoring and Restoration Program's CVPIA-funded activities and accomplishments during the last fiscal year to interested stakeholders. An in-depth presentation on the instream flow studies is given in the final reports for these studies. The annual reports serve as final reports for the fisheries investigation tasks.

The field work described herein was conducted by Ed Ballard, Mark Gard, Rick Williams and Steve Schoenberg.

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Electronic versions of our final reports and previous years' annual reports are available on our website:

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[1] The scope of this program was broadened in FY 2009 to include fisheries investigations. This program is a continuation of a 7-year effort, titled the Central Valley Project Improvement Act Instream Flow Investigations, which ran from February 1995 through September 2001.

OVERVIEW

In response to substantial declines in anadromous fish populations, the Central Valley Project Improvement Act provided for enactment of all reasonable efforts to double sustainable natural production of anadromous fish stocks including the four races of Chinook salmon (fall, late-fall, winter, and spring), steelhead trout, white and green sturgeon, American shad and striped bass. In June 2001, the Service's 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 last report for the Lower American River study was completed in February 2003, the final report for the Butte Creek study was completed in September 2003, and the last two reports for the Sacramento River were completed in December 2006. In 2004, Clear Creek was selected as an additional river for studies. In 2007, the Tuolumne River was selected for a minor project to quantify floodplain inundation area as a function of flow, with a final report completed in August 2008. In 2008, South Cow Creek was selected as an additional river for studies. In 2010, the Stanislaus River was selected to perform activities to assist the Bureau of Reclamation with conducting an instream flow study. In 2011, the following fisheries investigation tasks were selected for study: 1) Clear Creek biovalidation – how well does IFIM compare to field observations; 2) American River gravel placement monitoring; 3) American and Sacramento River and Clear Creek redd dewatering monitoring; 4) Stanislaus River floodplain area versus flow; 5) Stanislaus River floodplain restoration project monitoring; 6) Tuolumne River Bobcat Flat monitoring; 7) Cottonwood Creek geomorphic data collection; 8) South Fork Cottonwood Creek fish habitat assessment; 9) Yuba/Feather River sturgeon spawning habitat suitability criteria data collection; and 10) Clear Creek inSALMO modeling.

The Yuba River study was planned to be a 4-year effort, beginning in September 2001. The goals of the study were to determine the relationship between stream flow and physical habitat availability for all life stages of Chinook salmon (fall- and spring-runs) and steelhead/rainbow trout and to determine the relationship between streamflow and redd dewatering and juvenile stranding. Collection of spawning and juvenile rearing criteria data for fall- and spring-run Chinook salmon and steelhead/rainbow trout was completed by April 2004 and September 2005, respectively. Field work to determine the relationship between habitat availability for spawning and juvenile rearing and streamflow for spring-run and fall-run Chinook salmon and steelhead/rainbow trout was completed in FY 2005 and FY 2007, respectively. A draft spawning report was completed in FY 2007 and draft rearing and redd dewatering/juvenile stranding reports were completed in FY 2008. In FY 2008 to 2010, we conducted peer and stakeholder reviews[2] of the three reports. In FY 2011, we issued all three final reports and response to comments documents.

The Clear Creek study was planned to be a 5-year effort, beginning in October 2003. The goals of the study are to determine the relationship between stream flow and physical habitat availability for all life stages of Chinook salmon (fall- and spring-run) and steelhead/rainbow trout. There are four phases to this study based on the life stages to be studied and the number of segments delineated for Clear Creek from downstream of Whiskeytown Reservoir to the confluence with the Sacramento River[3]. The four phases are: 1) spawning in the upper two segments; 2) fry and juvenile rearing in the upper two segments; 3) spawning in the lower segment; and 4) fry and juvenile rearing in the lower segment. Field work for the above four phases was completed in FY 2005, FY 2007, FY 2008 and FY 2009, respectively. In FY 2007 the final report and the peer review response-to-comments document for spawning in the upper two segments was completed. In FY 2011, with funding from the CVPIA Clear Creek program, final reports and the peer and stakeholder review response-to-comments documents for rearing in the upper two segments and spawning in the lower segment were completed. In FY 2011, we completed hydraulic modeling for three of the five lower segment rearing sites[4] and are in the process of conducting the hydraulic modeling for an additional site. An additional task, preparing a document that provides a synthesis of all four reports, was added in FY 2011. The remaining work on the Clear Creek reports will be completed in FY 2012.

The South Cow Creek study was planned to be a 5-year effort and began in October 2008 with habitat mapping and collection of spawning habitat suitability data for fall-run Chinook salmon. In FY 2009, fieldwork was completed on one site and started on an additional three sites to determine the relationship between stream flow and physical habitat availability for fry and juvenile rearing of fall-run Chinook salmon. In FY 2010, we completed fieldwork on the three remaining juvenile sites, hydraulic modeling on two sites, redd mapping and an upstream passage assessment, and completed most of the final report. Due to funding cuts, the South Cow Creek study was completed in FY 2011 with completion of hydraulic modeling of the two remaining sites and a final report on habitat quantity and quality in South Cow Creek.

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[2] Stakeholder review for the Yuba reports was agreed upon during scoping meetings prior to commencement of the studies.

[3] There are three segments: the upper alluvial segment, the canyon segment, and the lower alluvial segment. Spring-run Chinook salmon spawn in the upper two segments, while fall-run Chinook salmon spawn in the lower segment and steelhead/rainbow trout spawn in all three segments.

[4] Hydraulic modeling for another site was completed in FY 2010.

The Stanislaus River study activities conducted by FWS began in FY 2010 with biological validation data collection for both spawning and rearing, and initial development of hydraulic and habitat models for four sites. The hydraulic and habitat modeling continued in FY 2011 and will be completed in FY 2012.

Work on the fisheries investigations tasks, to provide scientific information to other CVPIA programs to use in assessing fisheries restoration actions, in FY 2011 was as follows:

1) Work on the task "Clear Creek Biovalidation – how well does IFIM compare to field observations" re-started in FY 2011, with funding from the CVPIA Clear Creek program, after we obtained bed topography data on study site 3A from Graham Matthews and Associates.
2) In FY 2011, with funding from the CVPIA Anadromous Fish Restoration Program (AFRP) and b(13) programs, we conducted post-restoration monitoring of the FY 2008 and 2010 gravel restoration projects on the American River and assisted with the design for the FY 2011 gravel restoration project. In FY 2012, we plan to conduct post-restoration monitoring of the FY 2011 gravel restoration project and collect data to be used for the next American River gravel project.
3) In FY 2011, we conducted redd dewatering monitoring on the Sacramento and American Rivers for the CVPIA b(2) program, and determined the effectiveness of the use of b(2) water on the Sacramento and American Rivers and Clear Creek in preventing redd dewatering. This activity will be continued in FY 2012.
4) We conducted the first phase of the Stanislaus River floodplain area versus flow task in FY 2011 with funding from the Comprehensive Assessment and Monitoring Program. We will conduct the remaining phases of the Stanislaus River floodplain area versus flow task in FY 2012 with funding from AFRP.
5) In FY 2011, we collected topographic data and ground-truthed LIDAR data for the Stanislaus River Two-Mile Bar project and collected pre-and post-restoration data for the Stanislaus River Lancaster Road project. In FY 2012, we will be collecting post-restoration data on the Stanislaus River Lancaster Road and Honolulu Bar projects.
6) In FY 2011, we collected pre-restoration data for the Tuolumne River Bobcat Flat project. In FY 2012, we will be collecting post-restoration data for the Tuolumne River Bobcat Flat project and modeling pre- and post-restoration habitat to determine the quantity of fall-run Chinook salmon spawning and rearing habitat created by the Bobcat Flat project.
7) In FY 2011, we collected topographic data for the ACID (Anderson Cottonwood Irrigation District) siphon restoration project on Cottonwood Creek to assess the effect of high flows. This activity will be continued in FY 2012, along with collection of geomorphic data and quantification of the amount of juvenile rearing habitat in Cottonwood Creek.
8) In FY 2011, we conducted an assessment of adult spring-run Chinook salmon holding habitat and upstream passage on South Fork Cottonwood Creek. We will be conducting a similar study on North Fork Cottonwood Creek in FY 2012.

9) In FY 2011, we collected habitat suitability criteria for green sturgeon spawning on the Yuba River just downstream of Daguerre Dam. This activity will be conducted for other locations on the Yuba and Feather Rivers in FY 2012.
10) In FY 2011, with funding from the CVPIA Ecosystem and Water System Operations Modeling program, we conducted beta testing of the inSALMO software as applied to Clear Creek.

Progress on many of these tasks was hampered by the high flows in Central Valley rivers in FY 2011, as detailed below. The following sections summarize project activities between October 2010 and September 2011.

YUBA RIVER

Habitat Simulation

Chinook salmon and steelhead/rainbow trout spawning

A draft report and response to peer review comments document was completed in FY 2007. In FY 2007, we sent out the draft report to interested parties for review and comment prior to finalizing the report. This review by interested parties was in response to commitments made by the Service during the initial planning meetings with those interested parties. This is the first of the CVPIA instream flow reports to be reviewed in this manner. In FY 2008 and 2009, we conducted a series of meetings with stakeholders regarding the draft report. In response to comments received at these meetings, we completed in FY 2009 a habitat modeling and biological verification sensitivity analysis. The sensitivity analysis included different methods for developing criteria (density-based criteria), different methods of calculating habitat (geometric mean), and alternative criteria (specifically steelhead/rainbow trout spawning criteria that we developed on Clear Creek). In FY 2009, we completed a response-to-comments document for the stakeholder review of the spawning study report and revisions to the draft spawning report stemming from the stakeholder review. A second peer review and a final report on flow-habitat relationships for spawning and the response-to-comments document were completed in FY 2010 and the final report (U.S. Fish and Wildlife Service 2010a) and response to comments document were issued on December 22, 2010.

Juvenile Chinook salmon and steelhead/rainbow trout rearing

Computation of spring/fall-run Chinook salmon and steelhead/rainbow trout fry and juvenile rearing habitat over a range of discharges was completed for all juvenile rearing sites in FY 2008. The draft report was completed in FY 2008. We sent this draft report out for concurrent stakeholder and peer review in FY 2009. Peer review, response-to-comments document and a final report on flow-habitat relationships for rearing were completed in FY 2010 and the final report (U.S. Fish and Wildlife Service 2010b) and response to comments document were issued on December 22, 2010.

Chinook salmon and steelhead/rainbow trout juvenile stranding and redd dewatering

A draft report was completed in FY 2008. We sent this draft report out for concurrent stakeholder and peer review in FY 2009. The final report (U.S. Fish and Wildlife Service 2010c) and response to comments document were completed in FY 2010 and were issued on December 22, 2010.

CLEAR CREEK

Hydraulic Model Construction and Calibration

Fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

We completed hydraulic model construction for site 3B in FY 2011, after we received additional bed topography data from Graham Matthews and Associates. We completed production runs for three of the study sites in FY 2011[5]. We intend to complete calibration and production runs of Site 3B in FY 2012.

Habitat Simulation

Juvenile spring-run Chinook salmon and steelhead/rainbow trout rearing (Upper Alluvial and Canyon Segments)

In FY 2010, as requested by the Red Bluff Fish and Wildlife Office, we distributed a draft report on 2-D modeling of the spring-run Chinook salmon and steelhead/rainbow trout rearing in the Upper Alluvial and Canyon segments to interested parties for comment in addition to peer review, as was done with the Yuba River Study reports. In FY 2011, we completed the peer review of the draft report and issued a final report (U.S. Fish and Wildlife Service 2011a) and response to comments document.

Fall-run Chinook salmon and steelhead/rainbow trout spawning (Lower Alluvial Segment)

We completed the hydraulic model production runs for all five study sites over the range of simulation discharges, computed fall-run Chinook salmon and steelhead/rainbow trout spawning habitat over a range of discharges for the five spawning sites and completed a draft report in FY 2009. A peer and stakeholder review of the draft report was completed in FY 2010. A final report (U.S. Fish and Wildlife Service 2011b) and response to comments document was issued in FY 2011.

[5] We had completed production runs for an additional site in FY 2010.

Fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

In FY 2011, we computed fall-run and spring-run Chinook salmon and steelhead/rainbow trout rearing habitat over a range of discharges for the five spawning sites. We will compute fall-run and spring-run Chinook salmon and steelhead/rainbow trout rearing habitat over a range of discharges for the five rearing sites and issue draft and final reports in FY 2012.

SOUTH COW CREEK

Hydraulic Model Construction and Calibration

Juvenile fall-run Chinook salmon rearing

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 data set 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 foot 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 Physical Habitat Simulation (PHABSIM) transect at the outflow end of each site is calibrated to provide the water surface elevation (WSEL) at the outflow end of the site used by River2D. The PHABSIM transect at the inflow end 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 (Tables 1 and 2). A multiplier is applied to the resulting bed roughnesses, with the value of the multiplier adjusted so that the WSEL generated by River2D at the inflow end of the site match the WSEL predicted by the PHABSIM transect at the inflow end of the site[6]. The River2D model is run at the flows at which the validation data set was collected, with the output used to determine the difference between simulated and measured velocities, depths, bed elevations, substrate and cover. The River2D model is also run at the simulation flows to use in computing habitat.

PHABSIM calibration and construction and calibration of the 2-D hydraulic model was completed for all four sites and running the production runs for the simulation flows was completed for two of the four sites in FY 2010. The production runs for the simulation flows for the remaining two sites were completed in FY 2011.

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

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 – 10
9	Boulder/Bedrock	> 12
10	Large Cobble	10 – 12

Habitat Simulation

Juvenile fall-run Chinook salmon rearing

Using the fall-run Chinook salmon fry and juvenile rearing HSC developed for the Lower Alluvial Segment of Clear Creek, fall-run Chinook salmon fry and juvenile rearing habitat were computed over a range of discharges for the four rearing sites in South Cow Creek. Completion of this phase of the study occurred in FY 2011. We completed draft and final (U.S. Fish and Wildlife Service 2011c) reports on the 2-D modeling of fall-run Chinook salmon juvenile rearing in South Cow Creek in FY 2011.

Table 2
Cover Coding System

Cover Category	Cover Code
No cover	0.1
Cobble	1
Boulder	2
Fine woody vegetation (< 1" diameter)	3
Fine woody vegetation + overhead	3.7
Branches	4
Branches + overhead	4.7
Log (> 1' diameter)	5
Log + overhead	5.7
Overhead cover (> 2' above substrate)	7
Undercut bank	8
Aquatic vegetation	9
Aquatic vegetation + overhead	9.7
Rip-rap	10

STANISLAUS RIVER

Hydraulic Model Construction and Calibration

Fall-run Chinook salmon and steelhead/rainbow trout rearing

The topographic data used for the four sites included total station data collected by the Bureau of Reclamation, as well as previously collected Light Detection And Ranging (LIDAR) and Sound Navigation And Ranging (SONAR) data. The LIDAR and SONAR data was also used to develop the topography for a two to four-channel-width upstream extension for the Horseshoe, Valley Oak and McHenry sites. Since SONAR data were not available for the Two-Mile Bar site, an artificial one-channel-width upstream extension was used, based on the cross-sectional profile at the upstream end of the site. 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 data set 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 foot 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 outflow end of each site was calibrated to provide the WSEL at the outflow end of the site used by River2D for flows up to two and half times the highest flow at which WSELs were measured. For higher flows, up to 5,000 cfs, the River2D depth-unit discharge relationship was used for the downstream boundary condition. Parameters for this relationship were determine by comparing WSELs simulated by River2D at the downstream boundary with the WSELs simulated by PHABSIM at the highest measured flow and the highest flow simulated using the PHABSIM-predicted WSEL. After the parameters were determined, a log-log regression of the parameters versus flow was used to determine the value of the parameters for the higher simulation flows.

The PHABSIM transect at the inflow end 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 generated by River2D at the inflow end of the site match the WSEL predicted by the PHABSIM transect at the inflow end of the site[7]. The River2D model is run at the flows at which the validation data set was collected, with the output used to determine the difference between simulated and measured velocities, depths, bed elevations, substrate and cover. The River2D model is also run at the simulation flows to use in computing habitat.

The bed files and computational meshes for two of the four sites were completed in FY 2010. In FY 2011, hydraulic models were constructed for the two remaining sites and calibration was complete for all four sites for the low flow range and for three sites for the high flow range. Hydraulic simulations were completed for one site and completed for the low flow range for the remaining three sites in FY 2011. Hydraulic calibration and simulations will be completed in FY 2012.

Habitat Simulation

Juvenile fall-run Chinook salmon and steelhead/rainbow trout rearing

Using the fall-run Chinook salmon and steelhead/rainbow trout fry and juvenile rearing HSC developed for the Yuba River, fall-run Chinook salmon and steelhead/rainbow trout fry and juvenile rearing habitat were computed over a range of discharges for the four rearing sites in the

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

Stanislaus River. Habitat was computed for flows up to 1,500 cfs in FY 2011 and will be computed for the remaining simulation flows up to 5,000 cfs in FY 2012. The resulting flow-habitat relationships will be presented in the FY 2012 annual report.

FISHERIES INVESTIGATIONS

Clear Creek Biovalidation

Methods

This task had the following six subtasks: 1) compare 2008 juvenile habitat use to juvenile Combined Suitability Index (CSI); 2) compare 2005 juvenile habitat use to juvenile CSI; 3) compare 2007 Spawning Area Mapping (SAM) to adult CSI; 4) compare 2008 SAM to adult CSI; 5) after building fall-run Chinook salmon adult criteria from unoccupied locations in model, rerun earlier analysis comparing SAM and CSI; and 6) review statistical approach for these. The juvenile habitat use and spawning area mapping data were supplied by the Red Bluff Fish and Wildlife Office. Discussions during FY 2009 narrowed the scope of this work to examining data from restoration sites 3A and 3B. CSI values for site 3B will be computed from the River2D model developed for the Clear Creek IFIM study. CSI values for site 3A will be computed from a River2D model that will be developed using: 1) bed topography data previously collected by Graham Matthews and Associates; 2) substrate and cover polygon mapping that the Energy Planning and Instream Flow Branch conducted in FY 2009; and 3) transect data collected by the Energy Planning and Instream Flow Branch in FY 2009.

Results

Transect and substrate and cover polygon data were completed in FY 2009. The substrate and cover polygon data were used to assign substrate, cover and bed roughness values to each of the bed topography data points previously collected by Graham Matthews and Associates. Hydraulic models were constructed using the same methods described above for South Cow Creek. We completed hydraulic modeling construction for the 3A study site in FY 2011 after we obtained the bed topography data previously collected by Graham Matthews and Associates. After we have completed the hydraulic modeling calibration and habitat simulation for the 3A and 3B study sites, we will be able to complete the first five subtasks. The sixth subtask was completed in FY 2009 by Western Ecosystems Technology, Inc. under a Cooperative Agreement funded by the Energy Planning and Instream Flow Branch. We plan to complete this entire task in FY 2012, with results to be presented in the FY 2012 annual report.

American River Gravel Placement Monitoring

Methods

The purpose of this task was to collect data to develop post-restoration hydraulic and habitat models of sites where gravel was placed in the American River in 2008, at Sailor Bar and 2010, above Sunrise Bridge. The purpose of the models is to quantify the amount of spawning and rearing habitat that was created by the restoration projects. The post-restoration topography data for the 2010 site was also used to design the 2011 gravel placement site. High flows in 2006 resulted in downcutting of the main stream river channel at the upstream end of an island downstream of the 2010 site. As a result, a side channel that used to flow at a total American River flow of 800 cfs no longer had flow until the total American River flow reached an estimated 3,200 cfs. The 2010 and 2011 gravel placement designs consisted of both placement of spawning-sized material upstream of the island to create spawning habitat, and placement of larger material in the downcut main channel location to raise the water surface at this location, so that the side channel would once again flow at lower American River flows. We used topographic, substrate and cover data we collected in FY 2010 at the placement locations, together with the remaining topographic data collected in FY 2011, to develop pre-restoration hydraulic and habitat models to quantify how much spawning and rearing habitat was created by the 2010 gravel placement. We collected data in 2008 immediately after the construction of the 2008 site to develop a hydraulic and habitat model of this site. This model will be used, together with the data collected this year for the 2008 site and information on changes in water surface elevations at the vicinity of the 2008 site associated with construction of the 2009 gravel site (downstream of the 2008 site), to quantify the change in spawning habitat at the 2008 site associated with construction of the 2009 site and effects of high flows since construction of the 2008 site. Data is not available to model the amount of spawning habitat present at the 2008 site prior to construction; the amount of spawning habitat present prior to construction is thought to be minimal, based on aerial redd surveys prior to 2008 (John Hannon, USBR, personal communication).

A PHABSIM transect was placed at the upstream and downstream end of each study site. The downstream transect was modeled with PHABSIM to provide water surface elevations as an input to the 2-D model. The upstream transect was 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 7,000 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. Vertical benchmarks were established at each site to serve as the vertical elevations to which all elevations (streambed and water surface) were referenced. Vertical benchmarks consisted of lag bolts driven into trees. In addition, horizontal benchmarks (rebar driven into the ground) were established at each site to serve as the horizontal locations to which all horizontal locations (northings and eastings) were referenced. The precise northing and easting coordinates and vertical elevations of two horizontal benchmarks were established for each site using survey-grade Real Time Kinematic (RTK) Global Positioning System (GPS). The elevations of these benchmarks were tied into the vertical benchmarks on our sites using differential leveling. The data collected on the upstream and downstream transect included: 1) water surface elevations (WSELs), measured to the nearest 0.01 foot (0.003 m) 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 bank-full discharge surveyed to the nearest 0.1 foot (0.031 m); 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 (Tables 1 and 2) at these same locations and also where dry ground elevations were surveyed.

Topographic data between the upstream and downstream boundaries of the 2008 and 2010 gravel placement sites were collected using survey-grade RTK GPS units or a robotic total station and stadia rod for the dry and shallow portions of the sites, and with a combination of an Acoustic Doppler Current Profiler (ADCP) and a survey-grade RTK GPS unit for the deeper portions. For each traverse with the ADCP, the RTK GPS was used to record the horizontal location and WSEL at the starting and ending location of each traverse, while the ADCP provided depths and distances across the traverse. The WSEL of each ADCP traverse is then used together with the depths from the ACDP to determine the bed elevation of each point along the traverse. For the 2010 site, we used the same method downstream of the downstream boundary to determine the stage of zero flow for the downstream transect. We also collected substrate and cover data for each topographic point collected with the survey-grade RTK GPS unit or total station and stadia rod, and mapped in substrate and cover polygons for the areas sampled with the ADCP; the vertices of these polygons were recorded with the survey-grade RTK GPS unit. The RTK GPS and total station data had an accuracy of 0.1 foot horizontally and vertically.

Results

We completed collection of all data for the 2010 site and all data for the 2008 site, with the exception of WSELs at medium and high flows, in FY 2011. We completed a post-restoration bed file and computational mesh and began a pre-restoration bed file for the 2010 site, using the methods given above for South Cow Creek. We expect to complete pre- and post-restoration hydraulic modeling for the 2010 site, and post-restoration modeling for the 2008 site, in FY 2012.

Sacramento and American River and Clear Creek Redd Dewatering Monitoring

Methods

The purpose of this task was to quantify the benefits of using water dedicated to fish and wildlife benefits under Section b(2) of the CVPIA to reduce dewatering of fall-run and late-fall-run Chinook salmon and steelhead/rainbow trout redds in the Sacramento and American Rivers and Clear Creek. On October 25-27, 2010, we surveyed the shallow portions of eight two-dimensional hydraulic and habitat modeling sites on the Sacramento River between Keswick Dam and Battle Creek (Figure 1), that we had developed using hydraulic and structural data that

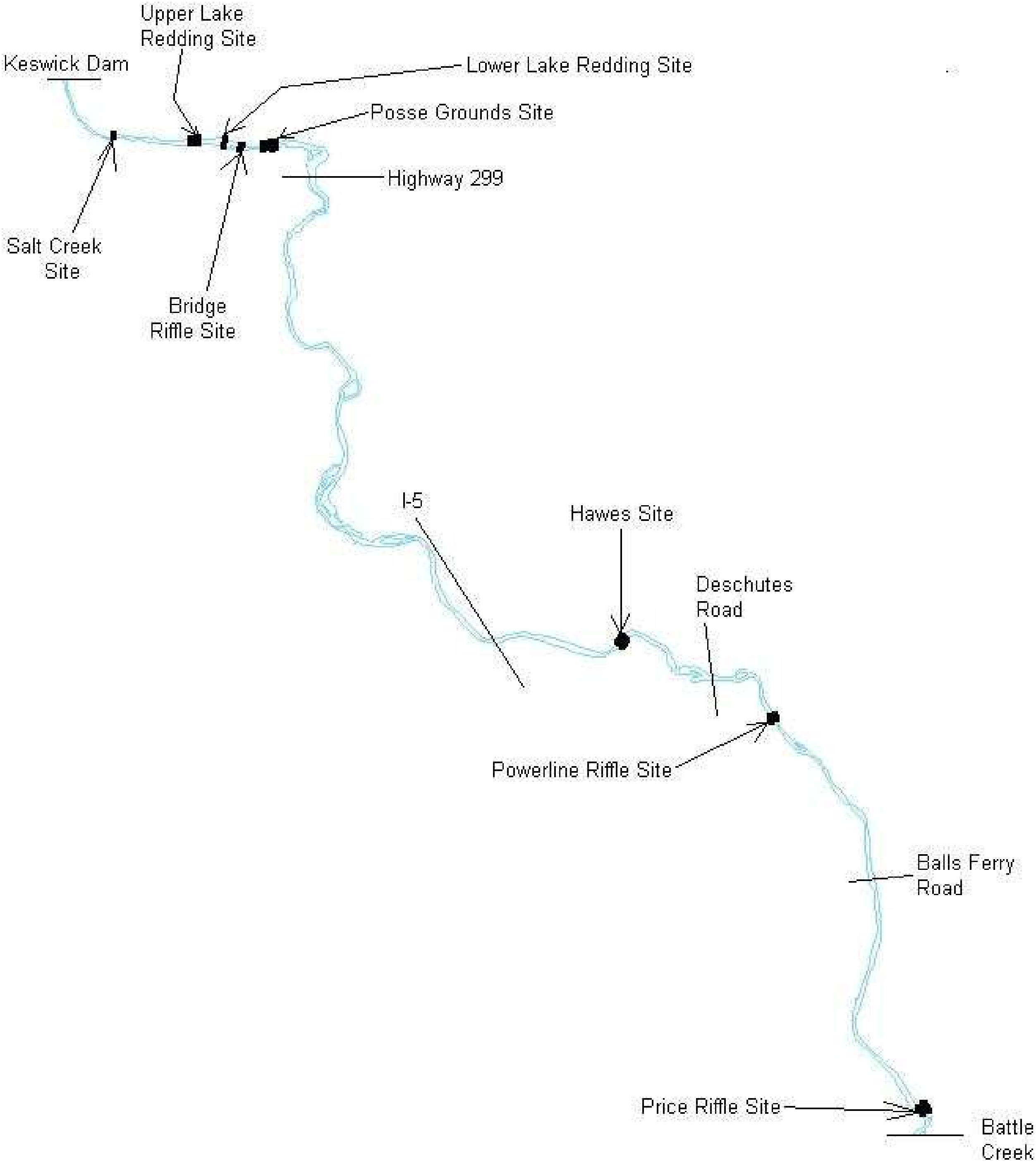

Figure 1
Sacramento River study sites for FY 2011 b(2) redd dewatering monitoring

we collected in 1997 to 1999, for fall-run Chinook salmon redds. Data for redds 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 (Gard 1998). Depth was recorded to the nearest 0.1 foot and average water column velocity was recorded to the nearest 0.01 ft/s. Measurements were taken with a wading rod and a Marsh-McBirney^R model 2000 velocity meter. Substrate was visually assessed for the dominant particle size range (i.e., range of 1-2 inches) at three locations: 1) in front of the pit; 2) on the sides of the pit; and 3) in the tailspill. The location of each redd was recorded with a survey-grade RTK GPS unit, with the measurement taken at the center of the pit of the redd. On February 28 to March 1, 2011, we collected the same data for late-fall-run Chinook salmon redds in our eight Sacramento River sites. On February 22-23, 2011, we collected the same data for steelhead/rainbow trout redds for five sites on the American River that we had developed using hydraulic and structural data that we collected in 1997 to 1998. For both the Sacramento and American Rivers, data collected in FY 2010 were used to convert the UTM coordinates of each redd into the local coordinate system used in the hydraulic models. As a result of high American River flows in the first week of December 2010, when data collection was scheduled, we were unable to collect the same data for shallow fall-run Chinook salmon redds in our five American River sites. Subsequent even higher flows made it unlikely that we would have been able to locate any American River fall-run redds. We used the funding that had been allocated for that survey to start an analysis of the effects of Sacramento River flows and water temperatures on spawning, using historical data (discussed below).

For Clear Creek, the Red Bluff Fish and Wildlife Office supplied us with spawning area mapping polygons for fall-run Chinook salmon and locations for steelhead/rainbow trout redds. From this data, we used the redds located in five two-dimensional hydraulic and habitat modeling sites on the lower alluvial segment of Clear Creek, that we had developed using hydraulic and structural data that we collected in 2006 to 2007. Since we had established these sites based on State Plane coordinates, we were able to convert the redd locations to local coordinates by just subtracting given numbers from the State Plane coordinates. For the spawning area mapping, we determined how many redds were in each mapped polygon by dividing the area of the polygon by 211 ft^2/redd[8] and then equally spaced points for that many redds in each polygon, using GIS.

We ran the hydraulic models for all of the study sites in all three streams at the lowest flow that would have been present if b(2) water had not been used, and plugged in the surveyed redd locations to determine what the depth and velocity would have been at each redd location at that flow. Using the criteria in Table 3[9], we then determined how many of the redd locations would have been dewatered if b(2) water had not been used.

[8] This was the average area of single-redd fall-run Chinook salmon polygons in 2003 on Clear Creek.

[9] A redd was considered dewatered if the depth was less than the depth in Table 3 or the velocity was less than the velocity in Table 3. The depth criteria were based on the assumption that redds would be dewatered if the tailspills were exposed, while the velocity criteria were based on the assumption that there would be insufficient intragravel flow through the redd if the velocity was less than the lowest velocity at which we found a redd. See U.S. Fish and Wildlife Service (2006).

Table 3
Dewatering Criteria

Stream	Species/Race	Depth (ft)	Velocity (ft/s)
Sacramento	Fall-run	0.5	0.32
American	Fall-run	0.5	0.10
American	Steelhead[10]	0.2	0.30
Clear	Fall-run	0.5	0.10
Clear	Steelhead	0.2	0.61

Results

For the Sacramento River, we found a total of 56 shallow fall-run Chinook salmon redds and 15 shallow late-fall-run Chinook salmon redds in our eight study sites. For the American River, we found a total of 39 shallow steelhead or late-fall-run Chinook salmon redds in our five study sites. Likely some portion of the American River steelhead redds were actually late-fall-run Chinook salmon redds, which spawn at the same time as steelhead. The only redds we were able to positively identify were those with fish on them; of these, none had late-fall-run Chinook salmon on them and eight had steelhead on them[11]. For Clear Creek, there were a total of 495 fall-run Chinook salmon redds and 95 steelhead redds in our five study sites.

Figures 2 through 4 show what the Sacramento and American River and Clear Creek flows were from initiation of spawning through emergence of fry and what the flows would have been if b(2) water had not been used. For the Sacramento River, use of b(2) water potentially prevented dewatering of 19 (34%) shallow fall-run Chinook salmon redds and 3 (20%) shallow late-fall-run Chinook salmon redds. Use of b(2) water potentially prevented dewatering of 99 (20%) fall-run Chinook salmon redds and 42 (44%) steelhead redds on Clear Creek. No b(2) water was used on the American River in FY 2011; accordingly, no redds would have been dewatered if b(2) water had not been used.

[10] These criteria were developed for steelhead, but were applied to both steelhead and late-fall-run Chinook salmon redds, as we were unable to determine which species created most of the redds.
[11] In contrast, in FY-2010, the redds we were able to identify were almost equally split between steelhead and late-fall-run Chinook salmon.

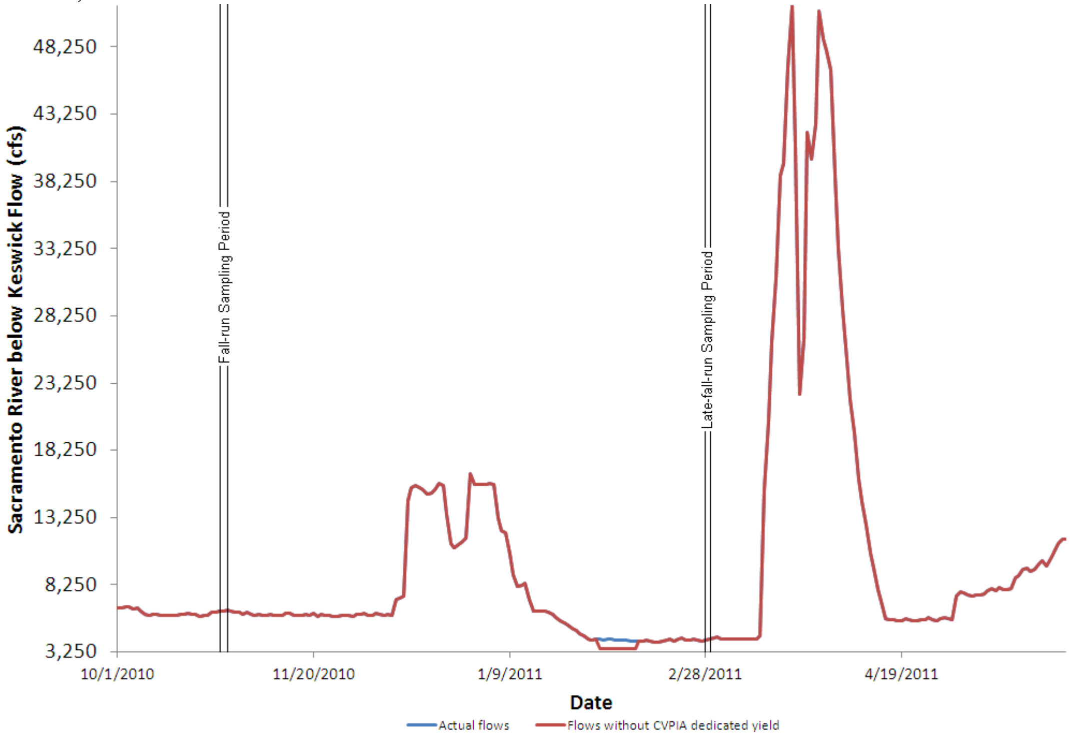

Figure 2
Sacramento River flows for FY 2011 b(2) redd dewatering monitoring

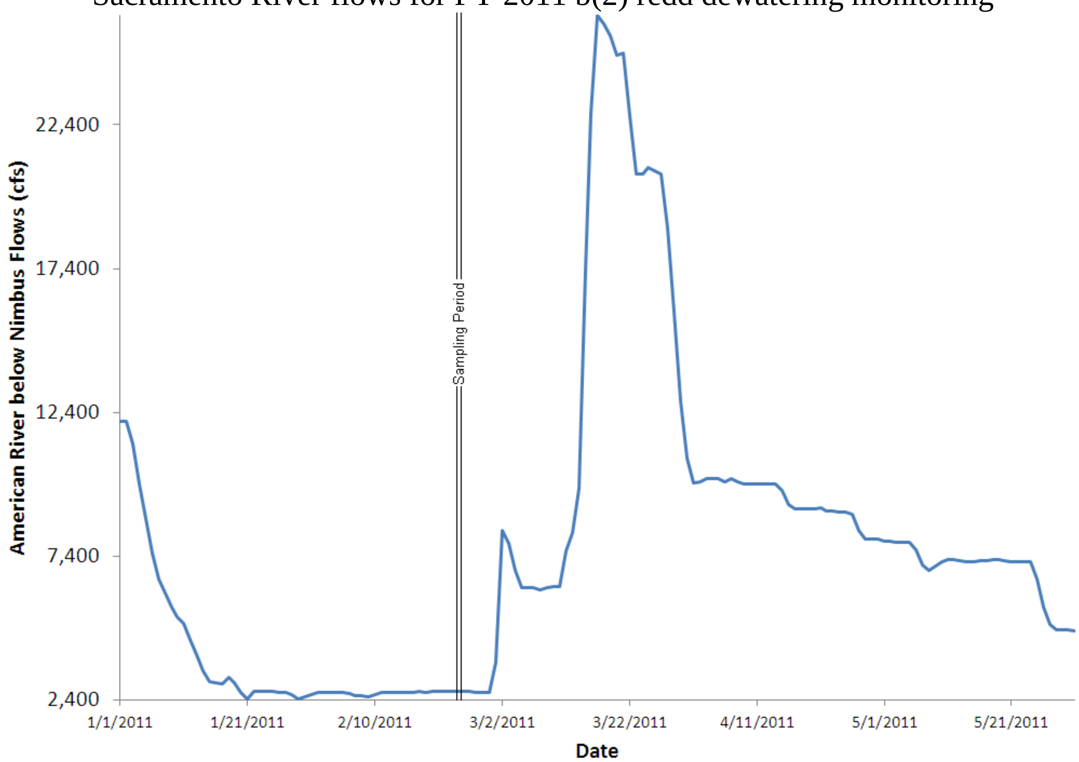

Figure 3
American River flows for FY 2011 b(2) redd dewatering monitoring

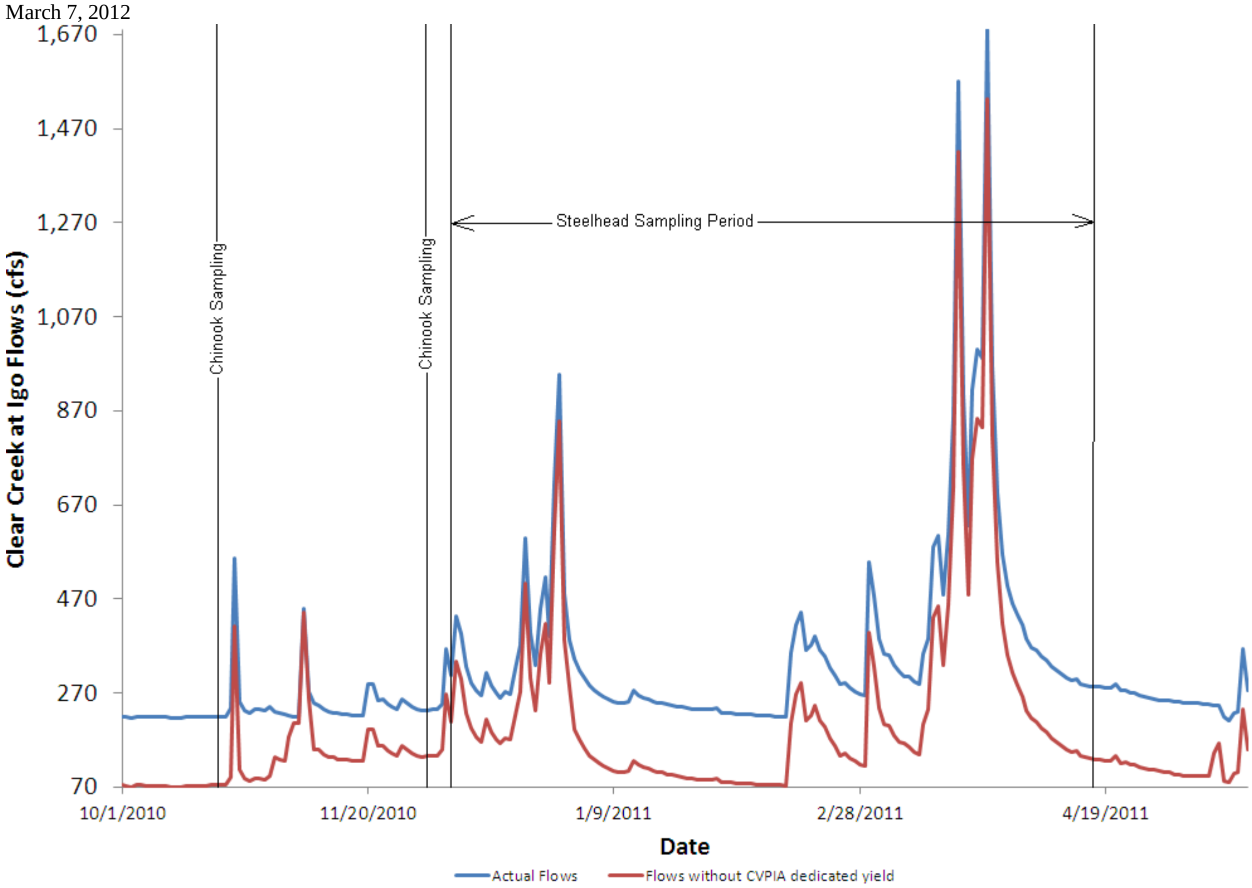

Figure 4
Clear Creek flows for FY 2011 b(2) redd dewatering monitoring

Discussion

The redd dewatering monitoring proved to be an effective method to quantify the benefits of using b(2) water for reducing redd dewatering. However, the relative benefits of using b(2) water for redd dewatering, as compared to other uses of b(2) water, is difficult to estimate. Questions that still remain to be answered included how to extrapolate the monitoring results to the entire stream in question, and if the sites have changed to the extent that the results are no longer valid. On a qualitative level, the Sacramento River sites have not appeared to change, while several of the American River sites (Sunrise and Above Sunrise) have changed due to restoration projects and river downcutting. We plan to perform a quantitative evaluation of this question in FY 2012 using the measured depths and velocities at the redd locations, by comparing them to simulated depths and velocities at the flow present during data collection. In addition, we plan to evaluate the benefits of b(2) water for the Sunrise and Above Sunrise sites in FY 2012 using: 1) a current hydraulic and habitat model of the lower portion of the Sunrise site, developed by National Marine Fisheries Service Santa Cruz staff; and 2) the hydraulic and habitat model we are in the process of developing of the restored Above Sunrise site in FY 2011, as part of the American River gravel placement monitoring. A source of uncertainty in the American River results is the relative benefit of b(2) water for steelhead versus late-fall-run

Chinook salmon; regardless, the monitoring demonstrates benefits overall to anadromous salmonids. For Clear Creek, most of the fall-run Chinook salmon redds were dewatered as a result of shallow depths, while most of the steelhead redds were dewatered as a result of low velocities, indicating that there may be different mechanisms causing egg and pre-emergent fry mortality from redd dewatering for different species. For the Sacramento River, the b(2) monitoring compliments redd dewatering monitoring, funded by the AFRP, being conducted by the Pacific States Marine Fisheries Commission (PSMFC). The PSMFC monitoring (USFWS/CDFG/PSMFC 2011) quantifies, on a river-wide basis, the number of redds that are being dewatered as a result of actual releases from Keswick Dam, while the b(2) monitoring quantifies, for our eight study sites, how many redds would have been dewatered if b(2) water had not been used.

Sacramento River Flow/Temperature/Spawning Relationships

Methods

The purpose of this task was to examine how the location and timing of Chinook salmon spawning in the Sacramento River is affected by temperature and flow management. There is considerable uncertainty in how fish respond to temperatures and flows to initiate spawning. An assumption with temperature management on the Sacramento River is that fish will move to colder water to spawn. Our analysis used historical flow and water temperature data and aerial redd counts. We used daily mean flow data from Keswick Dam (USGS Gage Number 11370500) and Bend Bridge (USGS Gage Number 11377100) for the period October 1, 1969 to December 31, 2010. Daily water temperature was available for four locations (Keswick [RM 303], Balls Ferry [RM 276.2], Jellys Ferry [RM 266.8] and Bend Bridge [RM 257.8]) for the period January 1, 1970 to December 31, 2010. Aerial redd count data for 13 river sections (going from Keswick Dam to Princeton Ferry [RM 164]) are available starting in 1969 for fall-run Chinook salmon. The greatest amount of spatial data is available for fall-run, while the greatest amount of temporal data is available for winter-run. For the spatial analysis, we selected two dependent variables: 1) the river mile at the 50th percentile of the cumulative distribution of redds; and 2) the number of river miles between the 25th and 75th percentiles of the cumulative distribution of redds. For the temporal analysis, we selected one dependent variable, the julian date of the 50th percentile of the cumulative distribution of redds. We started our analysis with fall-run Chinook salmon. For fall-run, we selected the following independent variables: 1) mean Oct 1-15 and Oct 16-Nov 1 flows at Keswick Dam and Bend Bridge; and 2) mean Oct 1-15 and Oct 16-Nov 1 water temperatures at Keswick, Balls Ferry, Jellys Ferry and Bend Bridge.

Results

In FY 2011, we were able to assemble a complete dataset for flows and spawning, but are still waiting on assembling water temperature data. An initial analysis of the effect of flows on the spatial distribution of fall-run Chinook salmon redd distribution (Figures 5 to 12) does not show any significant effects.

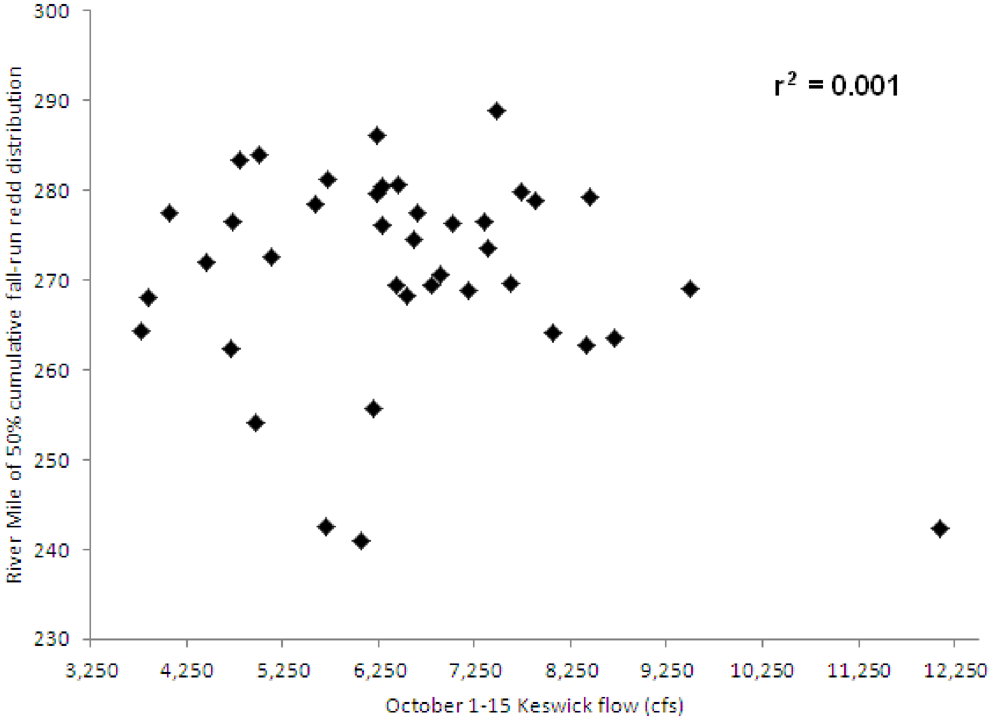

Figure 5

October 1-15 Keswick flows versus 50% cumulative fall-run distribution

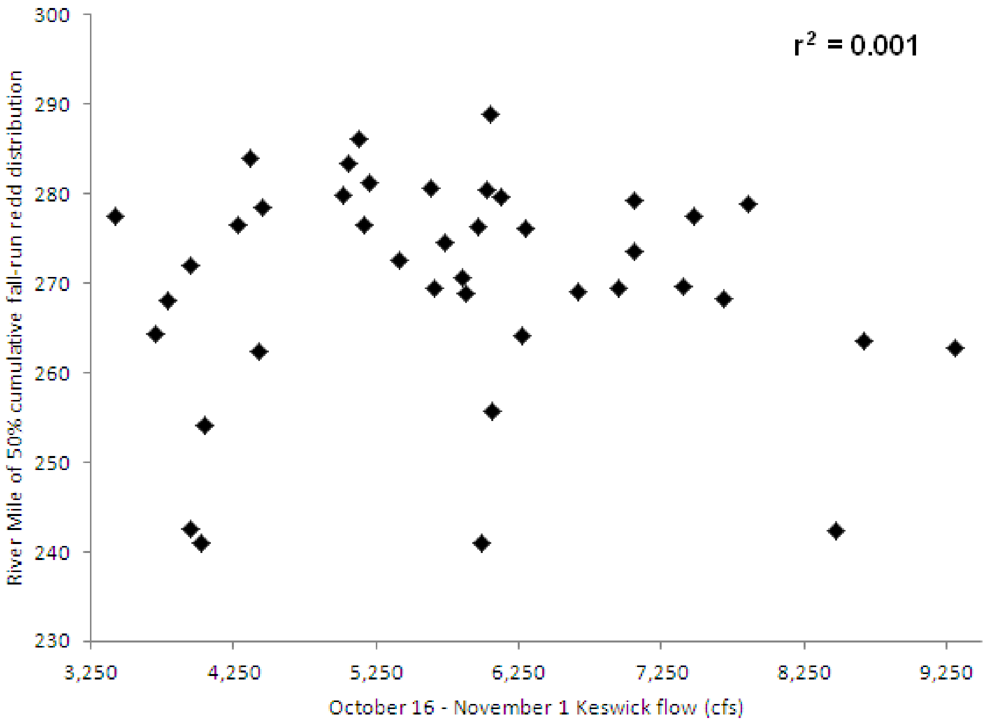

Figure 6

October 16 – November 1 Keswick flows versus 50% cumulative fall-run distribution

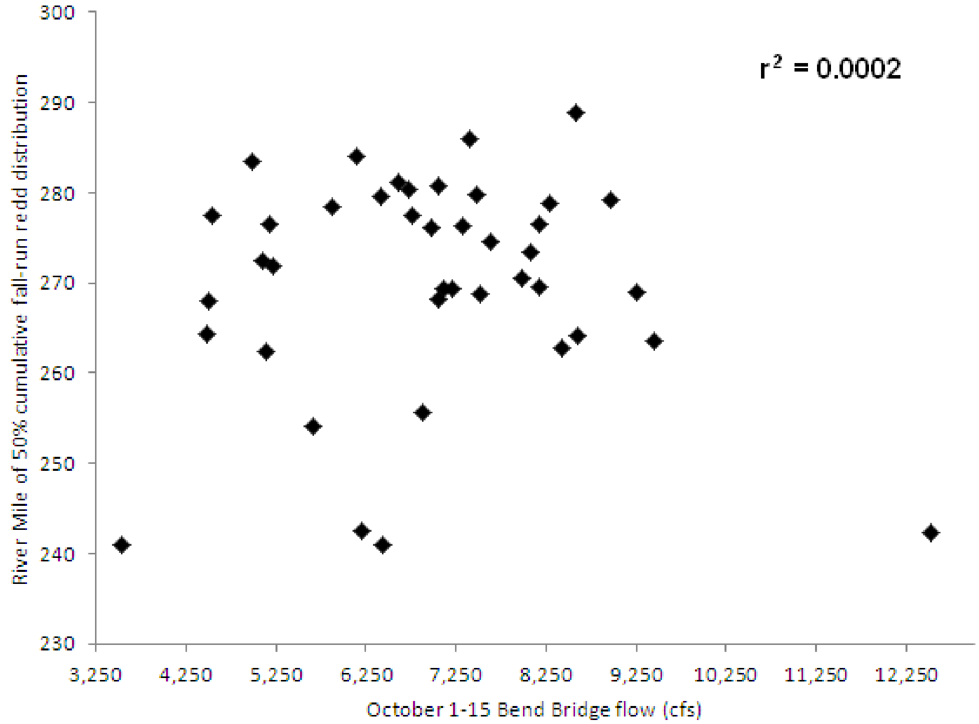

Figure 7
October 1-15 Bend Bridge flows versus 50% cumulative fall-run distribution

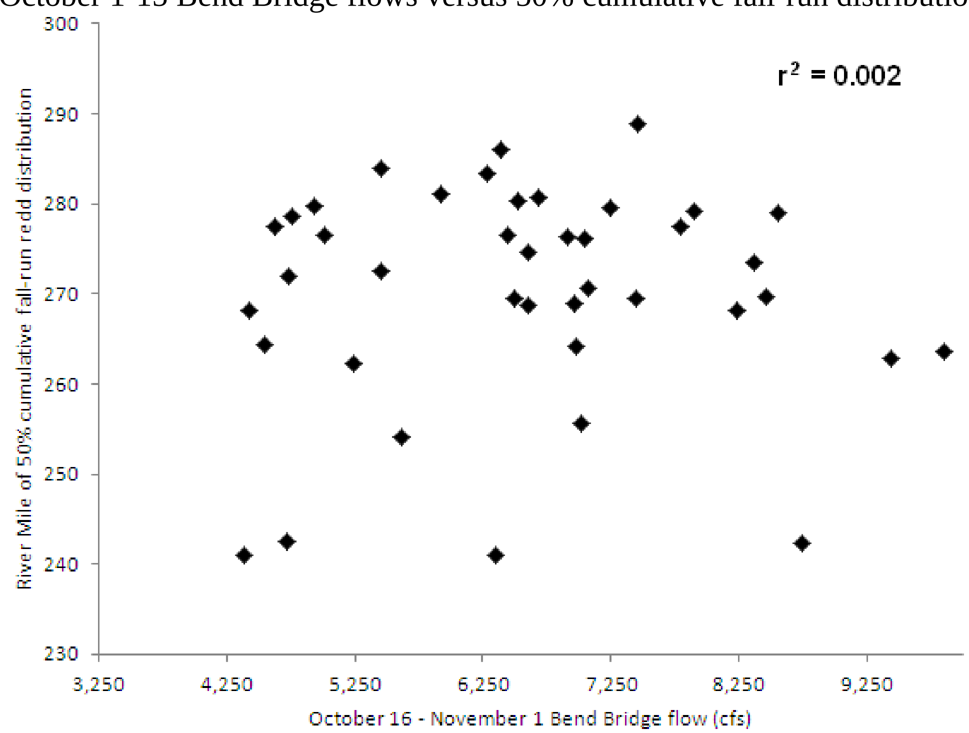

Figure 8
October 16 – November 1 Bend Bridge flows versus 50% cumulative fall-run distribution

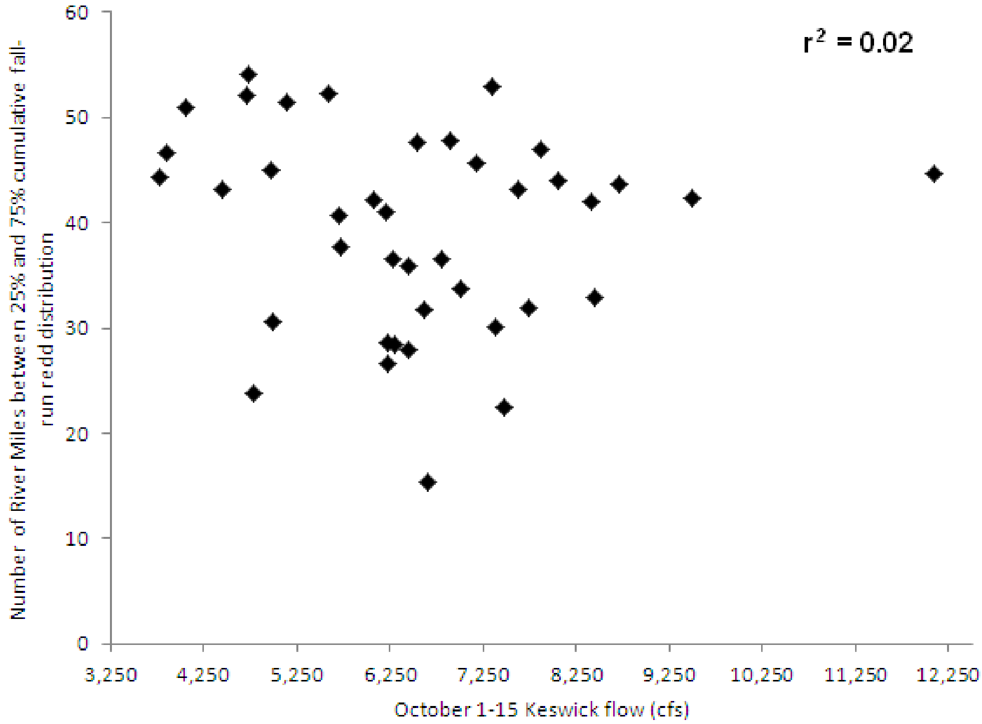

Figure 9

October 1-15 Keswick flows versus 25-75% cumulative fall-run distribution

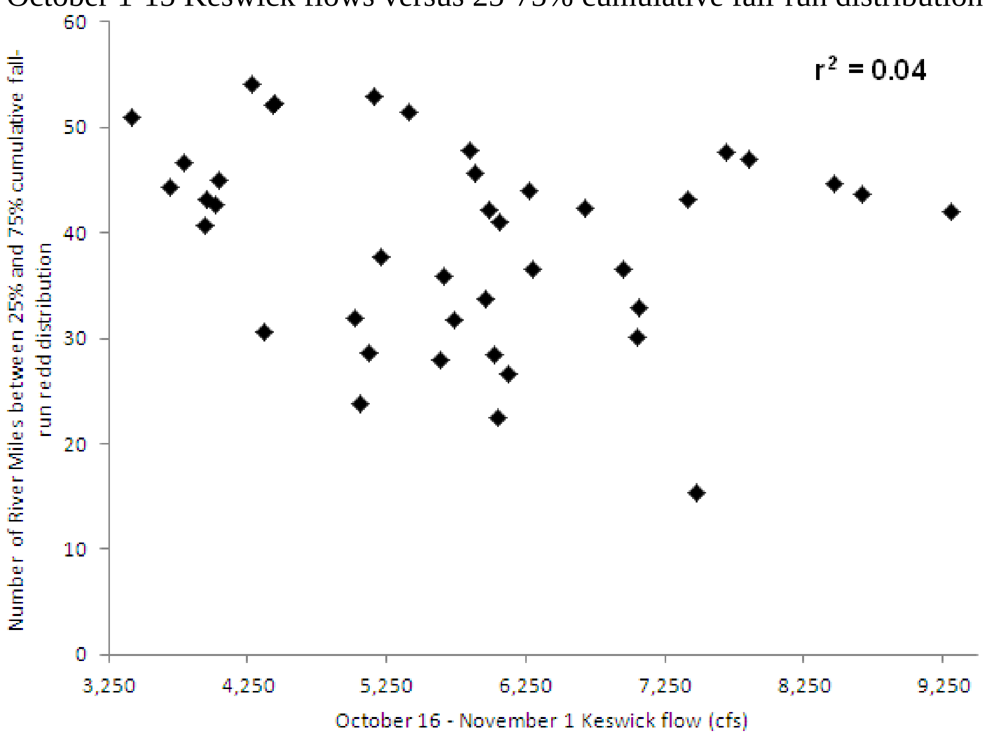

Figure 10

October 16 – November 1 Keswick flows versus 25-75% cumulative fall-run distribution

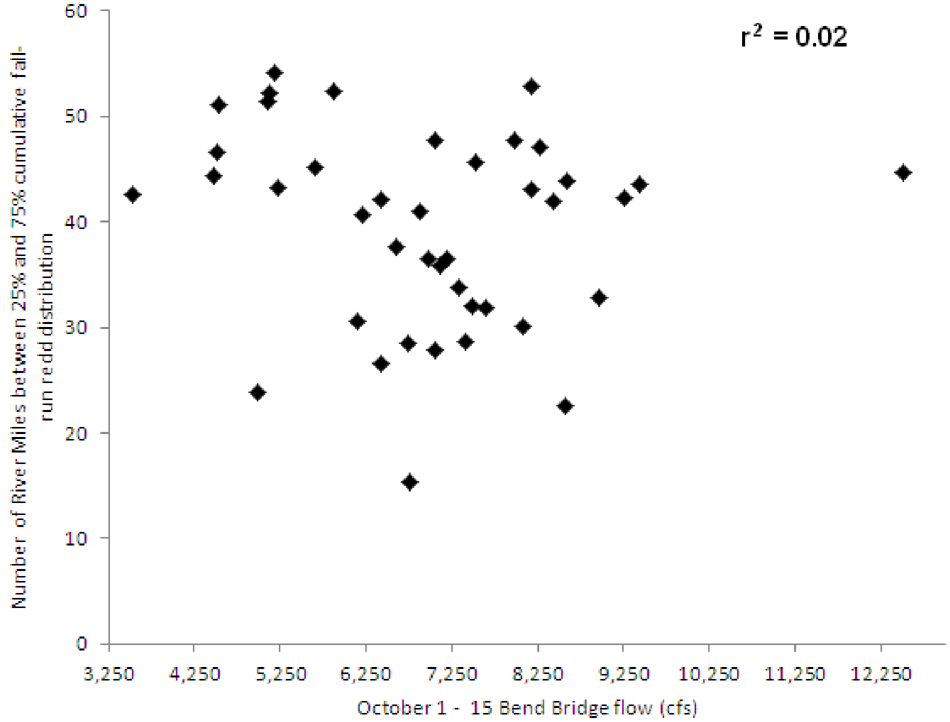

Figure 11
October 1-15 Bend Bridge flows versus 25-75% cumulative fall-run distribution

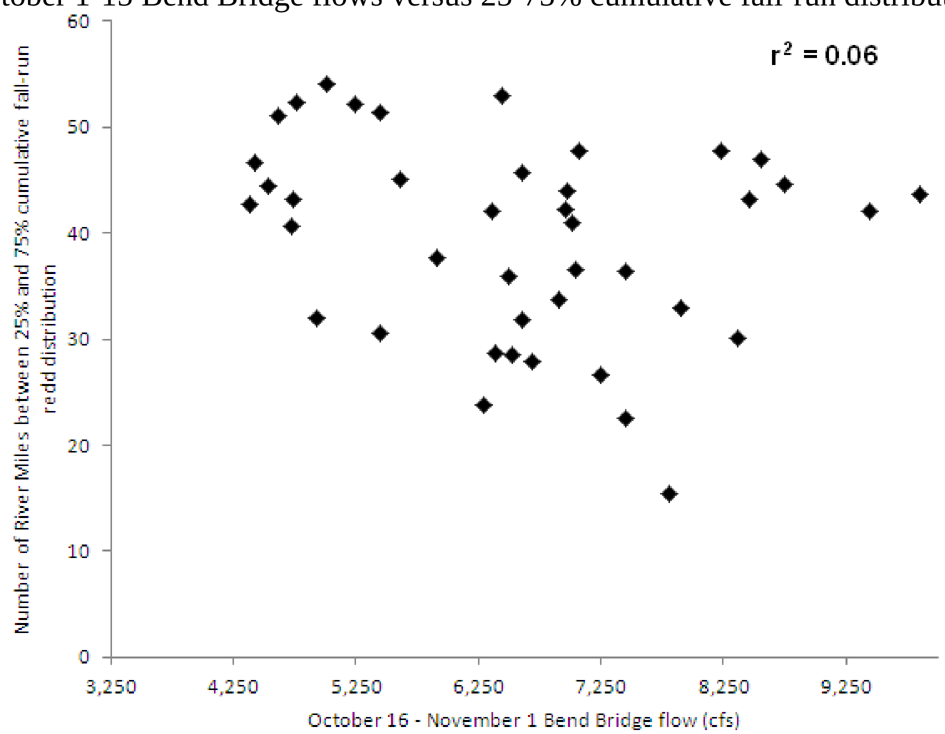

Figure 12
October 16 – November 1 Bend Bridge flows versus 25-75% cumulative fall-run distribution

Discussion

It does not appear likely that the datasets we have identified are adequate to explore the effects of flows and temperature on the spatial and temporal distribution of Chinook salmon spawning in the Sacramento River. Further discussions are needed to determine whether additional effort on this task in FY 2012 is warranted.

Stanislaus River Floodplain Versus Flow Relationships

Methods

The goal of this task was to develop a two-dimensional hydraulic model to quantify the relationship between floodplain area and flow for the Ripon to Jacob Myers reach of the Stanislaus River (RM 17.2 to 34.7), for flows ranging from 250 to 5,000 cfs. The LIDAR and SONAR data mentioned above for the Stanislaus River instream flow study was used as the topographic data source for the hydraulic model. The first step in developing the topographic input for the model was to georeference in Arc Map (ESRI, Redlands, CA) digital aerial photos of the Stanislaus River taken on January 15, 2006 at a flow of 5,000 cfs. Heads up digitizing[12] was then used to produce a 5,000 cfs water's edge polygon from the georeferenced aerial photos. The polygon was used, with a 10 meter buffer, to produce shapefiles of the portion of the LIDAR and SONAR data that would be used to develop the hydraulic model. A triangular irregular network (TIN) was produced from the LIDAR data to separate the portion of the LIDAR data that was actually ground elevations (steep slopes) from the LIDAR data that was actually water surface elevations (flat slopes). The TIN was used together with NAIP imagery and heads up digitizing to produce a LIDAR water's edge polygon. LIDAR data from within the polygon, consisting of water surface elevations, was then discarded, leaving only ground elevation LIDAR data.

Comma delimited files of the resulting LIDAR and SONAR data were then produced to input into the Surface-water Modeling System (SMS, ver. 10.1.6 64 bit) software, where they were merged to create one scatter data set. A computational mesh was developed in SMS by first defining polygons based on the 5,000 cfs water's edge and LIDAR water's edge polygons. Two material types were defined for the polygons: 1) floodplain for the polygons located between the 5,000 cfs water's edge and LIDAR water's edge polygons; and 2) channel for the polygons located within the LIDAR water's edge polygon. Patch meshes, with rectangular mesh elements 3 meters long (in the longitudinal direction) by 1 or less meters wide (in the lateral direction)[13], were used for the channel polygons, while 3 meter by 3 meter square paving meshes were used for the floodplain polygons. The scatter dataset was interpolated to the computational mesh

[12] Heads up digitizing refers to on-screen digitizing, an interactive process in which a map is created using previously digitized or scanned information. In heads up digitizing, the user creates the map layer up on the screen with the mouse, with referenced information as a background.
[13] Mesh elements one meter wide were used for wider portions of the channel while narrower elements were used for narrower portions of the channel.

using the inverse distance weighted interpolation option in SMS. The resulting computational mesh was used as an input to SRH-2D (USBR, Denver, CO), along with the stage from the rating table of the Ripon gage (USGS Gage Number 11303000), located at the downstream boundary of the model, as the downstream boundary condition for the hydraulic model. The hydraulic model was calibrated by running the model at 1,500 cfs and varying the Manning's n values for the channel and floodplain, with the resulting simulated water surface elevations compared to those measured at the McHenry site, located approximately half-way through the study reach. We used initial Manning's n values of 0.025 for the channel and 0.07 for the floodplain, based on values used by cbec Engineering for the Orange Blossom Bridge to Knight's Ferry reach (Chris Hammersmark, cbec Engineering, personal communication).

The calibrated model is then used for hydraulic simulations at flows ranging from 250 to 5,000 cfs, with the stage from the rating table of the Ripon gage used as the downstream boundary condition for the hydraulic model. The model output is then processed in SMS to compute the total wetted area at each flow. The resulting total wetted area versus flow graph is then examined to determine the flow at which floodplain inundation begins, as shown by an inflection point in the graph. The total wetted area at higher flows is then subtracted from the total wetted area at which floodplain inundation begins to determine the inundated floodplain area at each flow.

Results

Calibration indicated that the lowest Manning's n values that still resulted in a stable model were 0.025 for the channel and 0.05 for the floodplain[14]; the model crashed at lower Manning's n values. With these Manning's n values, the water surface elevations predicted at McHenry were 2.39 to 2.65 feet higher than the measured values[15]. The total wetted area at 1,500 cfs was 856,544 m^2. The model results at 1,500 cfs (Figure 13) showed some floodplain inundation. In FY 2011, we started hydraulic simulations at flows of 500 to 5,000 cfs by 500 cfs increments. In FY 2012, we will likely conduct hydraulic simulations at intermediate flows as needed to identify the inflection point in the flow-area graph and adequately quantify the flow-floodplain area relationship. In addition, we will be developing and running hydraulic models, using the same methods presented above, for three other reaches: 1) Knight's Ferry Bridge to Orange Blossom Bridge; 2) Orange Blossom Bridge to Jacob Myers; and 3) Ripon to San Joaquin River confluence. We will not be able to develop hydraulic models for the Goodwin Dam to Knight's Ferry Bridge reach, since SONAR data is not available for that reach.

[14] Typical manning's n values from the literature range from 0.04 to 0.07 (Milhous et al. 1989).
[15] While these deviations are high, we did not have any options to reduce the deviations. Comparisons of simulated water surface elevations at 1,500 cfs to those simulated by the U.S. Bureau of Reclamation (not yet available) will serve to better evaluate the accuracy of the hydraulic model for this reach.

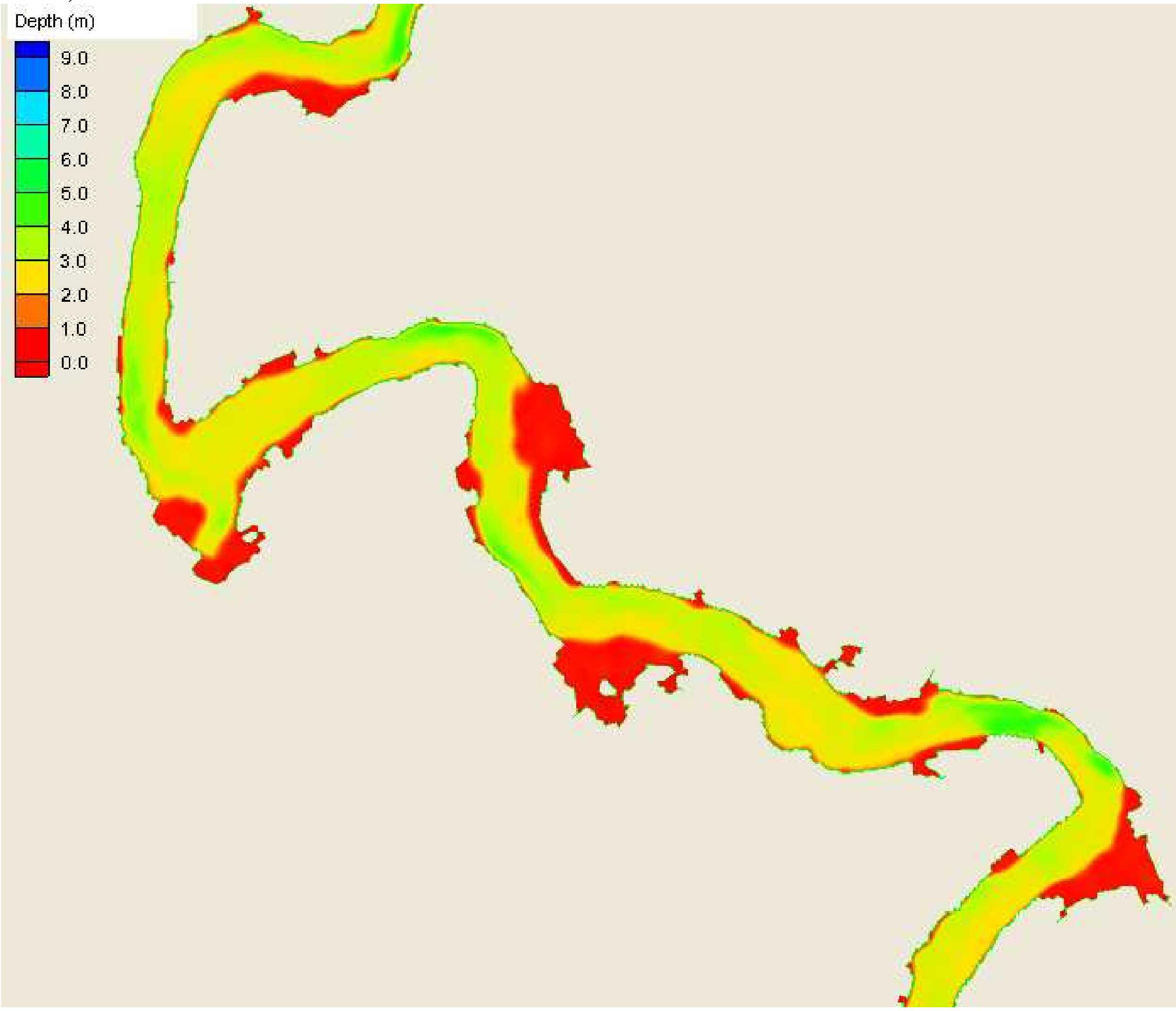

Figure 13
Portion of Inundated Floodplain (in red) at 1,500 cfs for the Ripon to Jacob Myers reach

Stanislaus River Floodplain Restoration Project Monitoring

Methods

Originally this task was going to involve work on the Lover's Leap and Honolulu Bar projects. Due to project delays associated with high flows and other factors, the work shifted to two other Stanislaus River floodplain restoration projects, Two-Mile Bar and Lancaster Road. For the Two-Mile Bar site, the tasks were ground-truthing LIDAR data, conducting a control survey and collecting deep-water topography data, with the ultimate goal of producing an integrated topographic dataset that can be used to design a floodplain restoration project at Two-Mile Bar.

For the Lancaster Road site, the tasks were collecting additional topography data and substrate/cover polygon data to be used by Cramer Fish Sciences to develop pre- and post-restoration two-dimensional hydraulic and habitat models of the site.

For the Two-Mile Bar site, there were two previous sources of topographic data: 1) topographic data collected with a total station in 2001 (McBain & Trush 2001); and 2) a portion of the LIDAR data discussed above for the Stanislaus River floodplain versus flow relationship task. It was discovered during data collection for the Two-Mile Bar River2D site that there was a significant error in the horizontal control for the 2001 total station data. The horizontal control included a site benchmark and seven control points (McBain and Trush 2001). In 2011, we attempted to locate these controls and determine the correct coordinates for them using a survey grade RTK GPS. The LIDAR data had a nominal vertical accuracy of ± 0.5 feet. We systematically selected 302 LIDAR points within the Two-Mile Bar site and navigated to them with the survey grade RTK GPS; we used the stake-out feature of the RTK GPS to determine the difference between the given elevation of the LIDAR points and the elevation measured with the RTK GPS. Neither the total station nor the LIDAR data had points in the wetted channel; we used the methods described above for the American River gravel project to collect bed topography in the wetted channel using our ADCP and survey grade RTK GPS.

For the Lancaster Road project, Cramer Fish Sciences had previously collected some topographic data, with most of the data in the southern portion of the floodplain. We used the methods described above for the American River gravel project to collect supplemental topography, substrate and cover data for Cramer Fish Sciences to use to develop pre- and post-restoration River2D models to quantify the amount of spawning and rearing habitat that was created by the Lancaster Road project.

Results

We were able to locate five of the McBain & Trush (2001) control points. Our survey data indicated that the following transformations of the McBain & Trush (2001) topography data would convert the data into Universal Transverse Mercator (UTM) Zone 10, NAD 83 meters: 1) subtract 49.0144 m from northings; 2) subtract 135.8304 m from eastings; and 3) add 0.799 m to bed elevations to convert them from NGVD29 to NAVD88. We were able to stake out 273 of the LIDAR points; of the remaining 29 points we selected, at least eight could not be staked out because the RTK GPS stayed in float due to being under vegetation. The three points with the largest difference between the LIDAR and ground-truthing elevations were likely due to changes in topography since the LIDAR data was collected. Of the remaining 270 points, 257 (greater than 95%) had elevations within 0.5 feet of the LIDAR elevations. The average difference in elevation between the LIDAR and ground-truthing elevations for the 270 points was 0.005 m. We collected 4,230 topographic data points in the wetted channel.

For the Lancaster Road project, we collected topographic data points, and mapped out substrate and cover polygons for the entire site. These polygons will be used to assign substrate, cover and bed roughness data to the previous topographic data that Cramer Fish Sciences had collected, to LIDAR data, and to the ADCP topographic data that we collected.

Discussion

The LIDAR data is sufficiently accurate for purposes of designing the Two-Mile Bar restoration project. The combined dataset of topographic data from LIDAR, ADCP, McBain & Trush (2001) and the River2D site should serve as a good topographic dataset for designing the Two-Mile Bar restoration project. The data that we collected for the Lancaster Road project should greatly improve the accuracy of the pre- and post-restoration hydraulic and habitat models, and thus increase confidence in the quantification of habitat gained as a result of the project.

Tuolumne River Bobcat Flat Pre-restoration Monitoring

Methods

We established a 1,280 foot long study site that included all of the mesohabitat types (Bar Complex Run, Bar Complex Riffle, Bar Complex Pool and Flatwater Run) present in the restoration site. This study site has one downstream boundary and two upstream boundaries – one with the main river flow, and the other where a side channel enters the river. As a result, an additional data item was needed – the discharge of the side channel at three flows, to develop a flow-flow regression between the side channel and total Tuolumne River flow. We used the same methods given above for the American River to collect the remaining data needed to develop a pre-restoration hydraulic and habitat model of the Bobcat Flat site. We also collected additional data upstream of the study site, using the same methods, to supplement existing LIDAR and SONAR data, for purposes of developing an upstream extension for the hydraulic model, similar to that discussed above for the Stanislaus River instream flow sites.

Results

We completed all pre-restoration data collection, with the exception of some of the data for the side channel upstream boundary. We were unable to complete data collection for the side channel upstream boundary, as well as low-flow water surface elevations at the upstream and downstream boundaries, due to high flows. We will be collecting the remaining side channel upstream boundary data during post-restoration monitoring, since the restoration project is not changing conditions in the side channel. We will have to use a different technique in PHABSIM (MANSQ) to develop the stage-discharge relationships for the upstream and downstream boundary conditions, since we only have two sets of WSEL measurements to use in developing these stage-discharge relationships. In FY 2012, we will be collecting data for the post-restoration hydraulic and habitat model, and conducting both the pre- and post-restoration hydraulic and habitat modeling to quantify the amount of spawning and rearing habitat created by the Bobcat Flat project. Habitat modeling will use the Yuba River habitat suitability criteria discussed above.

Cottonwood Creek ACID Siphon Monitoring

Methods

The Cottonwood Creek ACID Siphon project involved replacing an existing siphon that created an upstream passage barrier with a new siphon that was eight feet deeper. Replacement of the siphon involved the construction of a bypass channel through a cobble bar into an old overflow channel and building a coffer dam. Due to high flows during the middle of construction, the coffer dam was washed away and the bypass channel was widened, resulting in insufficient material to fill in the bypass channel after construction. The purpose of the monitoring was to evaluate the stability of the site after construction, with particular emphasis on whether additional downcutting of Cottonwood Creek would result in the new siphon being exposed, and whether the bypass channel would capture the main flow of Cottonwood Creek, resulting in dewatering of the main channel. We collected topographic data for the Cottonwood Creek ACID Siphon project site on June 27-30, 2011 using survey-grade RTK GPS units for the dry and shallow portions of the site, and a combination of an ADCP and a survey-grade RTK GPS unit for the deeper portions of the site. The methods used were the same as those given above for the American River sites. We also performed a control survey for two controls that were used for a 2010 as-built survey, which only covered the bypass channel. We used the control survey to convert the as-built survey data from the local coordinate system used to collect the as-built data into California State Plane coordinates. This allowed us to overlay our data with the as-built data to quantify channel changes associated with high flows between when the as-built data was collected and the summer of 2011. We plan to repeat our survey in 2012 to evaluate channel changes associated with high flows in the winter and spring of 2011-12, with results to be presented in our FY 2012 annual report.

Results

We collected 10,470 data points, covering a much larger area than was sampled in the as-built survey. The topographic data are shown in Figure 14. There was both aggredation and erosion in the bypass channel (Figures 15 and 16), with a net loss of 1,759 ft^3 of material from the area sampled in the as-built survey. In general, aggredation appears to be occurring in the lower portions of the bypass channel and erosion appears to be occurring in the higher portions of the bypass channel (Figure 16). We were unable to assess potential downcutting of the main channel since there was no data collected in the main channel by the as-built survey due to high flows during the as-built survey. Based on the thalweg profile of the main channel and bypass channel (Figure 17), it appears unlikely at this point that the bypass channel will capture the entire flow of Cottonwood Creek.

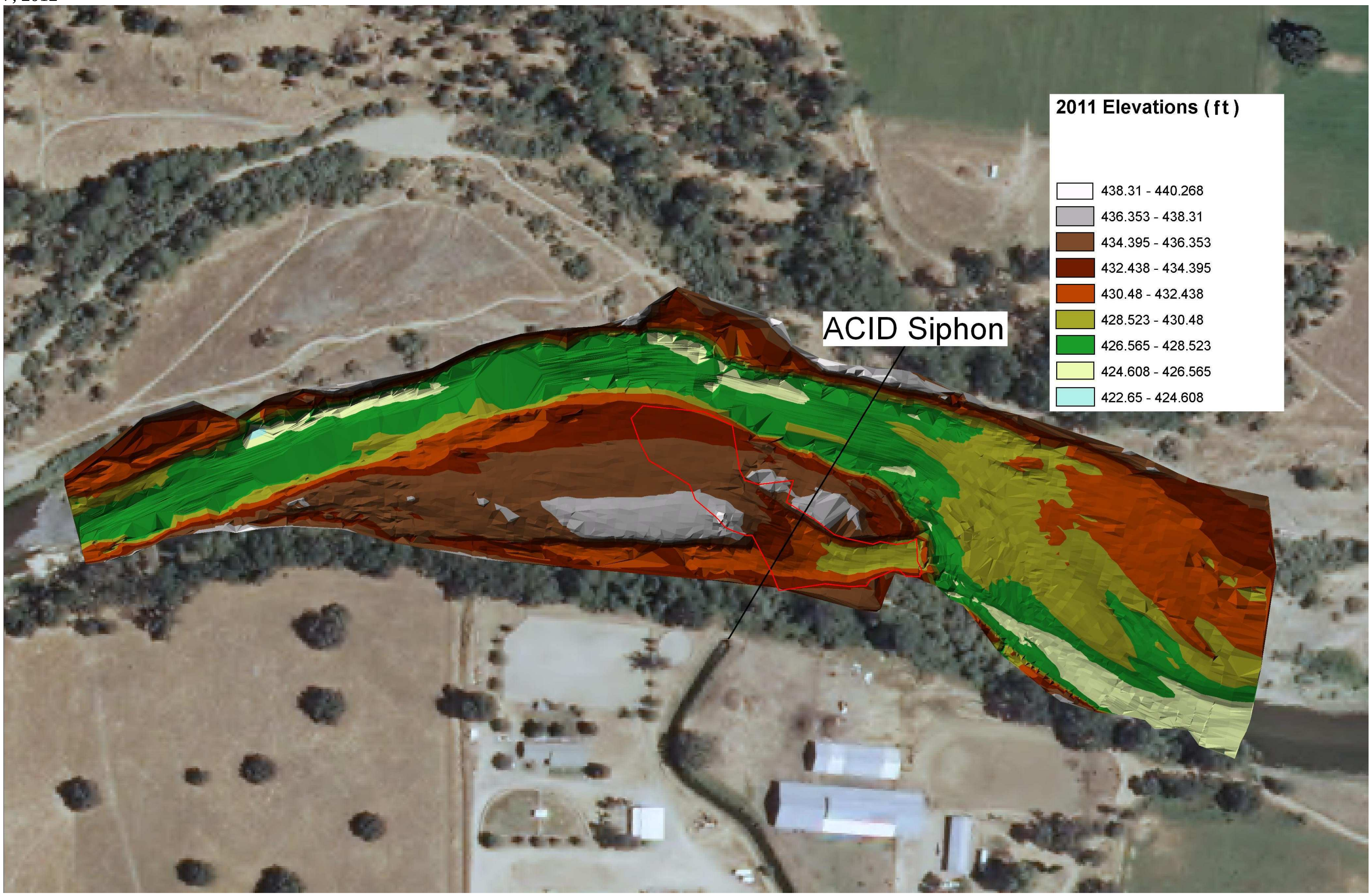

Figure 14
June 2011 bed topography of Cottonwood Creek ACID siphon restoration site. The red polygon indicates the portion of the bypass channel sampled in the as-built survey.

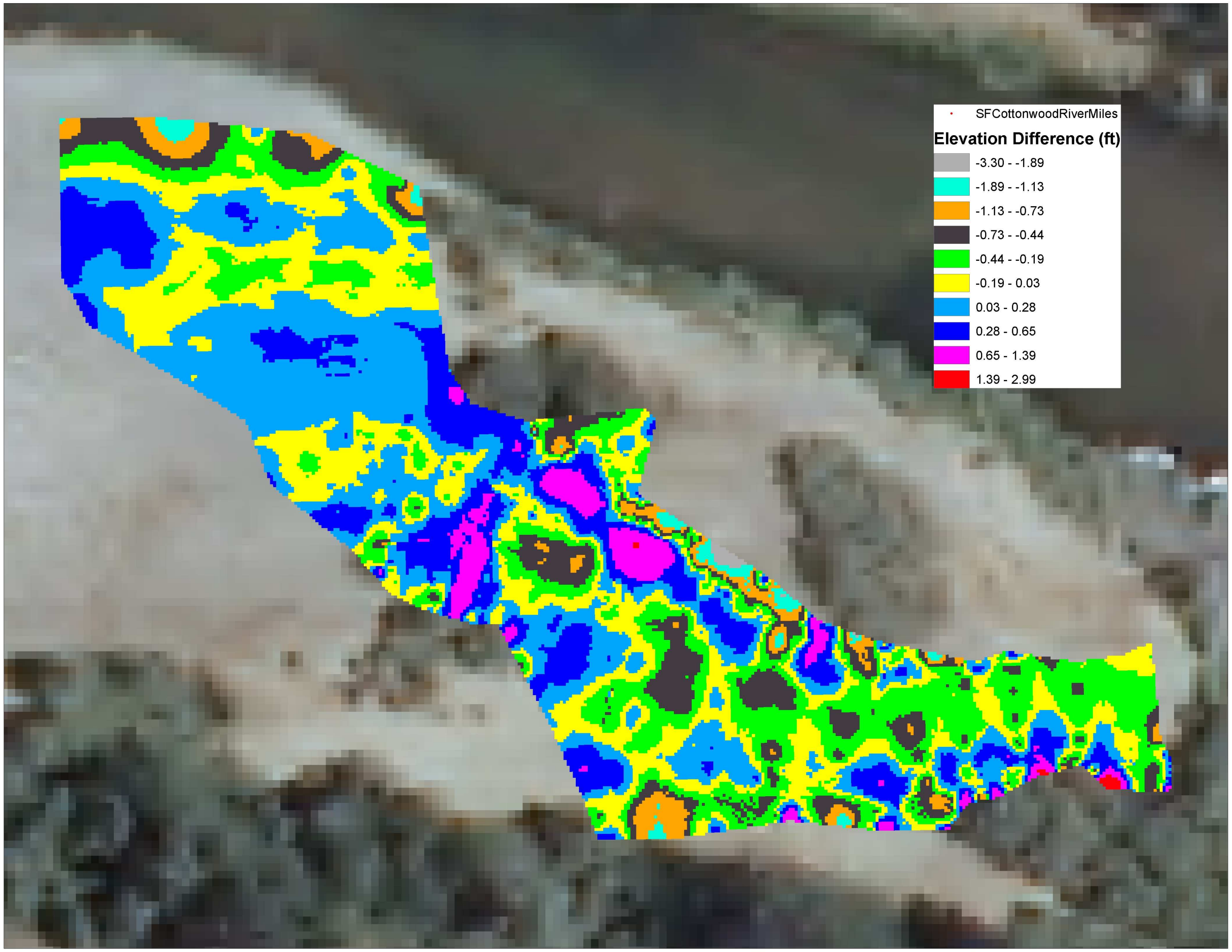

Figure 15
Topographic changes caused by high flows in the bypass channel portion of the ACID siphon restoration site. Positive values indicate aggredation, while negative values indicate erosion.

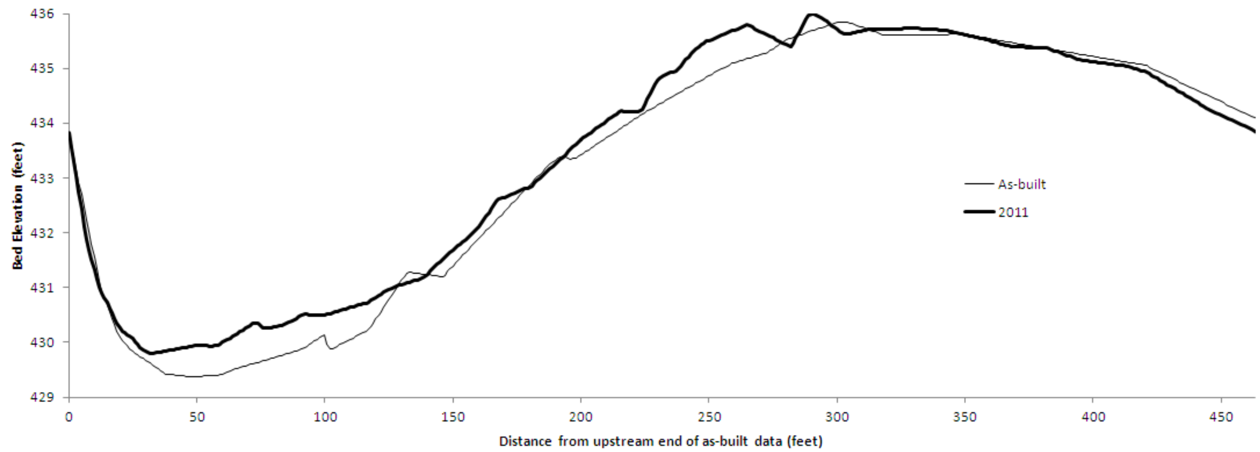

Figure 16

Longitudinal Bed Elevation Profiles of the Bypass Channel at the ACID Siphon Site

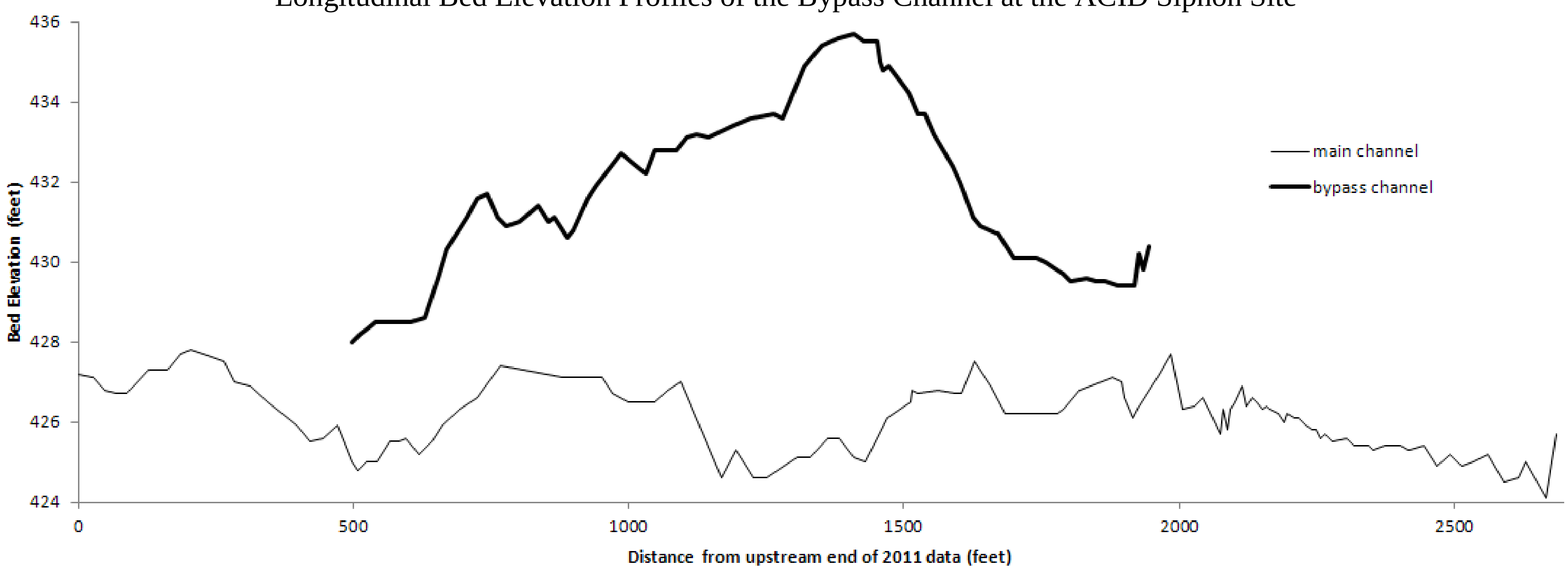

Figure 17

Longitudinal Thalweg Bed Elevation Profile of the Main Channel and Bypass Channel at the ACID Siphon Site

Discussion

The survey shows the dynamic nature of the restoration site due to the effects of high Cottonwood Creek flows. The survey provides an improved baseline to assess further effects of high flows on the topography of the restoration site. It should be noted that some of the differences shown in Figure 15 may be due to differences in the locations of the survey points between the two surveys affecting interpolated values in the two topographic surfaces, rather than to channel changes caused by high flows. This should be less of an issue for assessing channel changes associated with high flows in the winter and spring of 2011-12, since both data sets will have many more points than the 132 points collected for the as-built survey. If desired, additional displays, such as cross-sectional profiles, can be generated from the topography data.

South Fork Cottonwood Creek Habitat Assessment

Methods

An adult spring-run Chinook salmon habitat assessment was conducted on August 1-5, 2011 on South Fork Cottonwood Creek from RM 56.7 (elevation 3061 ft) to 43.3 (elevation 1520 ft) (Figure 18)[16]. Access to the start of the survey was via the Tomhead Saddle Trail, with the survey beginning on the morning of August 2. Adult holding habitat was assessed by collecting the following data for each pool: 1) length and 3-6 widths[17]; 2) maximum pool depth and riffle crest depth; 3) water temperature[18]; 4) a visual assessment of the percent embeddedness of pool tails; and 5) a visual assessment of the percentage of the pool with each of the following cover types: bedrock ledges, boulder cascades, pocket water, large wood, bubble curtains. In addition, the upstream and downstream end of each pool was recorded with a Garmin GPS unit. We also made a visual assessment of the percentage of spawning gravel in the intervening habitats between pools (i.e. in riffles, runs and glides). Each pool was snorkeled and the number of adult spring-run Chinook salmon and steelhead/rainbow trout, juvenile salmonids, other fish species and California red-legged frog were recorded. Potential upstream passage barriers were assessed using the methods in Gallagher (1999) and Powers and Orsborn (1985), with the following parameters measured: 1) visual classification of the barrier as a fall, chute or cascade; 2) depth of pool below barrier (fish entrance zone) and pool above barrier (fish exit zone); 3) vertical distance from the falls crest to the water surface of the pool below the barrier; 4) depth of penetration of falling watering into pool below barrier; 5) horizontal distance from the falls crest to the standing wave in the pool below the barrier; 6) for chutes, the depth of water in the chute; 7) width of barrier; and 8) velocity at top and bottom of barrier. We also measured the discharge of South Fork Cottonwood Creek at the beginning of the survey and the discharge of tributaries within the study reach.

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[16] River Mile 0 is at the confluence of South Fork Cottonwood and the mainstem of Cottonwood Creek. River Miles increase going upstream.
[17] More widths were measured for longer and less uniform pools.
[18] Instantaneous water temperature measurements were taken in the middle of each pool at the time of the survey using a Taylor Model 5395 digital thermometer.

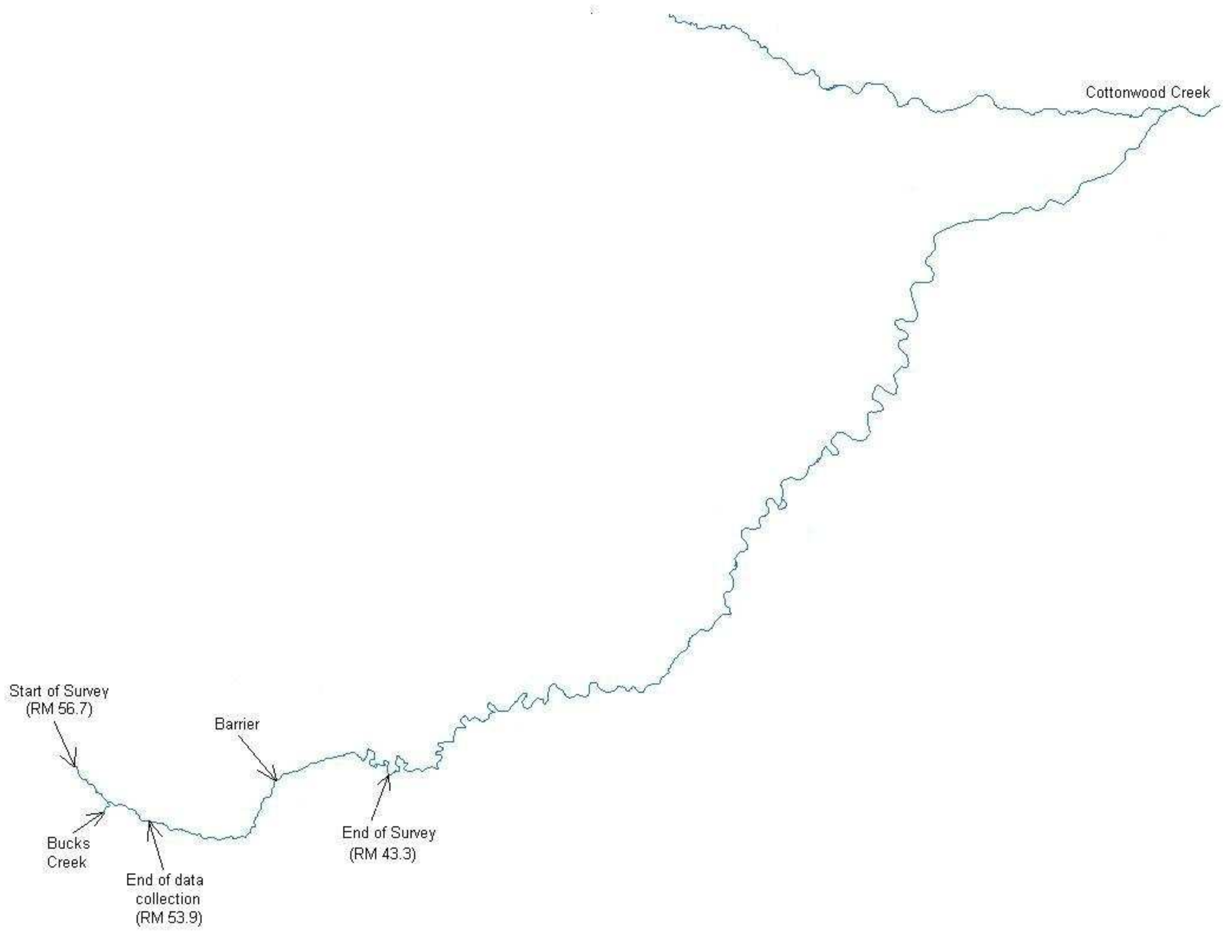

Figure 18
South Fork Cottonwood Study Area

On August 2, we sampled every pool, ending the day at RM 55.3. On August 3, due to the limited length of stream that had been sampled thus far, we only sampled every third to fourth pool for the parameters identified above. For the remaining pools, we only recorded the upstream and downstream end of the pool with the Garmin GPS unit. We completed our extensive surveys at 2 PM on August 3 (at RM 53.9), due to the need to finish hiking to the exit point in a timely manner. Thereafter, only occasional temperature measurements and qualitative observations were made.

Results

We identified three barriers on South Fork Cottonwood Creek: a 30-foot waterfall at RM 49.5 (Figure 19), a 20-foot cascade at RM 49.8 and an 8-foot waterfall at RM 56.5. Both the 30-foot waterfall and 20-foot cascade would be total barriers to both Chinook salmon (with a maximum jump height of 7.9 feet) and steelhead (with a maximum jump height of 10.8 feet). These barriers were located at the upstream and downstream ends of an extremely high gradient section

Figure 19
Downstream-most barrier (30 foot waterfall) on South Fork Cottonwood Creek

of South Fork Cottonwood Creek (Figure 20). The 8-foot waterfall would be a low-flow barrier to both species, based on the criteria that the jump pool needs to be either more than 1.25 times the jump height or at least 8.2 feet deep (Gallagher 1999); in contrast, at the time of the survey, the jump pool was 7.1 feet deep. Water temperatures exhibited both a diel pattern of variation and an increasing trend going downstream, with water temperatures reaching 71.6 ^{o} F at 7 PM (likely near the maximum daily water temperature) just upstream of the 30 foot waterfall (Figure 21). Maximum air temperatures during the survey were 94 to 102 ^{o} F in Redding. The discharge of South Fork Cottonwood Creek was 6.8 cfs at RM 56.7, increasing to 20.6 cfs by RM 51.4.

We sampled 19 pools for all parameters. The only fish seen during the snorkel surveys, with the exception of one juvenile pike-minnow, were juvenile rainbow trout. We had six unconfirmed sightings of California red-legged frog in the sampled reach, with all observations located between RM 56.7 and 56. We also observed numerous California yellow-legged frogs further downstream, starting at RM 53.3. There was an average of nine juvenile rainbow trout per pool,

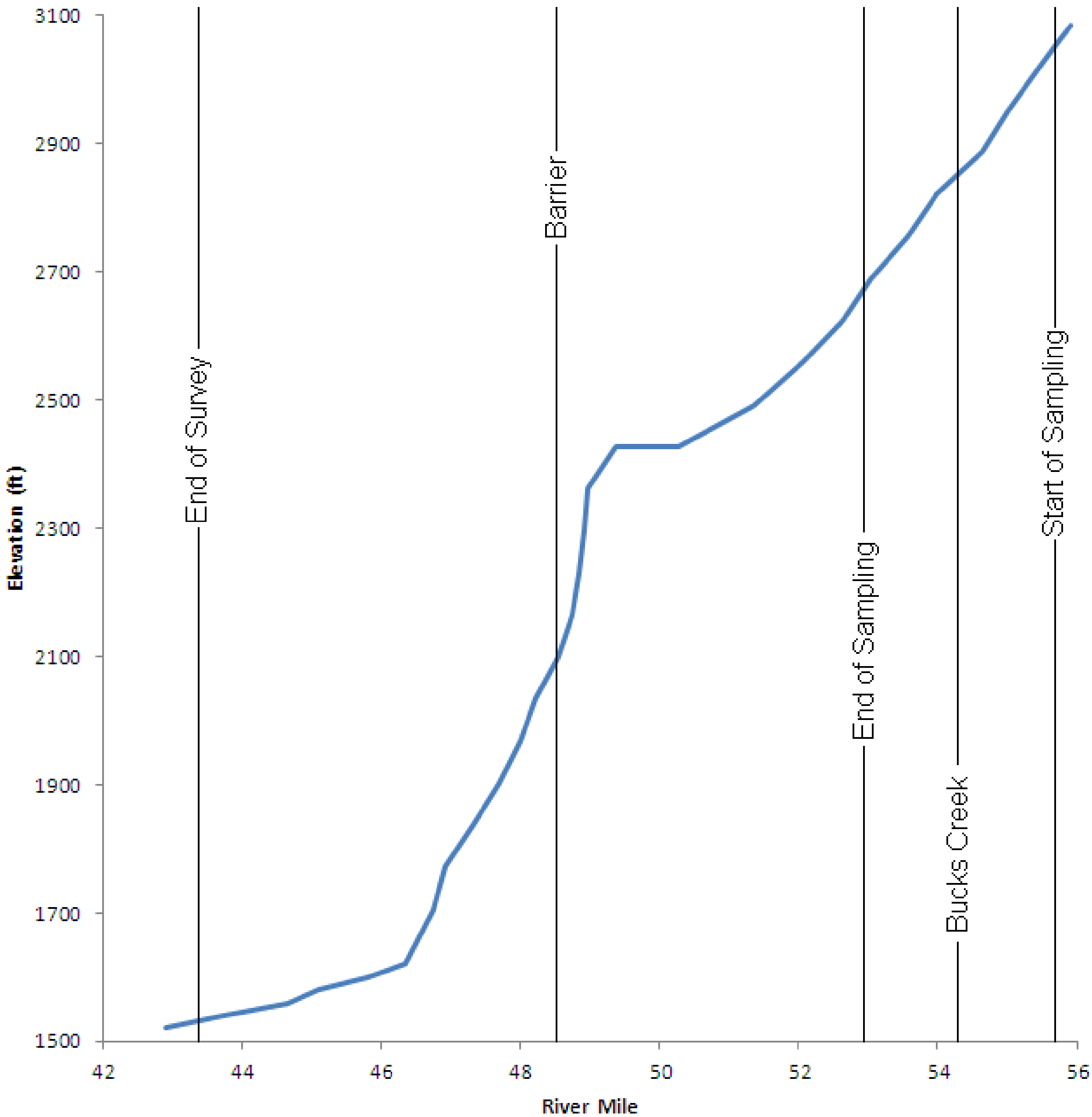

Figure 20
South Fork Cottonwood Creek Profile

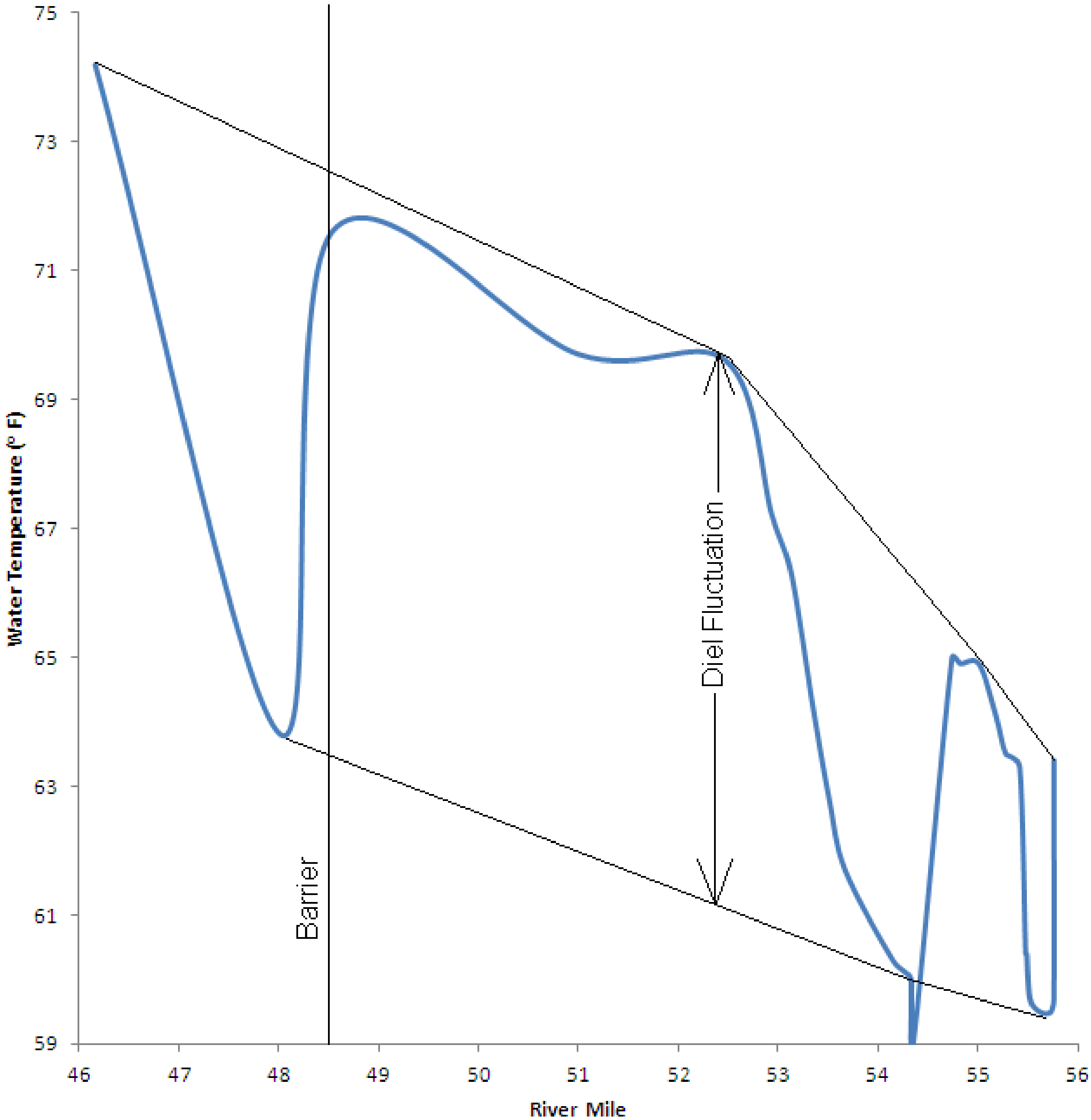

Figure 21
South Fork Cottonwood Creek Water Temperatures[19]

[19] The rapid temperature change at River Mile 54.3 was due to the effect of Bucks Creek, which was 2.4 degrees F warmer than South Fork Cottonwood Creek upstream of Bucks Creek.

ranging in size from approximately 2 to 12 inches in length. Pools comprised 19.5 percent of the length of the sampled reach, with an average area of 2,076 ft^2, an average maximum depth of 4.3 feet and an average residual pool depth of 3.6 feet. The average cover composition of the pools surveyed was 43 percent bedrock ledge, two percent large wood and two percent bubble curtains. Only one pool had boulder cascade cover and no pools had pocket water. The average pool tail embeddedness was three percent. The average percentage of spawning gravel in the non-pool portions of the sampled reach was nine percent; most of the spawning gravel seen in the sampled reach was in pool tails. The amount of spawning gravel in pool tails was not quantified. Although we did not do any sampling below the 30 foot waterfall barrier, no adult spring-run Chinook salmon were seen during a snorkel survey of the pool directly below the waterfall on August 31, 2011 (Doug Killam, CDFG, personal communication).

Discussion

The water temperatures below the lower-most barrier in South Fork Cottonwood Creek are likely marginal for adult spring-run Chinook salmon. In comparison, the highest daily mean and daily maximum water temperatures that have been observed within the spring-run holding reach in Butte Creek are, respectively, 74.4 ^{o} F and 79.6 ^{o} F[20] (unpublished data, Tracy McReynolds, CDFG), while the highest daily maximum water temperature where adult spring-run are observed holding in Beegum Creek, a tributary to Middle Fork Cottonwood Creek, is 76 ^{o} F (Doug Killam, CDFG, personal communication). Given that Redding summer air temperatures can be much higher than those during the survey, and given the higher than normal South Fork Cottonwood Creek flows in 2011, it is likely that in many years water temperatures below the lower-most barrier in South Fork Cottonwood Creek would be too high for adult spring-run Chinook salmon holding. Thus, the combination of the 30 foot waterfall barrier excluding adult spring-run from suitable holding habitat above the barrier and high water temperatures precluding holding below the barrier make it unlikely that South Fork Cottonwood Creek could support any population of spring-run Chinook salmon. In contrast, CDFG historical records indicated the presence of spring-run Chinook salmon in South Fork Cottonwood Creek (Hewitt 1961). It is likely that the South Fork Cottonwood Creek watershed upstream of the 30 foot waterfall was originally fishless, and that the rainbow trout seen above the barrier are the progeny of historical stocking[21]. Accordingly, it might be most appropriate to manage the South Fork Cottonwood Creek watershed upstream of the 30 foot waterfall for native frog species. A first step in any future assessments of spring-run holding habitat below the 30 foot waterfall barrier would be installing a thermograph to better evaluate water temperature conditions below the barrier. The data from such a thermograph could be used to calculate maximum weekly average water temperatures. In this regard, Stillwater Sciences (2012) gives a criteria that adult spring-run Chinook salmon holding habitat should not have more than three exceedances of a

[20] These water temperatures were associated with significant pre-spawning mortality of adult spring-run Chinook salmon (Tracy McReynolds, CDFG, personal communication).
[21] Records indicate that trout were stocked in the South Fork Cottonwood Creek watershed in 1946 to 1970, but that all stocking (at RM 46 to 47.2 or in Cold Fork, which enters South Fork Cottonwood at RM 23.75) was downstream of the 30 foot barrier (CDFG files).

66 ^{o} F maximum weekly average water temperature. In contrast, South Fork Cottonwood Creek, with almost 50 miles of habitat below the 30 foot waterfall barrier, has significant potential for fall-run Chinook salmon, which would not experience such high water temperatures since they are not present during the summertime. South Fork Cottonwood Creek could also have potential for steelhead, although summer water temperatures could be stressful for oversummering yearling steelhead. Future studies would be warranted to assess habitat conditions and potential passage barriers for these races/species, since all of our assessments were upstream of the barrier and were focused on adult holding habitat.

Yuba/Feather River Sturgeon Spawning HSC Data Collection

Methods

Cramer Fish Sciences sampled for green sturgeon on the Yuba River immediately downstream of Daguerre Point Dam on May 24-26, 2011 (Cramer Fish Sciences 2011). Flows during the surveys ranged from 6,903 to 7,292 cfs. We were provided with 29 geographic coordinates where the sturgeon were observed. On July 15, 2011, we attempted to navigate to these locations using our survey-grade RTK GPS and measured depth and velocity at the locations using our ADCP. We also visually classified the substrate at each location where we measured depths and velocities, using the substrate codes in Table 1. Flows during our data collection were 3,390 to 3,460 cfs.

Results

We were able to collect data at 19 of the locations where sturgeon had been observed. Most of the remaining locations were judged to be too close to one of the 19 locations to represent an independent measurement location. There were two locations at which we were not able to hold the boat long enough to collect depth and velocity data, as a result of complex hydraulic patterns. Depths at the 19 locations where we collected data ranged from 3.7 to 11.0 feet, while velocities ranged from 0.92 to 4.02 feet/sec. Substrate sizes at the sturgeon locations ranged from 0.1-1 inches to 1-3 inches.

Discussion

The depths and velocities that we measured are likely significantly lower than those present during Cramer Fish Sciences' sampling, since our data was collected at a much lower flow. Thus, any spawning criteria that would be developed in part from this data would be biased towards low depths and velocities. However, we did observe adult sturgeon in the vicinity of the measurement locations. It is not clear to what extent these measurements represent spawning habitat for green sturgeon, since Cramer Fish Sciences did not actually observe spawning. It is also not clear how many spawning observations these data are equivalent to, since Cramer Fish Sciences estimated that there were four to five sturgeon present. This data, in itself, is too small a sample size to develop spawning habitat suitability criteria for green sturgeon. We suggest that this data be combined with data from other locations in the Central Valley to develop green sturgeon spawning criteria with a Delphi process, as we did for Sacramento River white sturgeon (U.S. Fish and Wildlife Service 1996).

Clear Creek inSALMO Model Beta Testing

Methods

Lang, Railsback and Associates and USDA Forest Service, Pacific Southwest Research Station, developed the Improvement of Salmon Life-Cycle Framework Model (inSALMO) individual-based Chinook salmon model (Railsback et al. 2012) and applied it to two sites on Clear Creek (3A and 3C), using as input hydraulic modeling that we had conducted for these sites. We conducted beta testing of several versions of inSALMO during 2011, identifying program errors and evaluating the performance of the model.

Results

We provided feedback to Lang, Railsback and Associates on errors that we identified and suggested improvements to model features and parameter values. The model was completed at the end of FY 2011.

Discussion

Additional validation efforts are needed before the inSALMO model can be applied either more broadly to Clear Creek, or to other streams.

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