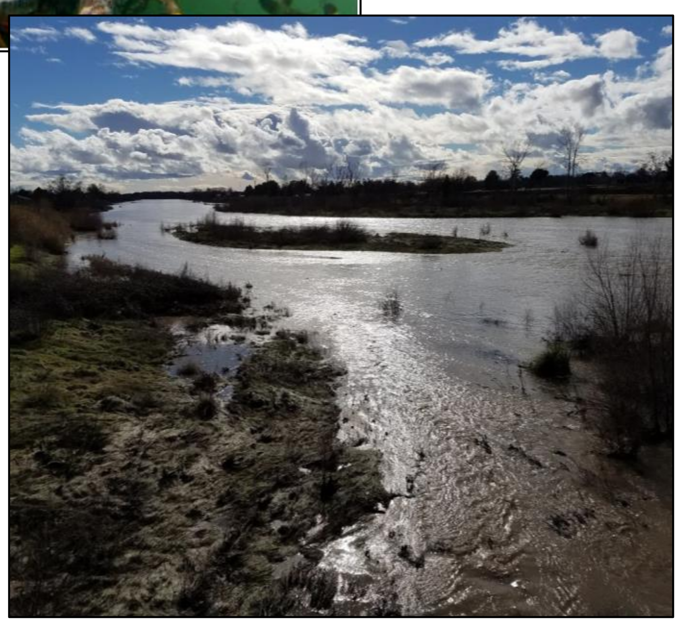
Upper Sacramento River
Anadromous Fish Habitat Restoration Project
Monitoring Plan and Protocols
August 31, 2017





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Introduction

This monitoring plan is designed to determine the effectiveness of the Upper Sacramento River Anadromous Fish Habitat Restoration Project (referred to Project henceforth) in meeting identified objectives and to validate the linkage between restoration actions and the biologic response to those actions. This monitoring plan follows the framework for detecting biological responses to flow management described by Souchon et al. (2008). Monitoring methods structured as field protocols are described in Appendix A.

Problem Statement

The Central Valley Chinook Salmon and Steelhead Recovery Plan identifies the current stressors to threatened and endangered anadromous salmonid stocks in the Central Valley (NMFS 2014). The juvenile rearing and outmigration life stage of winter and spring runs of Chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *Oncorhynchus mykiss* utilizing the upper Sacramento River (Keswick Dam downstream to Red Bluff Diversion Dam) are confronted by several stressors that are ranked as high to very high including: loss of floodplain habitat; loss of natural morphologic function; loss of riparian habitat and instream cover; and competition and predation (NMFS 2014). The upper Sacramento River is where initial juvenile rearing occurs for anadromous salmonid stocks that spawn in the Sacramento River. The middle and lower Sacramento River reaches primarily serve as a migration corridor (NMFS 2014).

Channelization and disconnection from historical floodplains in the upper Sacramento River is due to a combination of natural geologic formations, controlled flow regimes, and flood control levees (NMFS 2014). Most historic side channel features are either not connected to main stem river flows or are connected at higher flows and disconnect at lower flows, effectively stranding fish as river flows recede.

Scientific Basis for Side Channel Restoration

The proposed approach for the Project derives from the hypothesis that connecting side channels for the range of flows that salmonid juveniles encounter will provide the physical and biological habitat characteristics to support a greater abundance of salmonid juveniles that are larger and in better condition to out migrate. The conceptual model underlying this hypothesis and which forms the basis for the monitoring plan approach is provided below (Figure 1).

This conceptual model posits that side channel topography and connectivity to the main channel will drive the physical and biological habitat features that support juvenile rearing habitat. Juvenile salmonids seek streamside habitats containing beneficial aspects such as riparian vegetation and associated substrates that provide aquatic and terrestrial invertebrates for food, cover for predator avoidance, and slower water velocities for resting (NMFS 2014). These shallow water habitats have been described as more productive juvenile salmon rearing habitat than the deeper main river channels (NMFS 2014). Modeling results indicate that first year and estuarine survival are key factors that influence a cohort’s success (Kareiva et al. 2000) and first year survival rates are likely important in the population dynamics of every salmonid stock (Holtby et al. 1990; Sommer et al. 2001).

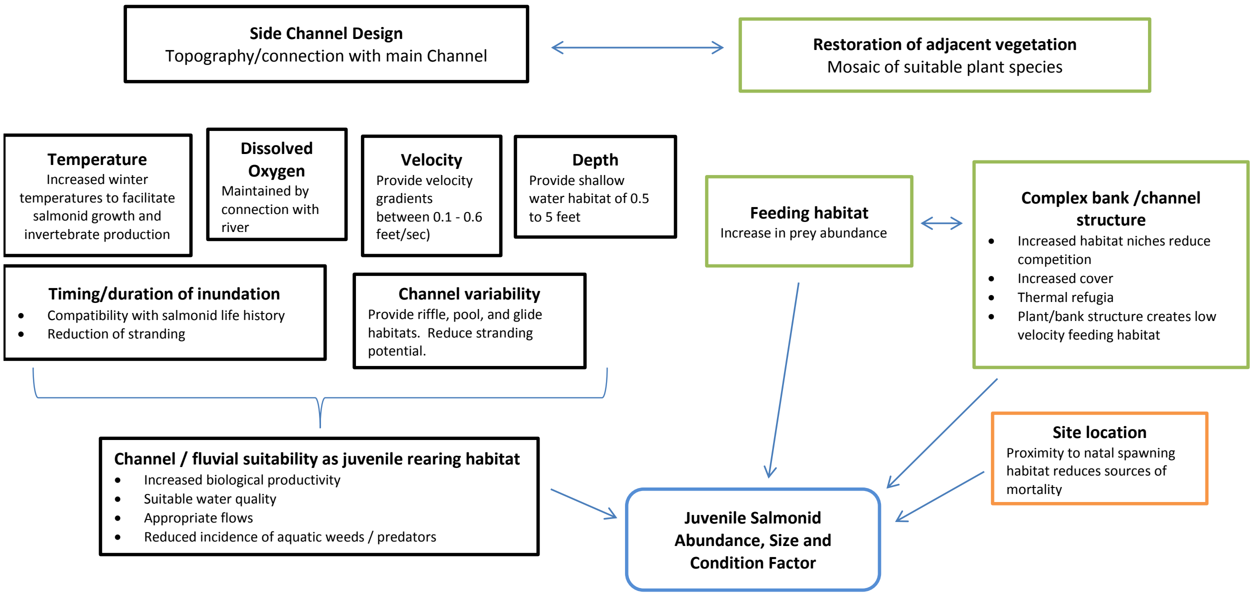

Figure 1 - Conceptual model of design-related elements and their influence on biotic and abiotic juvenile salmonid habitat elements

Physical characteristics of side channels that support juvenile rearing habitat typically have shallower and lower velocity habitats present (Sommer et al. 2001). Side channels exhibit lower flows, providing refuge from high flows and sediment loads than can impair juvenile growth (Crouse et al. 1981). The increase in overall habitat when these side channels are inundated likely reduces competition and lowers predation risk (Sommer et al. 2001, Schlosser 1987).

Connected side channels also exhibit water quality characteristics that contribute to increased growth. Optimum temperature for all Chinook rearing habitat is between 10 - 15.6° C (USEPA 2001). The low-temperature growth threshold in juvenile Chinook salmon is reported as 4.1°C, while 23.3°C is considered potentially lethal to juvenile Chinook salmon (Carter 2005). Juvenile steelhead growth can be enhanced by temperature increases up to 16.5°C (USEPA 1999).

The Sacramento River at Bend Bridge is generally below the optimum temperature for juvenile salmonid growth in the winter months. The constructed side channels will be designed to raise the water temperature during the cooler months when flows are lower. The sloped scarps of the channel will allow greater solar heating of the water column and substrate in shallow areas. This will provide thermal refugia for juvenile salmonids where growth can be increased (Limm and Marchetti 2009). The potential for the warmer temperatures to negatively affect salmon during summer months can be mitigated by strong main stem connections, allowing juveniles to escape as temperatures approach lethal levels (Kondolf and Stillwater 2007).

Side channel water quality is influenced by the hydrologic connectivity to the main channel. Kondolf and Stillwater (2007) found average dissolved oxygen rates of side channels with adequate connectivity to the main channel averaging over 90%.   Disconnected channels had low percent dissolved oxygen ranges of 50% or less, and may pose a limiting factor for aquatic organisms.

Benefits of water temperature, and quality of side channels to rearing habitat are further enhanced by the increased productivity of prey. Greater prey densities are found in off channel habitats relative to the main-channel, supporting improved feeding rates and faster growth (Swales and Levings 1989). Higher juvenile salmon growth rates, partially due to greater prey consumption rates, as well as favorable environmental temperatures have been associated with shallow water habitats (Sommer et al. 2001). Limm and Marchetti (2009) documented that for fall run salmon sampled in February and March, off channel habitats in Tehama County CA were associated with enhanced growth rates as measured by otolith increment and greater prey densities.

The complex bank and channel structure of a side channel also provides support for enhanced condition of juvenile salmonids. Benefits of Shaded Riverine Aquatic (SRA) cover are well documented on the Sacramento River. Juvenile Chinook salmon are more commonly found in association with natural (as opposed to riprapped) river banks and in areas of SRA (CDFG 1983; Michny and Hampton 1984; Michny and Deibel 1986; Michny 1987, 1988, 1989; Fris and DeHaven 1993). Lister and Genoe (1970) found juvenile Chinook salmon preferred slow water adjacent to faster water. This velocity gradient will be included in side channel design by a gradually sloped bank. Rearing winter run juveniles that overwinter in tributaries choose areas with cover and low water velocities. These areas are often characterized by well-vegetated, undercut banks (Hillman et al. 1987).

Side Channel Restoration Approach

Constructed side channels will be designed to provide the hydraulic and structural characteristics of rearing sites for salmonids as determined by the study documented Flow-Habitat Relationships for Chinook Salmon Rearing in the Sacramento River (USFWS 2005), part of the Central Valley Project Improvement Act Instream Flow Investigations, a seven-year study which began in 1995. The study developed flow-habitat relationships for fall run, late-fall run and winter run Chinook salmon from Keswick Dam to Battle Creek. It developed preference criteria by dividing use by availability and produced flow velocity and depth criteria that are used as targets in modeling potential restoration sites. These criteria, along with other physical and biological characteristics as depicted in the model, are important drivers for the enhanced rearing habitat of side channels. They produce enhanced biological productivity, water quality suitable for salmonids, flows appropriate for juvenile rearing and reduced incidence of predators and weeds. Together with restoration of the riparian vegetation and bank features, channel flow and depth design should produce habitat that enhances the growth of salmonids.

The Department of Water Resources (DWR) will develop a mathematical approximation of the river in both existing and proposed conditions to evaluate how the river will react to multiple design alternatives in a 1-D and 2-D model. Inputs to the models will include Light Detection and Ranging (LiDAR) data and surveyed topography and bathymetry. FEMA water surface profiles will be used to calibrate the model to higher flows. Calibrating the 1-D model will help ensure the channel project design does not adversely impact flood flows. The 2-D model is effective for calculating flow patterns around micro-topography, such as the eddy patterns that occur downstream of an obstruction to flow. Surveyed water surface elevations will be used to calibrate the 2-D model and velocity data from Acoustic Doppler Current Profilers will be used to validate the model. DWR will use the output boundary conditions from the 1-D model as the downstream boundary condition for the 2-D model when running it for flows where water surface elevations were not physically measured. The resulting 2D model will provide a tool to analyze and evaluate the effectiveness of channel design alternatives.

Using standard Computer-Aided Design (CAD) software, DWR will develop ground surfaces associated with each of the design alternatives based on the following assumptions: The target flow in the side channel will be approximately 10% of the total river flow at base flow but something less than 10% of the total river flow in the side channel during summertime high flows. The 1-D model will be used to evaluate the effects of side channel design alternatives on FEMA 100-year flood water surface elevations and zones of inundation. The design goal is to create no change in the flood water surface elevation.

The 2-D model will be used to evaluate shear stress and sediment transport over a range of flows. The design goal is to avoid increasing shear stresses (scour) on the bank, and to have sufficient sediment transport to avoid sedimentation build up within the side channel. The model will also be used to evaluate the amount of predicted rearing habitat that would be associated with each side channel design alternative. The design goal is to produce an abundance of low velocity and shallow water habitat, as depicted in the conceptual model. Adjustments may be made to the criteria for the presence of closely adjacent cover features such as large woody debris. The side channel sides will be sloped to maximize the slow water velocities at higher than design flows.

To maintain the function of constructed side channels it is important to minimize the rate of sedimentary fill and maintain the hydraulic connection with the main channel at low-flow stages. Kondolf and Stillwater (2007) found a strong relation between the sedimentation rates and the diversion angle of oxbows in the Sacramento River. Low diversion angles (≤ 50°) allow flows within side channels with a greater capacity to transmit bed material, which can slow or prevent aggradation of bed material at the entrance. Low diversion angles were also found increase the proportion of gravel within sediment entering the side channel. To minimize infilling by fine grained sediment, and maintain main channel connectivity, side channels will be designed with low diversion angles.

Restoration Goals and Objectives

Primary management goals of the Project are to:

1. Increase the availability, quality and quantity of spawning and rearing habitat for Sacramento River Basin Chinook salmon and steelhead trout;
2. Restore, maintain or enhance natural system processes whenever possible

3. Determine project effectiveness, including cost, project longevity and maintenance requirements, with an efficient and scientifically-robust monitoring program;
4. Demonstrate a positive, detectable salmonid population response to habitat enhancement activities;
5. Contribute to the long-term health of the river ecosystem (water quality, invertebrate and fish assemblages, riparian and floodplain habitat function, etc.);
6. Incorporate information learned to improve future projects (adaptive management)
7. Contribute to scientific understanding of aquatic ecology; and
8. Work collaboratively with partners to identify and implement projects that are cost effective and benefit aquatic resources, emphasizing anadromous salmonids, in the short and long term.

The primary objectives of the Project are to provide:

1. An increase in the areal extent of spawning habitat meeting suitability criteria and the use of spawning habitat;
2. An increase in the areal extent of rearing habitat meeting juvenile salmonid rearing habitat suitability criteria;
3. Increase in salmonid juvenile abundance/density at restoration sites after implementation, as compared to before implementation;
4. Improvement in the average condition factor of salmonids using the side channels;
5. An increase in available prey abundance, including both drift and benthic macroinvertebrates;
6. Improved size and average condition of salmonids using the side channels, as compared to those that have not been documented using the side channels; and
7. Increased extent and quality of riparian habitat at Sand Slough.

Hypotheses and Assumptions

The hypotheses listed below are null (baseline) hypotheses. If environmental characteristics associated with restored habitat influence salmonids, these hypotheses will be falsified.

1. There is no significant difference in the presence/absence or numbers/density of juvenile salmonids within habitats affected by defined channel features (e.g. secondary channel, floodplain, cover, shear zones, islands, substrate size classes. etc.);
   Assumptions:
   a. Direct observation (dive counts) can provide a useful index of fish abundance for comparisons within and among side channels given fluctuations in streamflow (seasonally) and turbidity (both seasonally and longitudinally).
   b. Potential changes in foraging behavior due to lower winter water temperatures will not affect detectability of fish by direct observation during the day.
2. Rearing habitat use is not affected by habitat attributes (depth, velocity, substrate, cover, flow, temperature, channel location);
3. Rearing habitat use does not differ among species/run or time of year;
   Assumptions:

    a. Species / runs will be detectable given current low abundance of the population (i.e. winter run Chinook).
4. Juvenile Chinook salmon and steelhead have no preference for different habitat features during the rearing period;
5. There is no significant difference in the average size and condition factor of salmonids using the side channels when compared across side channels, and compared to juveniles rearing in the main stem;
   Assumptions:
    a. Size and condition of juveniles captured within side channels are influenced by residence within side channels, when actual residence times are not known.
    b. Enclosure studies will provide a useful surrogate for size, growth rate and condition of unconfined fish within side channels (e.g. confined fish will not be responding to predation and cover attributes).
6. There is no significant difference in the available prey abundance, including both drift and benthic macroinvertebrates, in side channels when compared across side channels, and compared to the main stem;
7. There is no significant difference in the presence / absence or numbers/density of salmonid redds within habitats affected by defined channel features (e.g. secondary channel, floodplain, cover, shear zones, islands, substrate size classes etc.);
8. Spawning habitat use is not affected by species/run or time of year;
9. Rearing habitat use is not affected predation or occurrence of predators; and
10. Rearing habitat use is not affected by the proximity of redds.

Variables, Metrics, and Methods

Response Variables

Monitoring efforts will generate data for the following response variables for the purposes of testing hypotheses (Table 1). Specific response variable metrics are identified while methods reference field protocols that are documented in Appendix A (Table A - 1).

Table 1 - Response variables, metrics and methods to be used in the testing of hypotheses

Response Variables	Metrics	Methods
Juvenile Fish Abundance (Index)	Density (juveniles/m^2)	Snorkel survey protocol will identify salmonid species, and distinct Chinook runs based upon size class data.
Juvenile Fish Condition and Size	Fulton's Condition Factor (or relative CF), fork length (mm), and lipid content where fish size permits.	Seining protocol Enclosure Studies
Juvenile Fish Growth Rates	Instantaneous Growth Rate (g/day)	Enclosure Studies
Juvenile Fish Site Fidelity	Recapture rate (% of marked)	Seining mark-recapture
Adult Redd Abundance	Density (redds/m^2 of spawnable habitat)	Redd Survey Counts

Explanatory Variables

Monitoring efforts will generate data for the following explanatory variables to test causal mechanisms and validate the linkage between restoration actions and the biologic response to those actions (Table 2). Specific explanatory variable metrics are identified while methods reference field protocols that are documented in Appendix A (Table A - 2).

Table 2 **-** *Explanatory variables, metrics and methods to be used in the testing of mechanism for response to habitat restoration*

Explanatory Variables	Metrics	Methods
Channel Variability / Habitat Type / Microhabitat	Total area by type (e.g. riffle, pool, glide)	Habitat Mapping, Habitat Models (Juvenile Habitat Mapping–Depth, Velocity, Cover, and Habitat Types protocols)
Fish Cover	% cover, total and by type; distance to cover	Juvenile Habitat Mapping–Depth, Velocity, and Cover Protocol
Substrate Size Classes	d50, % fine particles, % of size class serving as cover	Pebble Counts (Longitudinal Profile and Cross Sections protocol)
Embeddedness	% embeddedness	Pebble Counts (Longitudinal Profile and Cross Sections protocol)
Temperature	Weekly average temperature, weekly average maximum temperature	Data Loggers (Stream Temperature protocol)
Dissolved Oxygen	mg/L	Hand held DO meter, DO data logger
Water quality (general):	Conductivity, pH.	Handheld meters, field labs.
Velocity	Habitat velocities at range of flows	hydraulic models, handheld flowmeter for microhabitat
Discharge	CFS for total flow in side channel; Maximum and minimum for high and low flows	handheld flow meter
Depth	Average depth of habitat types; maximum depths; depths at cross sections	Habitat unit measurements (Juvenile Habitat Mapping–Habitat Types protocol; Longitudinal profile and cross section protocol)
Prey Abundance / Availability	Drift, zooplantkton	Drift net sampling (Invertebrates: Drift Sampling protocol)
Prey Consumption	Diet composition	Gut samples from seining and enclosure studies
Predator Abundance	Density (#/m^2) by species and all species pooled.	Snorkel survey protocol will identify predator species, and size classes.
Aquatic Weeds	% Area	Should define (primrose etc.) and add to habitat protocol
Proximity to spawning habitat	Uncertain	Uncertain

Study Design

The side channel restoration project monitoring study design presented below will evaluate the effectiveness in meeting identified project objectives and is designed to validate the linkages between restoration actions and the biologic response to those actions. The study design is structured by hypotheses, response and explanatory variables, analysis design, and methods (data collection protocols). Detailed descriptions of the proposed methods can be found in Appendix A. Field Protocols.

Table 3- Primary Study Design

Hypothesis	Response Variable	Explanatory Variable(s)	Analysis Design	Data Collection Protocols
1. No difference in numbers/ density of juvenile salmonids	Juvenile Fish Abundance Index	Restoration treatment (control/impact)	Temporal Time Series Analysis (month to month and year to year)	Snorkel Survey Index Protocol
2. & 4. Rearing habitat use is not affected by habitat attributes, and habitat preference doesn't change throughout the rearing period.	Habitat Utilization Data from Direct Observation	• Mesohabitat Type • Cover • Distance to Cover • Cover Type • Water Depth • Mean Velocity • Focal Velocity • Particle Size • Embeddedness • Predator counts • Redd proximity	• Habitat Suitability Curves (HSC) for all numeric variables. • Multidimensional analysis to test for interactions, and juvenile fish size effects	• Juvenile Habitat Mapping–Depth, Velocity, and Cover protocol • Juvenile Habitat Mapping–Habitat Types protocol • Snorkel Survey Index Protocol • Snorkel Survey Microhabitat Use Protocol
3. Rearing habitat use is not affected by species/run or time of year.	Juvenile Fish Abundance Index; Habitat Utilization Data from Direct Observation	Species/run	• Perform Testing of Hypothesis #2 throughout the year to establish HSC for species/runs. • Stratify analysis by 4 seasons, informed by major changes in hydrograph.	• Snorkel Survey Index Protocol • Snorkel Survey Microhabitat Use Protocol
5. No difference in the average size or condition factor of salmonids	Condition Factor (CF) and Size (seining)	• Restoration Treatment (control/impact and main stem) • Season / run	Temporal Time Series Analysis	• Fish Capture: Seining Protocol
	Growth Rate, CF, Size (enclosure studies)	Restoration Treatment (control/impact and main stem)	ANOVA Year to year time series analysis possible	• Enclosure Study Protocol
5. No difference in the average size or condition factor of salmonids (cont'd)	Growth Rate, CF, Size (enclosure studies)	• Water Temperature • Prey abundance • Ecological Function (BMI MMI) • Dissolved Oxygen • Diet composition	• Generalized mixed linear models • Make direct hypotheses about explanatory variables (candidate models) • AIC for selecting best model	• Enclosure Study Protocol • Invertebrate drift sampling protocol

6. No difference in the available prey abundance	Prey Abundance	Restoration Treatment (control/impact and main stem)	• ANOVA, comparison of means • Index of relative importance (IRI) • Standardized forage ratios (SFR)	• Invertebrate drift sampling protocol • Gut contents: Seining and Enclosure Study (preference vs. availability)
7. No difference in the presence / absence or numbers/density of salmonid redds	Adult Redd Abundance, Density	Restoration Treatment (control/impact)	Time Series Analysis with Baseline (BACI)	Redd Survey Protocol
8. Spawning habitat use is not affected by species/run or time of year.	Adult Redd Abundance, Density	Stock/Run	Perform Testing of Hypothesis #7 throughout the year for species/runs.	Redd Survey Protocol
9. Rearing habitat use is not affected by predation or occurrence of predators			Added counts of predators as another explanatory variable in the analysis of hypotheses #2 and #4.	
10. Rearing habitat use is not affected by Redd proximity			Added Redd proximity as another explanatory variable in the analysis of hypotheses #2 and #4.	

Table 4 - Study Design for Testing Assumptions

Hypothesis	**Response Variable**	**Explanatory Variable(s)**	**Analysis**	**Data Collection Protocols / Methods**
A. Fluctuations in streamflow (seasonally) and turbidity (both seasonally and longitudinally), are not affecting abundance indices.	Juvenile Fish Abundance Index	Turbidity	Comparison of fish abundance indices over the range of turbidity values	Snorkel Survey Index Protocol based upon artificial fish targets
B. Potential changes in foraging behavior due to lower winter water temperatures will not affect detectability of fish by direct observation during the day	Juvenile Fish Abundance Index	Day / Night	Comparison of day vs. night fish abundance indices.	Snorkel Survey Index Protocol paired day/night dives

Study Implementation

Annual Schedule

The schedule for annual implementation of sampling protocols is presented in Table 5.

Table 5 - Annual Implementation Timing of Sampling Protocols

Protocol	Element	Period of Monitoring / Survey	Sampling Frequency
Snorkel Surveys	Abundance Index	Jan-Dec	Weekly
	Micro Habitat Use	Jan-Dec	Monthly
Juvenile Habitat	Longitudinal Profile, Cross Sections, Pebble Counts	Jan-Dec	Once Annually
	Habitat Mapping–Type, Depth, Velocity and Cover	Jan-Dec	3 times per year targeting a range of flows between 3,250 and 10,000+ cfs (Keswick release, KWK)
Seining	Fish Size and Condition	Jan-Dec	Monthly (informed by snorkel surveys)
	Gut Contents	Jan-Dec	Monthly
Invertebrates	Drift Net Samples	Jan-Dec	Monthly
Enclosure Study	Fish Size and Condition	Mar-May	Weekly (study duration 30-60 days)
	Gut Contents	Mar-May	Every 2 weeks
Redd Surveys		Jan-Dec	Every 2 weeks

Study Sites and Site Selection

As existing functional side channels are limited in number in Shasta and Tehama Counties, it is anticipated that the number of restoration sites will outnumber the number of control sites. The first year of data collection will help inform the best pairing of sites that share similar characteristics. Side channel control sites are identified in Table 6 below. Maps illustrating the locations of side channel control sites can be found in Appendix B. As a site is identified for restoration, it will be paired with a control site for analysis. Due to the lack of functional side channels in Tehama County that are geographically proximate to impact sites, it is likely a main stem site will be selected to serve as a control in Tehama County.

Table 6 - Side channel control sites

County	Side Channel Control Sites
Shasta	Wyndham
	Clear Creek
	Bourbon Island
Tehama	Main stem North
	Main stem South

Limiting Factors

Several uncertainties may pose potential limitations on the proposed study design and field methods; and will need to be adapted to as conditions dictate. The anadromous salmonids in the Upper Sacramento River that are the focus of this side channel habitat restoration effort include at-risk (Threatened/Endangered) species. This poses two limitations to the current study: low numbers of juvenile fish from which to detect a biologic response (e.g. winter run Chinook salmon); and permitting restrictions on the acceptable sampling methods and degree of handling that can be used to investigate the causal mechanism of a biologic response to habitat restoration.

Data collection methods have been selected that have the least possible impact on at-risk salmonid stocks and can still meet hypothesis testing objectives. As a result, data may be less quantitative than would be possible if a wider range of field methods were employed, and may include more assumptions when validating the linkage between restoration actions and the biologic response. Direct observation (snorkel surveys) is proposed as a less invasive measure to establish indices of abundance rather than estimating abundance and confidence intervals through mark-recapture methods. Proposed fish capture methods have been limited to seining, for which there is some uncertainty as to its effectiveness, and will require field testing. Additionally, investigations on side channel growth rates are limited to a study design using enclosures and hatchery fish, as individually marking and recapturing juveniles in side channel habitats was determined to be an unacceptable level of impact. Though, low densities of juvenile fish may have limited the feasibility and broad applicability of alternative field methods.

Additionally, environmental conditions may prove to be a limiting factor for implementing the study design at the proposed sampling frequency schedule (Table 5). For example, the study design is reliant on direct observation to establish indices of abundance (weekly schedule) and habitat use / suitability criteria (monthly schedule) but this method is only feasible at lower turbidity values. During the recent drought years, this method proved feasible to implement throughout most of the calendar year (Ryan Revnak, Pers. Comm.). However, in the 2017 water year, higher turbidity values prohibited direct observation from being implemented for approximately a 6 month period (November – March). Prior studies in the Upper Sacramento River have encountered similar prohibitive conditions. During the flow-habitat relationship study for Chinook salmon rearing implemented by the USFWS in April 1996 through August 2001, snorkeling techniques were prohibited due to high turbidity from December 1996 to August 1997, December 1997 to June 1998, and January to March 1999 (USFWS 2005).

Data Analysis and Reporting

More limited analyses and reporting will be performed annually and more extensive analyses and reporting will be performed less frequently when more extensive data sets are available from which to establish time series and account for environmental variability. Annual analysis and reporting will be important to: determine if data collection methods are effective at achieving data objectives; modify field protocols as needed to effectively meet those objectives; perform preliminary tests of hypotheses as data allows; and, to inform restoration efforts where a biological response to restoration can be established. More extensive and thorough analysis and reporting will be performed when there is sufficient data to analyze the full suite of hypotheses as described in the primary study design (Table 3) and provide more robust feedback to inform possible modifications to restoration prescriptions. It may require several years of post-restoration data collection to answer some of these hypotheses with an acceptable level of certainty.

Management Implications – Adaptive Management

It is beneficial to evaluate performance in meeting restoration objectives as soon as possible in order to inform potential modifications to restoration prescriptions that can better achieve the desired biological response. In general, this project contains most elements essential to the adaptive management process framework of CALFED (CALFED 2000; Healey et al. 2004; Figure 2). In the short term, this adaptive management feedback loop may be limited by the anticipated time scales of response and other limiting factors as identified in prior sections of this plan. The development of annual monitoring reports will be designed to report on successful restoration prescriptions in the event that linkages between restoration actions and biological response are observed. Though, it is anticipated that it may take several years of monitoring to determine the validity of linkages with any degree of confidence.

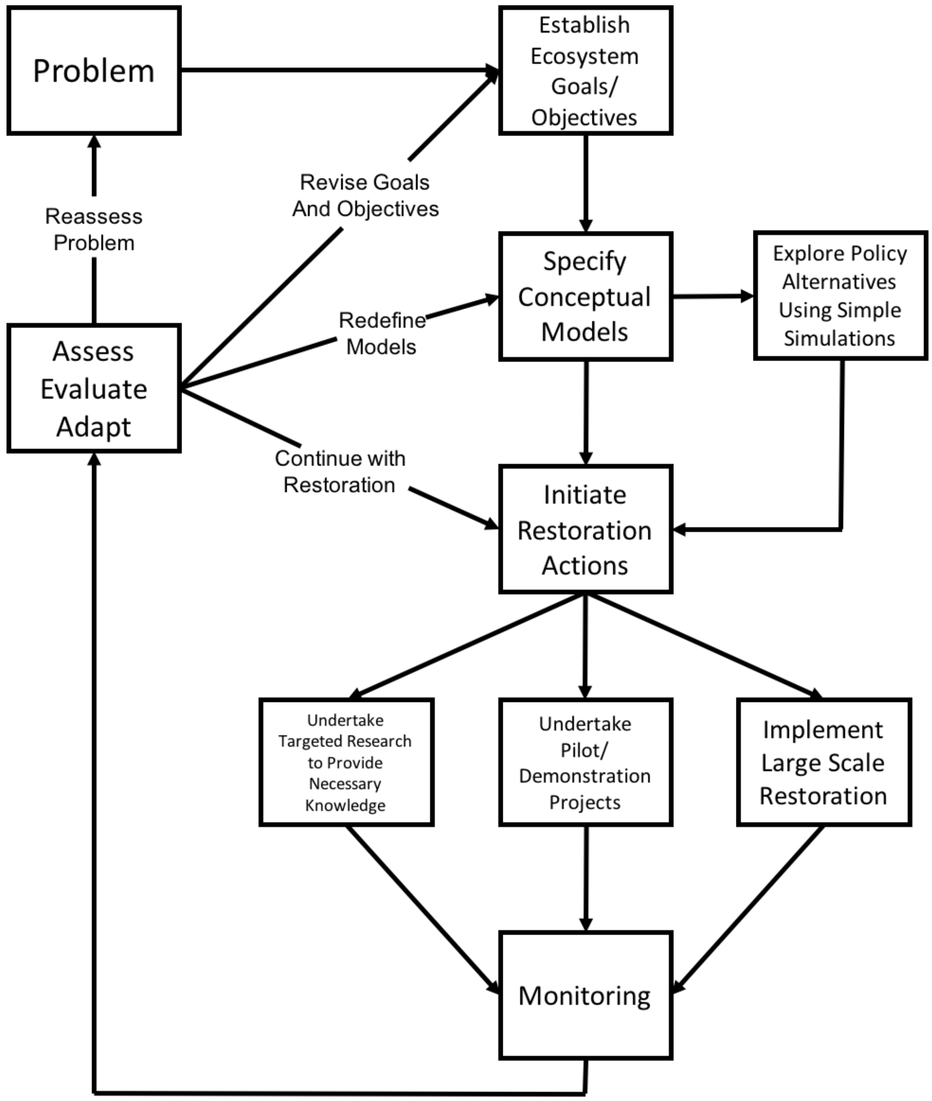

Figure 2 **-** *The Adaptive Management process as applied in CALFED (CALFED 2000; Healey et al. 2004)*

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Appendix A. Field Protocols:
Upper Sacramento River
Anadromous Fish Habitat Restoration Project
Monitoring Protocols
Working Version 1.0
Summer 2017

Control Site Selection

Step 1: Intitial Site Selection: Impact sites channels have been selected in order to create more rearing habitat for juvenile salmonids. Control sights that are similar to the impact sites must be selected to create a useful comparison. Select control sites that have features and habitat types that are similar to those being created at the impact site. They should also be relatively similar in size, and have a relatively close proximity to one another.

Step 2: Pairing: Determine which control side channels pair well with the proposed impact side channels based on the previously stated parameters. This will allow for a detailed comparison between an established side channel and a newly created one. Existing control side channels range in length from roughly 200 meters to just over 450 meters which coincide with the size of the footprint of the proposed impact channels.

Step 3: Control Site Sectioning: If control sites (e.g. Blethen Island), are longer than logistically feasible to sample in their entirety, delineate a section of a side channel as a control site. The subsection should similar in length to the side channels that are surveyed in full. The first sections to be eliminated should be areas that have unusual or uncommon features. For example, if the proposed control channel has a slough running into it, but the impact site does not, then the section downstream of the slough is a candidate for elimination. The remaining section of the side channel should be scouted for habitat that is most similar to the restored (impact) site in depth, velocity, cover, habitat types, snorkeler safety, and accessibility. If the majority of the control side channel meets these criteria, then a suitable GPS “start” point can be randomly selected from the potential “start” points.

Step 4: Revising Site Selection and Pairing: Amend your list of control and impact sites and the pairing of those sites accordingly using results of the habitat mapping and inventory (below). Use data gathered from the juvenile habitat mapping to select control sites that are similar to corresponding impact sites. Because of the scarcity of existing side channels in the Sacramento River, some of these control sites may be used as a comparison to multiple impact sites, or consider the addition of main stem control sites (step 5),as new sites are added during the duration of the project.

Step 5: Main Stem Control Selection: If there are not any candidate side channel control sites in close geographic proximity to impact sites, consider the addition of main stem control sites. Main stem habitat near the restoration site should be scouted for habitat that is most similar to our ideal restored site in length, depth, velocity, cover, habitat type (as defined in the protocol), snorkeler safety, and accessibility. If restoration activities are expected to affect the near-downstream areas of the main stem, then it is suggested that we limit selection areas to just upstream from the restoration. If multiple areas meet these criteria with no clear "best" match, random stratified sampling may be used to finalize selection (e.g. limit the possibilities to choose from to those that match the criteria above, and randomly select from those). The strengths of these control sites are that they will allow us to gather data from control sites that are in the same immediate geographic area. A weakness is that main stem sites will be unlikely to closely match our impact sites in physical, chemical, and biological characteristics.

Longitudinal Profile and Cross Sections

References:

California Department of Fish and Wildlife. (2013). Standard Operating Procedure for Discharge Measurements in Wadeable Streams in California, CDFW-JFP-002.

California Department of Fish and Wildlife. (2010). California salmonid stream habitat restoration manual. California Department of Fish and Wildlife 1(4).

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Schedule:

Longitudinal and cross section data collection is anticipated to occur annually at low flow conditions and at approximately the same time of year.

Field Collection Methods:

Step 1: Establish and Survey Cross Sections and Measure Substrate Particle Size.

i. Identify appropriate locations for 3 permanent cross sections within each control and treatment side channel. CDFW (2010) recommends velocity crossover areas where stream velocity changes from slower flatwater and pool habitats to faster riffle habitat velocities. The preferred locations are near the upstream, middle and downstream portions of the side channels total length. Insure that the cross section at the furthest upstream location is compatible with necessary site characteristics for repeated discharge measurements (see CDFW 2010 and Harrelson et al. 1994).
ii. Establish permanent benchmarks and permanent endpoints for cross sections following methods of Harrelson et al. (1994).
iii. Identify and temporarily flag bankful discharge and measure bankful width. Divide bankful width by 20 to establish the fixed interval for measures of elevation and substrate size within the bankful width.

iv. To begin cross sectional survey, stretch a tape between permanent endpoints and employ a tagline if the tape sags excessively.
v. Backsight to the permanent benchmark and begin the cross section survey with instrument and rod. Take elevation and distance measurements at all features of interest that capture the bank profile outside of the bankful width. Take an elevation at the bankful discharge (flagged). Within the bankful width take elevation measurements at 20 equidistant points across the bankful width (see CDFW 2010 and Harrelson et al. 1994).
vi. When permanent endpoint is reached, close the loop on cross sectional surveys by recording elevation of the original benchmark.
vii. Sample substrate at each of the 20 equidistant survey points within the bankful width cross section by recording pebble count measurements following the methods of Wolman (1954). Visually estimate percent embeddedness for cobble sized substrate (size class range 64 – 256mm).
viii. Additionally, establish 2 temporary intermediate bankful cross-sectional transects approximately midway between the permanent cross sections for the sole purpose of collecting additional pebble counts. Sample substrate at 20 equidistant points within the two temporary cross sections by recording pebble count measurements following the methods of Wolman (1954). Visually estimate percent embeddedness for cobble sized substrate (size class range 64 – 256mm). Total pebble counts for the entire side channel should equal 100. Total number of embeddedness measures will vary depending upon the amount of cobble sized substrate encountered.
ix. Document cross sections with photos.

Step 2: Measure discharge at the permanently benchmarked cross section furthest upstream following the Standard Operating Procedure for Discharge Measurements in Wadeable Streams in California (CDFW-IFP-002, 2013).

Step 3: Establish a longitudinal profile for each side control and impact side channel to monitor scour and fill changes in side channel habitats following methods in CDFW (2010). Use the field techniques identified in Harrelson et al. (1994) as a reference for standardized survey methods.

i. Utilize a permanent benchmark from a permanent cross section to start the longitudinal survey at the upstream end of the side channel.
ii. Begin survey where the side channel meets the main stem river at the upstream end of the side channel.
iii. Position a tape (recommend 300') along the channel centerline to enable the recording of distance measurements for stations where elevation measurements will be made. Alternatively, the tape can be positioned along the water's edge if flows do not permit using the channel centerline.
iv. Following the thalweg, record measurements of distance along channel centerline, streambed elevation, and water surface elevation using standard surveying techniques (Harrelson et al. 1994). It is important to capture elevation measurements at all locations where pronounced changes in bed slope occur. CDFW (2010) notes that while breaks in slope can be difficult to detect, pool habitats will likely require five elevation measurements whereas riffle may only need three.

v. Collect Trimble GPS points at the beginning and end of the survey and all locations along the thalweg that involve a change in bearing or change in habitat type. This will enable the thalweg position to mapped on site maps.
vi. Terminate the survey where the downstream end of the side channel meets the main stem river.
vii. Close the loop on longitudinal surveys by recording elevation at a permanent benchmark.

Juvenile Habitat Mapping: Habitat Types

References:

California Department of Fish and Wildlife. (2013). Standard Operating Procedure for Discharge Measurements in Wadeable Streams in California, CDFW-JFP-002.

California Department of Fish and Wildlife. (2010). California salmonid stream habitat restoration manual. California Department of Fish and Wildlife 1(4).

Schedule:

For the first two to three years pre (1 year) and post restoration (2 years), juvenile habitat mapping will be more intensively implemented to capture habitat attributes at a range of flows between 3,250 and 10,000+ cfs (Keswick releases, KWK). Sampling will occur three times annually to map habitat for the following target flows: Winter flows 3,250-4,500 cfs; Fall flow 4,500-7,000 cfs; Summer flows 10,000 + cfs. Implementation of this protocol from year to year will attempt to best capture the same targeted flows captured in the previous year. It is anticipated and desirable that all three habitat mapping protocols (habitat type, cover and depth / velocity) will be implemented on the same day if possible or on successive days at similar flows.

Field Collection Methods:

Step 1: Establish appropriate cross section location for discharge measurement, or locate the permanently benchmarked cross section location dedicated for discharge measurements. Measure discharge following the Standard Operating Procedure for Discharge Measurements in Wadeable Streams in California (CDFW-IFP-002, 2013).

Step 2: Complete a habitat typing and mapping survey of each impact and control site using methods from the California Stream Habitat Restoration Manual (CDFW 2010) aided by the use of a Trimble GPS.

i. Survey should begin at the downstream end of the control and impact side channels and proceed upstream to the side channel inlet.
ii. Classify habitat types to level III using the habitat types hierarchy provided in CDFW (2010; Figure 1 below). Map the wetted perimeter and breaks between discrete habitat types for the entire length of each control and impact side channel using a Trimble GPS.

iii. Calculate average depth measurements for all discrete habitat units by taking several random depth measurements across the unit with a stadia rod. Calculate and enter the mean depth, in feet.
iv. Record the measured maximum depth for each habitat unit, in feet.
v. Visually identify the dominant and co-dominant substrate composition within the wetted area for each habitat unit following classification of CDFW (2010; Table A-1 below)

Table A - 1 Dominant and codominant substrate size classification (from CDFW 2010).

Particle Size	Inches
Boulder	>10”
Cobble	2.5-10”
Gravel	0.8-2.5”
Sand	<0.08”
Silt/clay	N/A
Bedrock	N/A

vi. Measure the percentage of the stream area that is covered by tree canopy using a spherical densitometer. Measure canopy cover in the center of the wetted channel and at the upstream end of each habitat unit consistent with CDFW methods (CDFW 2010; Appendix M).
vii. Surface areas for all habitat units will be generated using GIS from discrete habitat polygons.

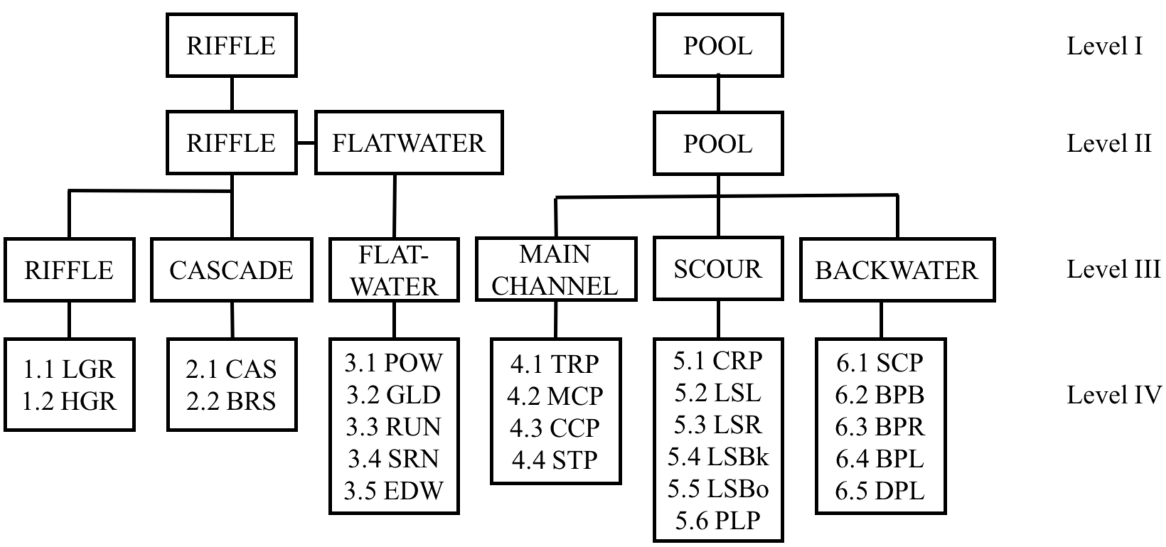


Figure A - 1 Habitat type hierarchy from California Salmonid Stream Habitat Restoration Manual (CDFW 2010)

Juvenile Habitat Mapping–Depth, Velocity, and Cover

References:

Goodman, D. H., et al. (2015). A mapping technique to evaluate age-0 salmon habitat response from restoration. Restoration Ecology, 23(2): 179-185.

U.S. Fish and Wildlife Service. (2005). Flow-Habitat Relationships for Chinook Salmon Rearing in the Sacramento River between Keswick Dam and Battle Creek. U.S. Fish and Wildlife Service: Sacramento, CA.

Schedule:

For the first two to three years pre (1 year) and post restoration (2 years), juvenile habitat mapping will be more intensively implemented to capture habitat attributes at a range of flows between 3,250 and 10,000+ cfs (Keswick releases, KWK). Sampling will occur three times annually to map habitat for the following target flows: Winter flows 3,250-4,500 cfs; Fall flow 4,500-7,000 cfs; Summer flows 10,000 + cfs. Implementation of this protocol from year to year will attempt to best capture the same targeted flows captured in the previous year. All habitat mapping protocols (habitat type, depth, velocity, and cover) should be implemented at the same stream flow (ie. same day or on successive days if possible) It is anticipated that, depending upon the restoration treatment, long term monitoring will likely be necessary to document fully restored conditions, especially where riparian vegetation is responding to the restoration treatment.

Juvenile Habitat Suitability Criteria:

Juvenile habitat mapping efforts follow the juvenile habitat suitability criteria of Goodman et. al (2015) that apply to age-0 presmolt (>50mm) Chinook salmon. These criteria include depth, velocity and distance to cover (Table A-2). Cover types to be mapped will follow the cover types previously identified during the study of Flow-Habitat Relationships for Chinook Salmon Rearing in the Sacramento River between Keswick Dam and Battle Creek, published by the US Fish and Wildlife Service in 2005 (Table A-3).

Table A - 2 Juvenile Chinook salmon (age-0, presmolt, >50mm) depth, velocity, and distance to cover habitat suitability criteria for juvenile habitat mapping (from Goodman et al. 2015). The lower ranges for all parameters are 0 (Goodman et al. 2015).

Parameter	Upper Range (m)	Upper Range (ft)
Depth	1	3.3
Velocity (/s)	0.24	0.8
Distance to Cover	0.6	2.0

Table A - 3 Juvenile salmonid habitat cover types (USFWS 2005).

Cover Type	Cover Code	Definition
No cover	0.1	
Cobble	1	3”-12” particle size, < 50% embedded
Boulder	2	>12” particle size

Fine woody vegetation	3	<1” Diameter
Branches, small woody debris	4	< 12” Diameter
Log, large woody debris	5	> 12” Diameter
Overhead cover	7	> 2’ above substrate[1], < 1.5’ off water surface[2]
Undercut banks	8	
Aquatic vegetation	9	In-water vegetative cover
Rip Rap	10	

[1] USFWS (2005); [2] Holmes et. al. (2014)

Field Collection Methods

Step 1: Depth and Velocity Mapping

i. Activate the handheld Trimble GPS unit and let it acquire satellites. Insure the accuracy reads less than 1 meter before initiating mapping.
ii. Using juvenile depth and velocity suitability criteria identified in Table A-2 above, outline areas (define perimeter) of suitable habitat with a handheld Trimble GPS unit by measuring depth and velocity using hand-held flow meters on top-setting rods. This will effectively identify discrete polygons throughout the side channel that simultaneously meet both depth and velocity criteria (i.e. depth and velocity are not mapped independently).
iii. Exclude small habitat areas of less than 2m x 2m to reduce geo-spatial error.
iv. Where small habitat areas are excluded, visually estimate the surface area and record the value in field notes and GPS the location.

Step 2: Fish Cover Mapping

i. Activate the handheld Trimble GPS unit and let it acquire satellites. Insure the accuracy reads less than 1 meter before initiating mapping.
ii. Using juvenile cover suitability criteria identified above (Table A-2, distance to cover), outline areas (define perimeter) of in-water escape cover and geo-reference locations of this outline using a Trimble handheld GPS unit.
iii. Outline in-water escape cover separately for each cover type present as defined in Table A-3 and record the cover type. Note that where cover types may overlap, map polygons separately for each cover type (e.g. cobble, and overhead vegetation may overlap with other cover types).
iv. For aquatic and overhanging vegetation record the species.
v. Exclude small habitat areas of less than 2m x 2m to reduce geo-spatial error.
vi. Where small habitat areas are excluded, visually estimate the surface area and record the value in field notes and GPS the location.
vii. If GPS points cannot be established to map discrete cover perimeters, measure and record the area of cover (length and average width), cover type, and general location.
viii. Record the presence of aquatic weeds (e.g. primrose) and visually estimate the size of area affected.

Step 3: Download data from the Trimble GPS unit at the end of each field day to prevent data loss, and to expedite the ability of staff to perform post-processing and archiving of data.

Repeatibility Testing

There is some uncertainty as to the repeatability of habitat mapping methods especially as it relates to the mapping of small fish cover elements. This protocol follows the same criteria of Goodman et al. (2015) where small habitat areas of less than 2m x 2m are not candidates for mapping. It is uncertain if our current Trimble equipment configuration and post-processing methods have high repeatability for habitat features that approximate 2m x 2m in size. It is recommended that repeatability is tested for this size of habitat feature by repeat mapping of several small cover features on successive days to compare polygon area estimates.

Snorkel Survey Protocol: Abundance Index

Schedule:

Step 1: Snorkel surveys of each and every control and impact site must be conducted every two weeks. Preferably, all sites will be done on the same day of the week every time, but other conditions including weather, crew availability, and scheduling conflicts may impede this from being the case.

Step 2: Surveys, will be done at the same time of day each time to avoid bias associated with fish movements based on time of day. Thus far, surveys have been conducted at roughly from around 9am to 3pm. This timing may change as new side channels are added to the overall monitoring project. Additionally, it may take more than one day to complete all sites, but as long as all impact sites and their coinciding control sites are done on the same day, bias is sufficiently limited.

Step 3: The order in which control and impact sites are visited on a given day will be randomized to the extent possible. At a minimum the order in which side channels are sampled will be altered on consecutive visits (i.e. alternating sampling from downstream to upstream and upstream to downstream).

Field Collection Methods

Step 1: Measure the visibility underwater using a secchi disk. To do this one member of submerges his or her face into the water and extends the pole upstream along the plane of their eyelevel until the disc can no longer be seen. The distance from the disc to the swimmers eye is recorded.

Step 2: Calibrate each swimmers' eyes to account for the 1.5X magnification of water. To do this have each swimmer submerge their face and mask underwater. Another crew member will hold a calibration tool equipped with model fish of known lengths in front of the swimmer for a short period of time. Repeat this process if swimmer feels it necessary.

Step 3: Snorkel the side channel going downstream. The swimmers will align themselves perpendicular to flow in a straight line prior to the start of the snorkel survey. A start time should be recorded before the swimmers submerge themselves to begin the survey. For most sites, two snorkelers is sufficient, one for each edge, but some larger sites do require a third person to survey the middle of the channel as well. The swimmers should stay together as much as possible to avoid double counting. Juvenile salmonids will be identified, classified by size, and counted as they are passed by the snorkeler. Any other fish species present are noted and counted as well, to provide a value of species richness. Take down an end time when all swimmers have snorkeled the length of the survey site.

Step 4: At the end of the site, surveyors' totals will downloaded onto a data sheet. Chinook Salmon are then classified by run based on their size in coordination with a fork length by date chart.

Step 5: Record observations of salmonid redds as per redd protocol.

Step 6: Repeat this process for each of the side channel sites that are scheduled for the day.

Snorkel Survey Protocol: Microhabitat Use

References:

Holmes, R. W., et al. (2014). Seasonal microhabitat selectivity of juvenile steelhead in a central California coastal river. California Fish and Game, 100(4): 590-615.

Goodman, D. H., et al. (2015). A mapping technique to evaluate age-0 salmon habitat response from restoration. Restoration Ecology, 23(2): 179-185.

Schedule:

Snorkel surveys to establish microhabitat use will be conducted in each control and impact site monthly.

Field Collection Methods:

Step 1: Based upon habitat inventory data, annually identify which habitat units within each side channel will be selected for the collection of habitat use data. Habitats should be randomly selected but stratified to include the full range of available habitat types to capture the range in depths and velocities present, at approximately equal surface areas each. Surveys should not focus on solely surveying suitable habitat as identified by juvenile habitat mapping efforts as it is important to establish the difference between fish use of preferred vs. available habitat. Habitat selection should also attempt to capture the full range of microhabitat cover types identified from microhabitat mapping efforts.

Step 2: Perform snorkel survey to achieve an abundance index, except that when a selected habitat unit is encountered, the location of fish observed will be marked with a weighted flag on the stream bottom. Record the species / run, and size of juvenile(s) and numbers observed at that location.

Step 3: After the selected habitat unit has been completely surveyed, revisit flagged locations and collect the following habitat data specific to each of those sample points.

- Habitat type
- Depth (total water column)
- Distance to bank
- Distance to cover (cutoff distance of 10', Holmes et al. 2014)
- Cover type (USFWS 2005; Table A-3)
  - o When multiple cover types are present, record the cover type possessing the greatest concealment opportunity (Holmes et al. 2014).
- Velocity (mean water column)
- Substrate (CDFW 2010; Table A-1)
- Species / run
- Size of juvenile(s)
- Numbers of fish observed

Fish Capture: Seining

References:

Hahn P.K.J., et al. (2008). Beach Seining. In Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations. Pages 267-324.

Perry, R.W., et al. (2016). Estimating juvenile Chinook salmon (Oncorhynchus tshawytscha) abundance from beach seine data collected in the Sacramento–San Joaquin Delta and San Francisco Bay, California: U.S. Geological Survey Open-File Report 2016–1099, 21 p., http://dx.doi.org/10.3133/ofr20161099.

Background:

Seining efforts were initially proposed to meet the objectives of estimating the average size and condition, and stomach content of salmonids within side channels and the main stem river. As high turbidity values can limit the utility of relying solely on dive counts to provide year round estimates of relative abundance, seining efforts will also explore the possibility of estimating relative abundance by catch per unit effort (CPUE) methods. To meet these multiple objectives, seining at fixed sites with beach seines will be included where habitat conditions permit, and wandering pole seine methods will be standardized as much as possible so that CPUE estimates can be generated.

Schedule:

Seining targeting juvenile salmonids will be performed monthly to establish species / run based average size, condition, and gut contents of fish, within control and impact side channel sites and the main stem Sacramento River. To explore the potential correlation between dive count indices and seining CPUE, seining efforts and a dive count should be performed on successive days if feasible.

Field Collection Methods:

Step 1: Identify randomized sample locations within side channels and the main stem in the vicinity of side channels. Randomized sample locations within side channels for wandering pole seining should be stratified by habitat type so that the range of available habitat type and quality can be sampled. Identify one to two fixed sampling sites for the application of beach seining methods, taking into consideration the need for a large area to accommodate the breadth of the seine that is free from obstructions, has finer substrate, and the ability to sample at higher flows. If more than two sites are compatible for beach seining, randomly select sites out of those available. Main stem sites should be selected far enough away from side channels so that juvenile fish are not likely to be using both habitats. Seining methods may not perform well with the presence of woody debris and other channel obstructions. Water depth can also be a limitation for nets and crews. Anticipate that random sampling locations may need to be bumped upstream or downstream to avoid an obstacle or skipped for cause (safety). Identify alternative randomly selected sites prior to field work.

Step 2: If available, rely on snorkel survey results to determine if juvenile salmonids are present in the side channel to be sampled.

Step 3: Utilize wandering pole seine and/or simple arc set beach seine methods (Hahn et. al. 2008) to capture juvenile salmonids. Utilize beach seining methods at fixed sites (see Perry et al. 2016). For all seining methods record the number of seine sets, and for each set, the time spent actively seining, the surface area seined, and the average water depth of the area seined. Objectives for juvenile fish capture are 100 fish for each run/stock present, taken throughout the available habitat types within the side channel.

Step 4: Use provided fish handling procedures (informed by collecting permit requirements) to anesthetize and take the following vital statistics from fish: fish fork lengths, weights, lipid reserves, and gut content samples (targeted # per side channel). For gut content sampling, use the stomach flushing methods of Meehan and Miller (1978). This water filled blunt syringe method proved effective on Coho salmon mean FL 65mm (52-92mm), 99% of prey items evacuated, high post handling survival. Insure the time of day for gut content sampling coincides with the time of day when drift sampling is performed.

Enclosure Study

References:

Jeffres, C. A., et al. (2008). Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes, 83(4): 449-458.

Background:

Enclosure studies will be used as a supplement to seining studies to provided more controlled data on fish growth in different habitats. While less “natural” than the seine data, these studies will ensure sampled fish have been using the sampled habitat for an appreciable amount of time

Schedule:

Step 1: This study can be conducted over a time period that is amenable to a master’s thesis at CSU Chico. Sampling will occur for a minimum of 30 days per year over a two year period. If logistically feasible, the study may extend up to 60 days. Jeffres et al. (2008) found this time scale to be sufficient to detect growth differences in floodplain habitat. Study timing is anticipated to be in late spring depending on flows and safety.

Field Collection Methods:

Step 1: Select study location. Ideally, there will be a minimum of two side channel control sites, two side channel restored sites and two main stem sites. Locations should be representative of control and restored habitat. Care should be taken to select sites without a large human presence to prevent vandalism. Check water quality to ensure metrics (oxygen, temperature, ?) are tolerable for juvenile salmon.

Step 2: Construct enclosures. Previous studies have used 0.6 x 0.6 x 1.2 meter PVC frames with 6.3mm extruded plastic netting, which was large enough to allow food sources (zooplankton, benthic, macroinvertebrates, larval fish, etc) in while preventing movement of the study fish.

Step 3: Obtain juvenile fish from Coleman National Fish Hatchery. Fish should be of similar age and size.

Step 4: Deploy six enclosures at each site. Previous studies have anchored enclosures with a rope and cinder block, this method may need to be modified depending on site characteristics. Fish number in each enclosure will be a function of availability, but previous studies have used a minimum of 10 fish per enclosure. Fish for each enclosure will be randomly selected from the pool of available fish. At deployment, individually mark fish, take condition metrics (Fulton’s Condition Factor (or relative condition factor), fork length (mm), lipid content where fish size permits) and scaled photographs of fish anethisized with MS-222.

Step 5: Deploy temperature loggers. If stream temperatures vary throughout a site where enclosures are placed, temperature loggers may need to be deployed in each enclosure to accurately control for the effect of temperature on growth.

Step 5: Check enclosures daily to ensure they are intact.

Step 6: Re-measure condition metrics and take additional photographs of anesthetized fish once per week over the course of the study.

Step 7: At the end of the study, select a sub-sample of fish to be used in diet analysis, following the stomach flushing methods of Meehan and Miller (1978). This water filled blunt syringe method proved effective on Coho salmon mean FL 65mm (52-92mm), 99% of prey items evacuated, high post handling survival.

Invertebrates: Drift Sampling

References:

CHaMP (Columbia Habitat Monitoring Program). (2015). Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program. Prepared by the Columbia Habitat Monitoring Program.

Survey Schedule:

Step 1: Drift sampling of invertebrates will be performed monthly to establish food availability within control and impact side channel sites and the main stem Sacramento River. Timing (day and time of day) should be close to the timing of fish gut sampling from fish capture seining efforts.

Field Collection Methods:

Note: These methods have been adapted from CHaMP (2015).

Step 1: Identify the drift cross section location.

i. Preferred location is in the center of the side channel longitudinal length, near the permanently benchmarked cross section. It is also preferable that drift nets be deployed near the downstream end of a riffle habitat, and placement can be moved off the cross section to achieve a more ideal location.
ii. Preferred locations have depths between 15-30cm (10cm min. and 40cm max.), and velocities between 0.3 and 0.6 m/s.

Step 2: Deploy drift nets

i. Deploy two 500µm mesh drift nets (net dimensions of 20 cm wide x 40 cm in height), perpendicular to flow, along the same transect in areas that best meet depth and velocity criteria identified above.
ii. Drift nets will be anchored with rebar and suspended off the stream bed by 2 cm using spacers. Drift nets must extend above the water's surface to capture surface drift.
iii. Timing of drift net deployment should coincide as close as possible to the time of day of fish gut sampling.
iv. Drift nets should be deployed for about 3 hours.

Step 3: Measure and record data including temperature, pH, conductivity, turbidity, discharge, drift net flow velocity, water depth at net (sample area), and the duration of net deployment.

Step 5: Collect drift sample and transfer to jars, adding 95% ethanol in a 1:1 ratio to sample size. Do not combine separate drift net samples.

Step 6: Complete chain of custody documentation and transport samples to the Aquatic Bioassessment Lab (CSU Campus, Chico) weekly.

Redd Surveys

Site Selection:

Step 1: Using Google Earth and previous aerial redds data select control sites similar in size, proximity, and substrate to the proposed spawning gravel injection sites. Total area should be comparable to that of proposed project footprints or completed project areas. This survey is a true BACI, meaning there are multiple control sites that will be compared to the one impact site at Market Street Bridge using data from before and after construction was completed.

Step 2: Map an area of each spawning gravel area using a Trimble GPS device.

Step 3: Flag the top and bottom of each survey area using gps points collected from the Trimble.

Step 4: Determine which spawning sites will pair together well. As of now 2 control sites have been selected to go with the one completed impact site. Assign each site a site ID number.

Step 5: Add comparable control sites to the project as new gravel injection sites are proposed and or completed.

Schedule:

Step 1: Redd counts of all control and injection sites should be completed every 2 weeks or monthly if deemed more appropriate, throughout the entire year, conditions permitting. Conduct surveys of each and every spawning gravel site on the same day if possible.

Step 2: Sites should be surveyed during peak light hours (between 9am and 4pm). Optimum lighting conditions will be needed because cameras will be used to conduct redd counts.

Step 3: Survey sites starting from the farthest upstream and proceed downstream to subsequent spawning gravel sites. This is to accommodate for the use of catarafts when necessary.

Field Collection Methods:

Step 1: Decide which vessel should be used to survey. River flows, weather, lighting conditions, and water depths flowing over gravel sites will determine which survey method will be used. If flows are low, water is shallow, and weather is fair, then a catraft will be used to complete the survey. If flows are high and, water deep, or weather is poor, then a jet boat will be necessary.

Step 2: Conduct a water clarity estimate using a sechi disc at the beginning of the day. Be sure that this is done in an area deep enough to collect an accurate account of the visibility.

Step 3: Count redds going downstream or upstream. The direction does not matter as long as the entire area of each survey site is surveyed accurately. Erect the camera mast with the attached

GoPro hero 3 equipped with a polarized lens and begin recording at the top or bottom of the survey site. One crew member will drive the boat while the other counts redds from the bow of the vessel. Differentiate and tally counts separately for trout and salmon.

Step 4: Make additional parallel passes over the survey site if necessary. Be sure not to take the same line over the area twice to avoid double counting redds.

Step 5: Record the presence of live trout and/or salmon

Step 6: When the entire survey area has been surveyed stop recording, and have the spotter download their results on a datasheet.

Step 7: Break down the mast and repeat steps 2-5 for each subsequent survey site.

The raft will be equipped with a mast that will have a GoPro Hero 3 camera equipped with a polarized filter attached. Redds will be counted by a surveyor standing on the bow of the raft, while the camera records as well. Additional passes over the spawning area will be made if necessary. Once the total spawning area has been observed, the spotter will record a total count of redds on a datasheet. The video data will be reviewed and a consensus redd count will be made back at the office for each site. If flows are high and deep this same procedure will be done using a jet boat equipped with the same video equipment.

Stream Temperature

<u>Schedule:</u>

Stream temperature will be continuously monitored at all control and impact side channels and main stem control sites using data loggers.

<u>Field Collection Methods:</u>

Step 1: Calibrate data logger using standard techniques as specified by manufacturer.

Step 2: Select an appropriate location at the top and bottom of side channel for data logger deployment. Anticipate potential changes in stream flow to insure the data loggers will not be dewatered in the selected location. Identifying appropriate sites near a permanent side channel cross section may be desirable to help to quickly relocate data logger. If a data logger is to be deployed at a main stem river control site, a single data logger can be deployed.

Step 4: Set data loggers to record temperature hourly.

Step 3: Securely anchor the data logger, and GPS the data logger location.

Step 4: Download logger data at a recurrence of 1-2 months. Data downloading can likely be coordinated with other data collection activities.

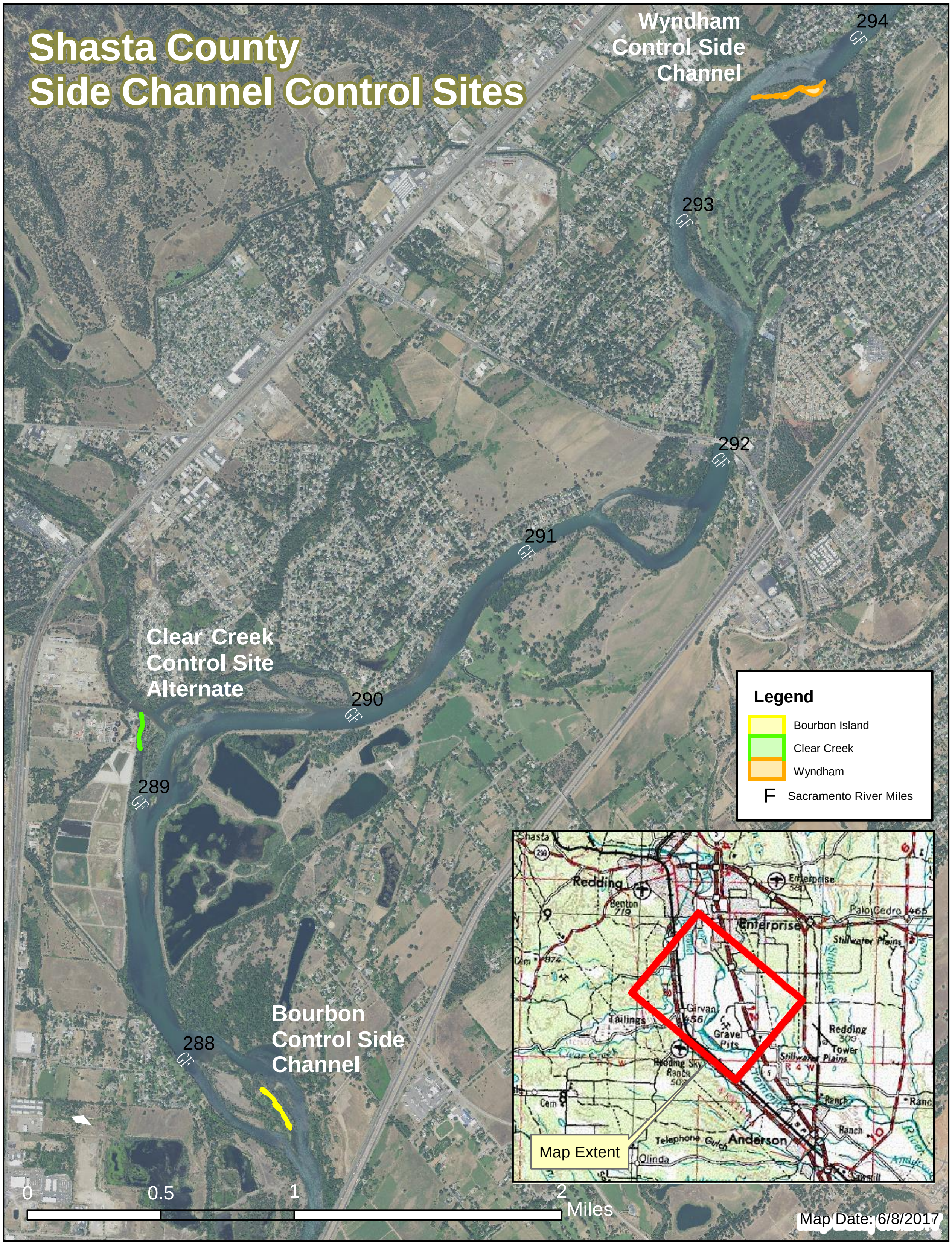
Step 5: Review data to verify quality of the data and to check for errors in a timely manner to insure that data logger is functioning correctly.

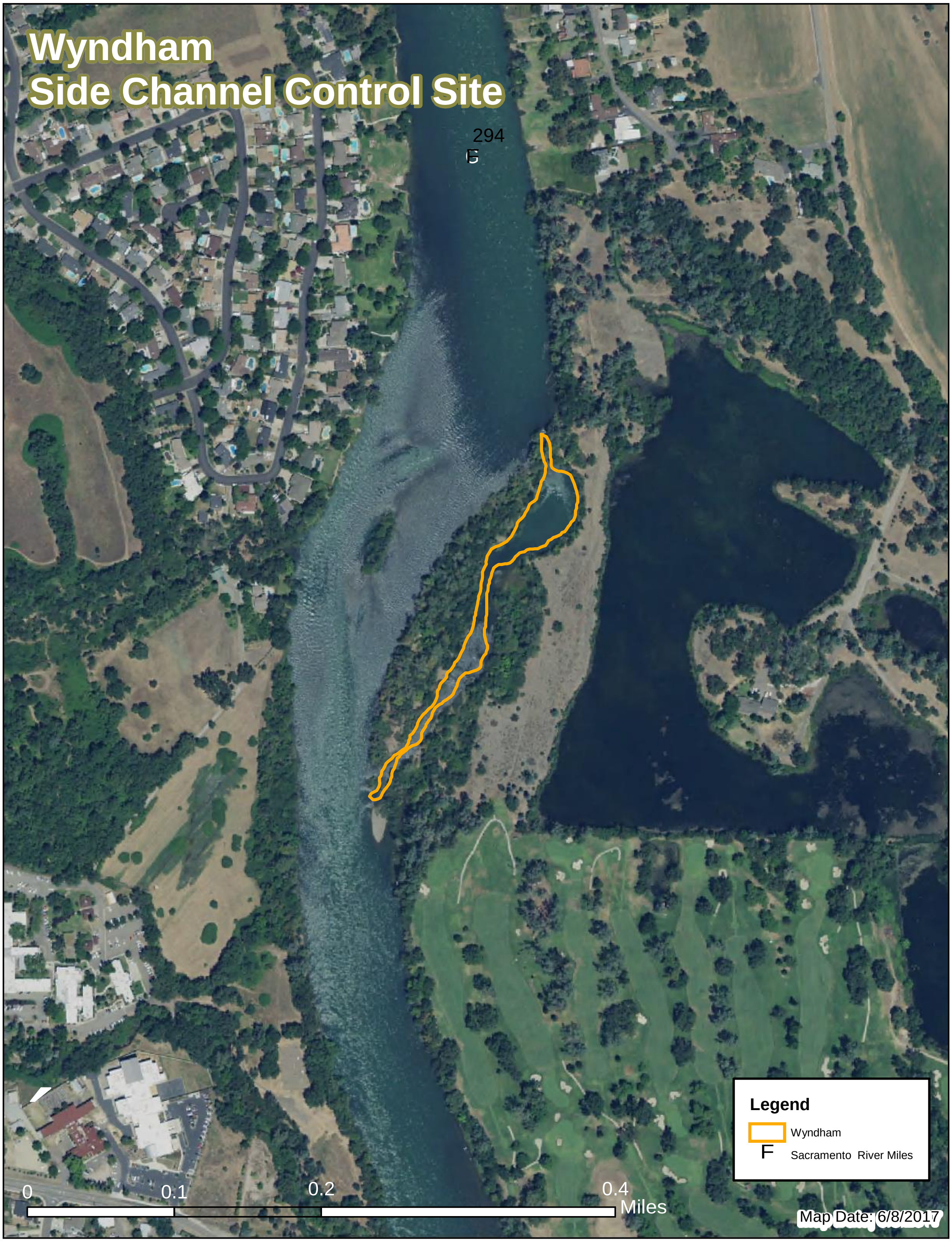
Upper Sacramento River Anadromous Fish Habitat Restoration Project

Monitoring Protocol Modification Log

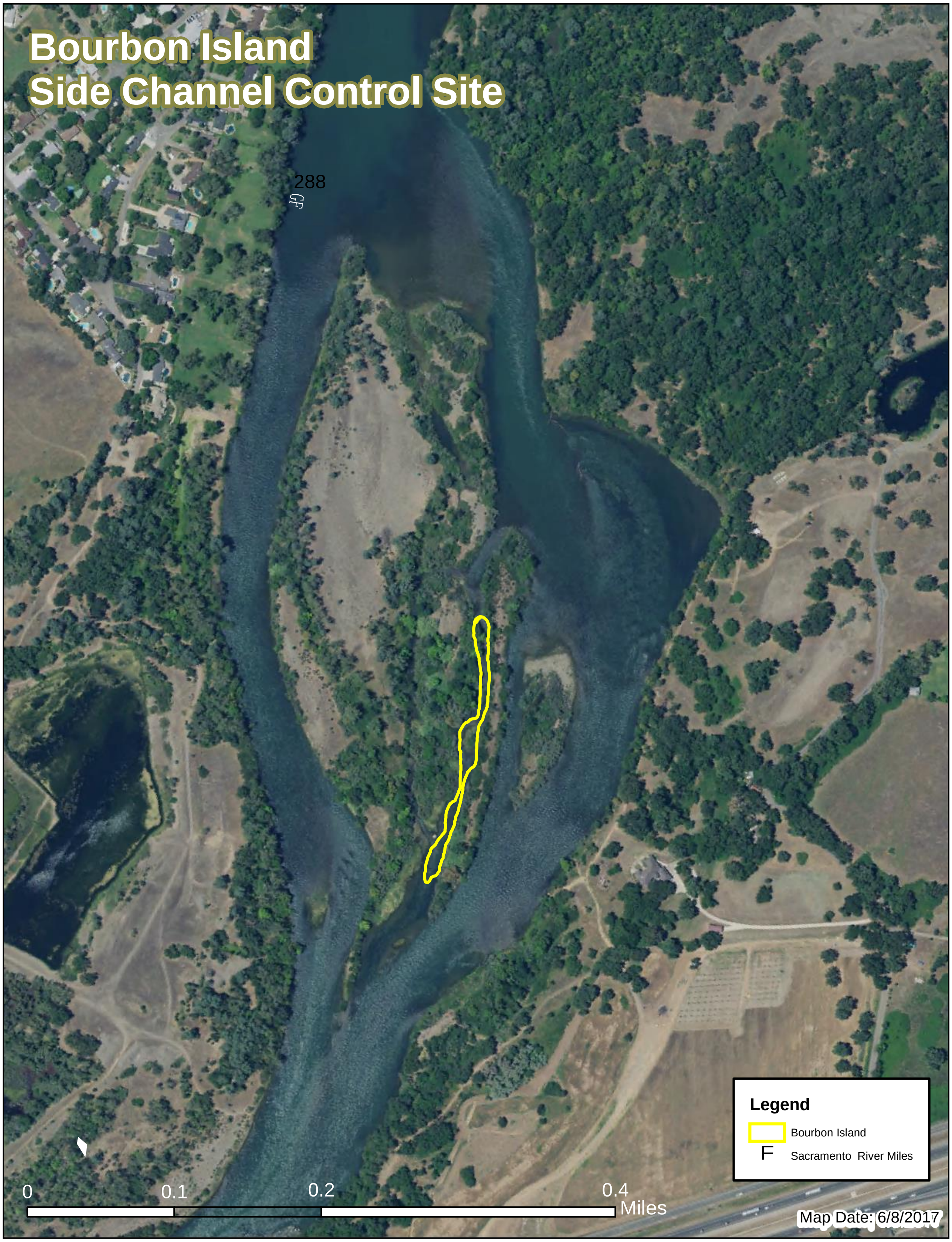
Date Implemented	Field Protocol	Description of Modification

Appendix B. Side Channel Control Sites




Wyndham
Side Channel Control Site
294
Legend
Wyndham
Sacramento River Miles
0
0.1
0.2
0.4
Miles
Map Date: 6/8/2017


Clear Creek
Side Channel Control Site
289
Legend
Clear Creek
Sacramento River Miles
0
0.1
0.2
0.4
Miles
Map Date: 6/8/2017


Bourbon Island
Side Channel Control Site
288
Legend
Bourbon Island
Sacramento River Miles
0
0.1
0.2
0.4
Miles
Map Date: 6/8/2017