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HALLWOOD SIDE CHANNEL AND FLOODPLAIN RESTORATION PROJECT

PRE-PROJECT MONITORING REPORT

Prepared for:

U.S. Fish and Wildlife Service – Anadromous Fish Restoration Program

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EXECUTIVE SUMMARY

The goal of the Hallwood Side Channel and Floodplain Restoration Project (Project) is to improve degraded and damaged Lower Yuba River ecosystem function through enhancement of side channel and adjacent floodplain habitat below Daguerre Point Dam. These actions prioritize increased quantity and quality of juvenile Chinook Salmon (*Oncorhynchus tschawytscha*) and steelhead (*O. mykiss*) rearing habitat. A secondary Project goal is to document restoration effectiveness through scientifically robust monitoring.

Our monitoring approach consists of four conceptual monitoring types: 1) pre-project site description, 2) implementation, 3) effectiveness, and 4) validation monitoring. This approach facilitates the Before-After-Control-Impact (BACI) study design structure that our team is implementing to test differences between non-restored and restored sites. This document summarizes pre-project monitoring activities, including site description and measurement of the pre-project environmental baseline. Description of Project site baseline is meant to clearly identify deficiencies in ecosystem health that drove Project development, and provide information required by state and federal permits. Pre-project monitoring is essential for effectiveness and validation monitoring because it establishes an objective ecosystem baseline with which to evaluate change caused by Project implementation. Pre-project physical and biological data presented in this report will be used to test a range of hypotheses related to ecosystem function after the Project is complete. Ultimately, this monitoring program will improve our understanding of the potential to restore salmonid populations through off-channel rearing habitat rehabilitation within streams impacted by flow regulation and historical hydraulic mining.

Summary of Pre-Project Conditions

Between 2014-2016 when pre-project monitoring was conducted, releases from Englebright Dam to the Lower Yuba River ranged from 282 to 31,000 cubic feet per second (cfs). Temperatures within the Project site were generally favorable for rearing Chinook Salmon and steelhead (<21°C) from October to late May. However, mean daily temperatures greater than 21°C were common during summer months, in some cases exceeding 30°C. In contrast, average daily main channel summer temperatures remained at or below 18°C. Dissolved oxygen was generally favorable for rearing juvenile salmonids in the main channel (range: 8.9 – 11.5 mg/l) and slightly lower but still high enough to support survival in the Project site (range: 5.4 – 10.8 mg/l). Turbidity ranged from 0.4 – 5.5 NTU in the main channel and 0.3 – 4.9 NTU in the Project site, both within ranges considered hospitable for juvenile salmonids.

No special-status plants were observed in the Project site during surveys; however, a total of 277 blue elderberry (*Sambucus nigra* ssp. *caerulea*) bushes [host plants for the endangered valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)] were documented. This number was reduced to 251 elderberries due to mortality following the high flow events of 2017. This information was used to develop mitigation measures in coordination with the U.S. Fish and Wildlife Service. Elderberries located within or near the Project footprint will be

avoided or transplanted, and mitigation planting will occur for any mortality that occurs as a result of Project implementation.

Benthic and drift macroinvertebrate samples were collected in spring 2014 and 2016 to evaluate aquatic food web conditions including the quantity and quality of potential juvenile salmonid prey items. Overall, 20 distinct taxonomic groups were observed. Diptera had the highest mean density (n/m^2) in all years at all sample sites. The density of Ephemeroptera, Plecoptera, Trichoptera (EPT), three insect orders commonly used as indicators of water quality, was relatively low in benthic invertebrate samples compared to the density of all other taxa in the control and Project site in both years. In 2014, the main channel and Project site had distinctly different benthic invertebrate communities, whereas in 2016 the two sites had similar communities. Drift invertebrate density was significantly higher in the main channel than in the Project site in 2016. The relatively low Project site drift densities suggest potential for prey limitation, since juvenile salmonids feed primarily from the drift.

Snorkel surveys were conducted in the main channel and Project site in 2014 and 2016 to determine relative densities of juvenile salmonids and other native and non-native fishes that may support, compete or prey upon juvenile salmonids and determine ecosystem health. Juvenile Chinook Salmon were observed at one or both control sites on all survey dates except August 2014 but were only observed in the Project site in May 2016. Across all sites, juvenile Chinook Salmon densities ranged from 0.00 to 0.68 fish per m^2. Juvenile *O. mykiss* were observed at one or both control sites on all survey dates except in April 2016, and were observed at the upstream end of the Project site in May 2014 and 2016. Across all sites, juvenile *O. mykiss* densities ranged from 0.00 to 2.25 fish per m^2. Overall, few salmonids were observed in the Project site, whereas salmonids were seasonally present in relatively high numbers in the main channel.

Other native species observed at the Project site included Sacramento Sucker (*Catostomus occidentalis*), Sacramento Pikeminnow (*Ptychocheilus grandis*), California Roach (*Hesperoleucus symmetricus*), Tule Perch (*Hysterocarpus traskii*), and sculpin (*Cottus* sp.). Non-native fish species at the Project site included Western Mosquitofish (*Gambusia affinis*), Largemouth Bass (*Micropterus salmoides*), and sunfish (*Lepomis* spp.). Striped Bass (*Morone saxatilis*) and American Shad (*Alosa sapidissima*) were also observed in the main channel. In the main channel, an average of 91% (±28% SD) of fish observed in each transect were native; in the Project site, an average of 69% (±47% SD) of fish were native. Although the percentage of native fish was generally higher in the main channel, variability was quite high across sites and transects. Several black bass, potential salmonid predators, were observed in the Project site and one Striped Bass was observed in the main channel.

Salmonid redd surveys were performed in the main channel adjacent to the Project site on foot in 26 November 2014 and by drone in 2 December 2016 to document use of the Project site by spawning salmonids. In 2014, a total of 140 redds were observed in the main channel adjacent to the Project, and 27 redds were observed in 2016. In addition, five redds were anecdotally observed in 20 November 2015 during a site visit in the downstream end of the Project site.

In spring 2016, we conducted an outmigration and predation experiment to characterize residence time, growth, diet, and predation rates of juvenile salmonids rearing at the Project site and to collect fish community data. We released ~2,000 Passive Integrated Transponder (PIT)-tagged juvenile hatchery salmon into the Project site and in another unrestored backwater habitat (Kino) located approximately a mile downstream from the Project that served as a control site. From 29 April to 21 May 2016, a fyke trap was operated at each site and a total of 3,822 fish were captured. Ten native taxa were observed; the most abundant native species were California Roach, Chinook Salmon, Sacramento Pikeminnow, Sacramento Sucker, and Tule Perch. Nine non-native species were observed; the most abundant non-native species were sunfish, including Bluegill (*Lepomis macrochirus*) and Warmouth (*Lepomis gulosus*).

At the Project site, 647 Chinook Salmon were recaptured in the fyke trap out of the 1,000 released PIT-tagged salmon. The maximum residence time of an individual PIT-tagged salmon in the Project site was 16 days. There was a peak for tagged hatchery salmon outmigration on 9 May. Wild juvenile Chinook Salmon outmigration peaks at the Project site occurred on 9 May and 14 May. Tagged juvenile hatchery Chinook Salmon grew an average of 0.31 mm per day (maximum 0.65 mm per day) based on otolith analysis. Thirty-seven stomachs were examined from Chinook Salmon captured at the Project fyke trap; fourteen were empty and the remaining stomachs contained insects, crustaceans, arachnids, and oligochaetes. Most prey items observed were small dipteran larvae.

At the control site, all juvenile salmon captures occurred over the first three days, with 376 recaptures of the 985 released fish (Figure 15). No wild juvenile Chinook Salmon were captured at the control site; higher water temperatures, lower DO, and relatively high predator densities at this site are all likely to have contributed to poor rearing conditions and subsequent low survival. We captured over 260% more warm-water piscivorous fishes at the control site compared to the Project site during seining surveys. Non-native predator stomach contents were dominated by small insects and crustaceans, and contents overlapped with prey items observed in juvenile Chinook Salmon stomachs. However, one Largemouth Bass stomach contained 8 PIT-tagged salmonids, and a predation event on PIT-tagged fish was directly observed at the control site immediately following release (visual observations of predator attacks on released salmon).

Overall, pre-restoration Project site rearing conditions were marginal. Water quality was within favorable ranges from October to through May, but declined in the summer months relative to the main channel Yuba River. The average growth rate of fish rearing at the Project site fell within the range observed in some other studies in other Central Valley rivers. Although predation events were relatively rare in our study, our observations suggest that a few large predators utilizing the deep pool at the downstream end of the site may consume high numbers of juvenile Chinook Salmon. Diet analysis of both juvenile Chinook Salmon and their predators in the Project site, coupled with observations of low invertebrate prey abundance collected in drift samples, suggest prey limitation and the potential for strong competitive interactions in the Project site.

INTRODUCTION

Gold was discovered on the Yuba River, California in 1848. The subsequent influx of thousands of miners forever changed the physical attributes of the Yuba River and numerous species that rely on the river ecosystem. Hundreds of millions of cubic yards of gravel and debris from hydraulic mining were washed into the river and its tributaries between 1849 and 1909 (Gilbert 1917). The resulting sedimentation and siltation of the Sacramento River channel and farmlands led to the construction of debris dams to block mining sediment from flowing down the river (Beak Consultants Inc. 1989). These dams also blocked anadromous fish migration upstream, eliminating up to 60% of Chinook Salmon and 80% of steelhead historical spawning habitat on the Yuba River (Beak Consultants Inc. 1989, Lindley et al. 2006).

In addition to hydraulic gold mining, subsequent anthropogenic factors included dredge mining, training wall construction, and flow regulation. These continue to reduce the quality and quantity of salmonid rearing habitat in the lower Yuba River (LYR) (NMFS 2014). Rearing habitat loss is a key factor in the precipitous decline of Pacific salmon (Nehlsen et al. 1991), and with additional impacts associated with river regulation, invasive predators, and climate change, already depressed salmonid populations have experienced a marked decline in the past several years (Mantua et al. 1997, Yoshiyama et al. 2001, Lindley et al. 2006, Katz et al. 2013). Habitat complexity and juvenile rearing habitat in the LYR is currently very limited (NMFS 2014), and enhancing off-channel rearing habitat is a key step in increasing salmonid populations in the LYR and the entire Sacramento River system (CDWR and PG and E 2010, cbec et al. 2010, cbec 2013). This Project aims to address the USFWS Anadromous Fish Restoration Program (AFRP) overall goal of improving salmonid populations in California by improving rearing habitat conditions in the Yuba River, which has been heavily impacted over the last century and a half.

Existing Conditions

The Project site is composed of gravel and cobble training walls that were constructed in the late 1800's and early 1900's to control the river flow during gold mining. The lower Yuba River at the Proposed Project site includes an existing overflow channel, remnant floodplain, and training walls on the North and South side of the river as well as a training wall in the middle that separates the main channel from the overflow channel. The main channel historically connected to the overflow channel at flows between 10,000 to 15,000 cfs at the upstream end. In 2017, the upstream connection evolved due to a high flow event, such that it currently connects at baseflow, and conveys ~50% of the flow at the upstream end of the Project site. The channel is also perennially connected at the downstream end as a backwater. The backwater has established aquatic vegetation and deep aquatic features, and non-native piscivorous fish have been observed in high abundance. An estimated 165 acres of potential floodplain habitats is available for rehabilitation.

Restoration Goals and Objectives

The Project goal is to enhance degraded side channel habitat to improve connectivity with the main channel and to restore remnant floodplain habitat so it is inundated with greater frequency and duration, enhancing juvenile rearing habitat quality and ecosystem function, to meet AFRP goals.

To effectively augment, rehabilitate and enhance productive juvenile salmonid rearing habitat, the Project objectives are to:

1. Incorporate the Project into an ecologically-sound, ecosystem context by designing the Project to function under current water management constraints (i.e., timing, frequency, magnitude and duration of elevated flows);
2. Reestablish main channel and off-channel connectivity and complexity to restore Project site ecological processes to increase the availability and maintenance of off-channel rearing habitats;
3. Create habitat conditions suitable for spring juvenile salmonid rearing (i.e., fry and sub-yearling smolts);
4. As possible, create habitat conditions suitable for summer holding of juvenile spring-run Chinook Salmon and steelhead;
5. Reduce the abundance of invasive predators and aquatic vegetation by modifying deep pool features at the downstream end of the site;
6. Create conditions suitable for natural riparian vegetation recruitment and survival (i.e., willows, cottonwood, alders, etc.);
7. Preserve existing habitat features (i.e., main channel spawning and incubation habitat).

To address whether these objectives will be met, our monitoring program will take an 'Ecosystem Perspective' as described by the Adaptive Management Forum (AMF 2002) by tracking physical and biological parameters, and the structural and functional responses of the restored ecosystem. By measuring the Project effects on ecosystem function using multiple ecologically-relevant physical and biological metrics, the monitoring program will determine how well the Project met its objectives. Monitoring results will also inform the design of future off-channel habitat restoration projects on the Yuba River and in other rivers where juvenile rearing habitat is a limiting factor.

Restoration Description

After the Project is implemented, off-channel habitats will be inundated more frequently during rearing periods. The Project will also most likely modify deep (>3 m deep) backwater pool sections in the downstream end of the site, reducing the abundance of non-native predatory fish and providing additional rearing habitat for juvenile salmonids. The Project will also implement a revegetation plan, including enhancing natural recruitment and actively planting and monitoring survival of riparian trees. The shallow off-channel habitats will provide refuge from predatory fishes and increased structural complexity in the form of riparian vegetation and increase water temperatures and primary productivity relative to the main channel. While salmonid spawning habitat and habitat for other native species are not primary goals of the Project, design criteria will specifically include measures to ensure that at a minimum, these habitats are not negatively impacted by the Project.

Monitoring Design

A Before-After-Control-Impact (BACI) study design structure will be used to test the differences between the non-restored and restored sites (Green 1979, O'Donnell and Galat 2008). This approach is ideal for restoration effectiveness monitoring because it utilizes a paired series of Control-Impact sites (in this case, "impact" is the restoration treatment), subjected to a series of Before-After replicated measurements, allowing for discrimination between response to restoration and stochastic environmental variability (Bernstein and Zalinski 1983, Stewart-Oaten et al. 1986, Smith 2002).

We will evaluate Project success by utilizing an efficient and scientifically-robust monitoring program to document pre-project site condition and implementation, determine effectiveness, and validate assumptions regarding benefits for salmonids. This includes:

1. *Pre-project site description*, including baseline surveys covering major regulatory environmental concerns, to develop project objectives and form the basis against which design suitability is assessed;
2. *Implementation monitoring* to verify and document that the project was installed according to design standards and meets permitting requirements for sensitive and listed species;
3. *Effectiveness monitoring* to document changes in ecosystem function and habitat conditions with a Before-After-Control-Impact (BACI) study design that includes pre-project monitoring to establish a baseline; and
4. *Validation monitoring* (i.e., experiments) to test hypotheses about the benefit of recovered river landscapes to rearing salmonids.

For monitoring to be successful, specific project goals need to be determined, monitoring questions need to be defined, baseline conditions must be documented, and data must be collected at appropriate times, scales, and locations relevant to the associated evaluation criteria (Kondolf and Micheli 1995). Sampling locations and extent, frequency, and duration will vary among the different types of monitoring (Table 1).

Table 1. Monitoring types for the Hallwood Side Channel and Floodplain Restoration Project.

Monitoring type	Question addressed	Time frame
Pre-project	What is the site baseline condition? Does the site contain special-status species?	1-3 years before project implementation
Implementation	Was the project installed as planned?	2+ years
Effectiveness	Was the project effective at meeting restoration objectives?	1 year to decades
Validation	Are the basic assumptions behind the project conceptual model valid?	1-10 years

In this document, we report *pre-project baseline* biological conditions. Pre-project monitoring establishes a baseline from which to measure change following a restoration action. It is a critical component of the other three types of monitoring because questions posed by effectiveness and validation monitoring can only be answered if the pre-project condition of the site is documented. Pre-project monitoring is also a component of regulatory compliance because pre-project wildlife and habitat surveys help resource agencies determine whether the Project is likely to negatively impact special status plants and animals and what mitigation measures need to be implemented to prevent these impacts.

During pre-project monitoring, we established sites both within the Project boundary (Project sites) and outside of the boundary (control sites) to measure Project impacts while accounting for background environmental variation. Pre-project permitting survey results specifically related to addressing special-status species impacts are reported in biological assessments associated with this Project (CFS and cbec 2016a, 2016b) so are not included in this report. Physical monitoring components such as topographic, bathymetric, and substrate surveys have been incorporated into the basis of design report (cbec 2017) and other permitting documents and are not included in this report. Topographic and bathymetric data will be used to address implementation monitoring to determine whether the site was conducted according to design plans. Here, we report results from the physical and biological surveys used to establish baseline condition for effectiveness and validation monitoring, using methods described below.

Sampling sites were located upstream, within, and downstream of restored reaches. Figure 1 depicts the general Project area, with example locations of sampling sites. Table 2 summarizes the monitoring questions, parameters and methods. These questions directly address the target objectives for the Project. Using the hypothesis testing approach, we will monitor the Project's effectiveness and provide detailed information to inform ongoing restoration for salmonids throughout the Central Valley. Below, we describe in greater detail the specific methods used to measure each parameter that will be used to address the effectiveness and validation monitoring questions following implementation.

Monitoring Timeline

We collected a minimum of two years of pre-project biological monitoring data at both control and treatment sites in order to establish a Project baseline. Fish and vegetation surveys and macroinvertebrate benthic and drift sample collection occurred multiple times during the spring and into early summer (Figure 2) and at several treatment locations within the proposed restoration site and two control locations (Figure 1). Pre-restoration growth and predation studies were conducted in April-May 2016 (Figure 2).

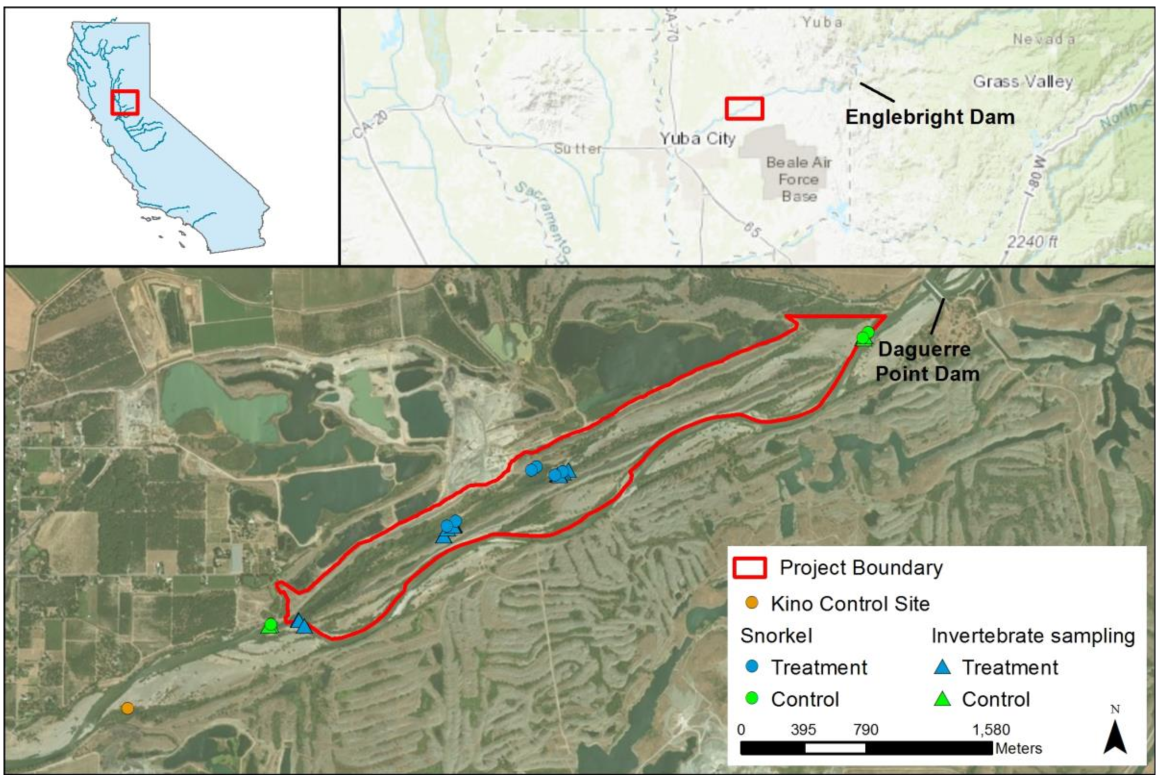

Figure 1. Location of Hallwood Side Channel and Floodplain Restoration Project site. Monitoring will be performed within Project boundary, and upstream and downstream (control sites) of boundary within the Yuba River.

Table 2. Monitoring questions and parameters and methodology used to address them.

QUESTION	PARAMETER / METHOD
Effectiveness monitoring	
Is the side channel and floodplain habitat inundated for a sufficient duration for juvenile salmonids to utilize it under normal spring flow conditions?	Water level loggers, snorkel surveys, seining
Will the restored sites support greater drift and benthic macroinvertebrate (BMI) assemblages relative to unrestored sites?	Macroinvertebrates (density, biomass, community composition)
Are physical habitat conditions (depth, flow, temperature, dissolved oxygen, substrate, physical structure) suitable for juvenile salmonids following restoration?	Depth, velocity (model and field measurements) Temperature, dissolved oxygen Physical structure mapping (woody material, aquatic and riparian vegetation) Photo points
Is suitable summer holding habitat available for spring-run Chinook and steelhead under normal flow conditions?	Temperature loggers, dissolved oxygen measurements, snorkel surveys
Will restoration negatively affect invasive plant and fish species abundance?	Project area vegetation mapping Field-collected vegetation data Fish community surveys (snorkel surveys)
Will native woody riparian plant species naturally recolonize the floodplain following restoration?	Project area vegetation mapping Field-collected vegetation data
Validation monitoring	
Will juveniles that rear in restored off-channel habitats exhibit greater growth rates than those that rear in non-restored habitats?	Juvenile rearing experiment (growth)
Will juvenile salmonid diet composition and fullness differ before and after restoration, and as compared with an unrestored control site?	Juvenile rearing experiment (stomach contents)
Will the abundance of invasive predatory fish decrease following restoration?	Snorkel surveys, fyke trap, seining
Will predation by invasive predatory fish decrease following restoration?	Gastric lavage
Will the abundance and diversity of potential competitor invasive fish species decrease following restoration?	Snorkel surveys, fyke trap, seining, gastric lavage

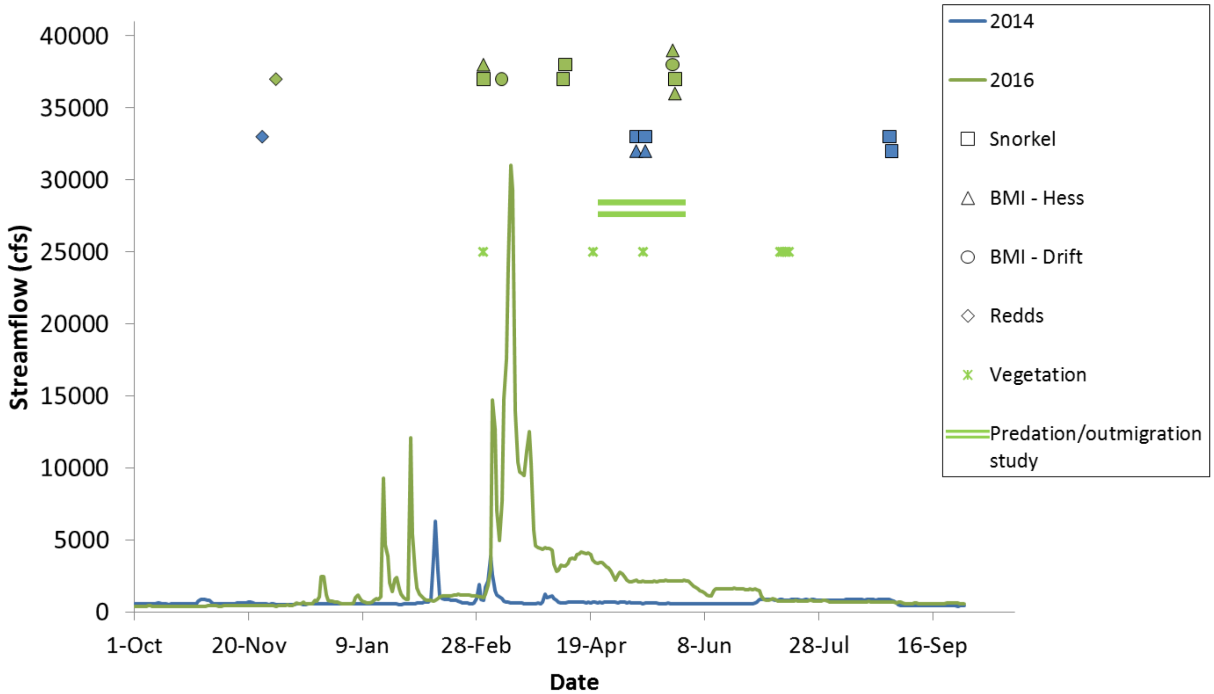

Figure 2. The mean daily flow (cfs) in the lower Yuba River at Marysville (USGS gage #114240000) for 2014 and 2016, with the dates that biological monitoring (snorkel, BMI – Hess, BMI – Drift, and redd surveys) was performed. Blue symbols are 2014 and green symbols are 2016.

METHODS AND RESULTS

Water Quality

Water quality and temperature monitoring was used to track water quality conditions and groundwater/river interactions. This monitoring will determine whether water quality conditions that support juvenile Chinook Salmon are present prior to implementation, and whether conditions improve following restoration. Surface water quality (e.g., dissolved oxygen, temperature, turbidity) monitoring will also be a component of regulatory monitoring during Project construction.

Continuously recording water temperature data loggers (Hobo Water Temp Pro and TidBit™; Onset Computer, Inc.) were installed throughout the main channel and side channels within the site (Figure 3). The water temperature data loggers recorded at either half hour or one-hour time steps. In 2016, two loggers were installed at all locations to minimize the potential for data loss due to logger loss or failure. Loggers were downloaded on a quarterly basis. The daily mean, minimum, and maximum water temperature were calculated for each location using Program R (R Core Development Team 2016).

During seasonal field trips, dissolved oxygen (DO) and temperature data were collected from each sampling location using an YSI Handheld DO meter (YSI; Model 550A) and turbidity was measured in Nephelometric Turbidity Units (NTU) using a turbidity meter (LaMott Company;

Model 2020). Temperatures measured with grab samples ranged from 10.2 – 17.9°C in the main channel and 11.3 – 24°C in the Project site. DO ranged from 8.93 – 11.49 mg/l in the main channel and 5.4 – 10.77 mg/l in the Project site. Turbidity ranged from 0.44 – 5.53 NTU in the main channel and 0.32 – 4.91 NTU in the Project site (Table 3).

The water temperature varied among locations and across years within the Project boundary. In general, the Yuba River main channel temperatures were cooler during the summer than temperatures in the backwater and pools within the Project site (Figure 4). Water temperature across all locations was generally cooler during 2016 than during 2015. The highest observed maximum temperatures occurred in Pool 4 during the summer of 2015. The upstream end of the backwater (Backwater 3 US) had the least variability in daily water temperature, likely due to the influence of sub-surface groundwater seepage (Figure 4). During the summer, Project site pools and backwaters generally reached temperatures considered stressful for juvenile salmonid rearing (>21°C), while the Yuba River main channel generally maintained favorable rearing temperatures (Myrick and Cech 2004).

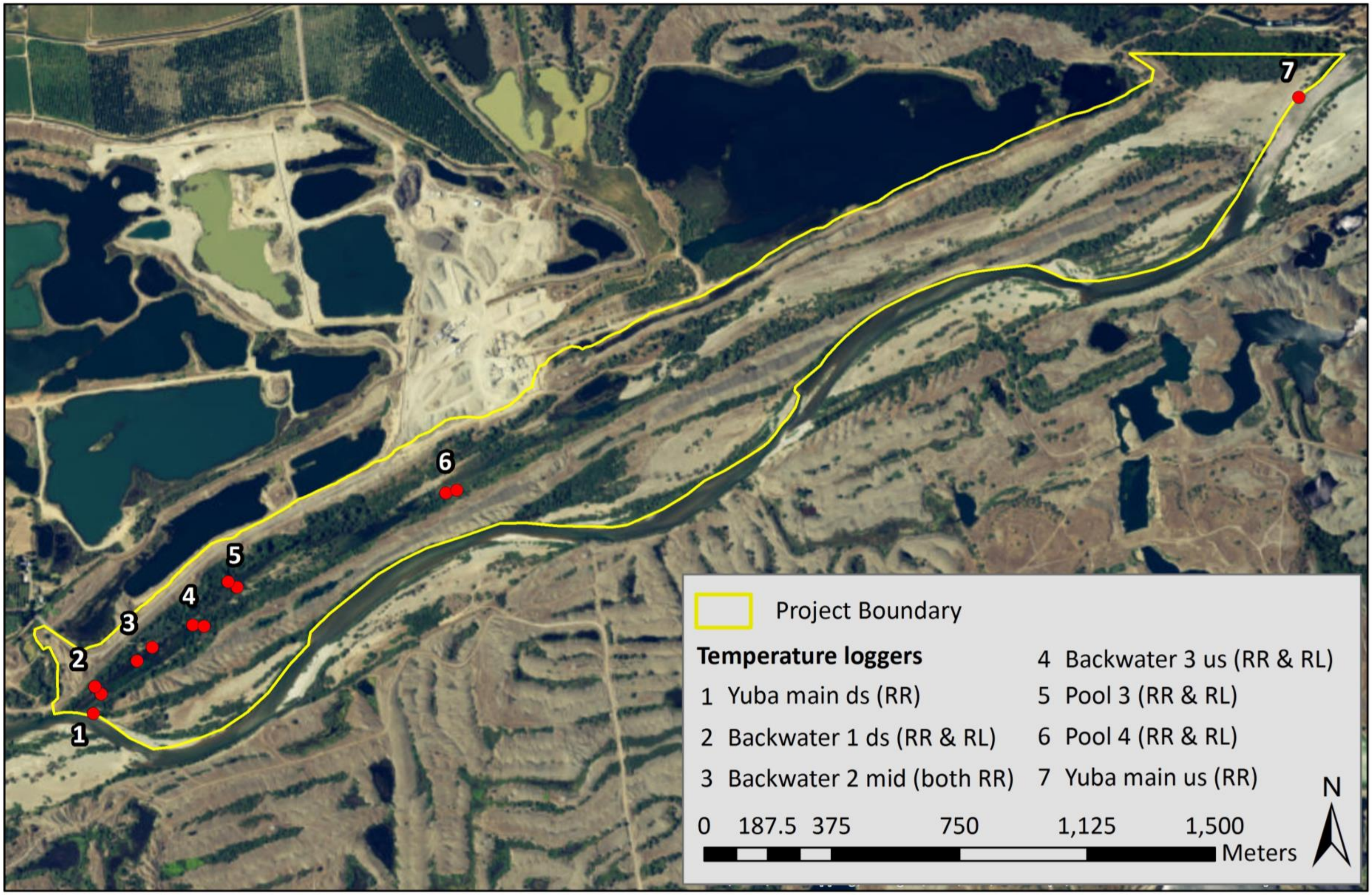

Figure 3. 2016 Hallwood water temperature data logger locations.

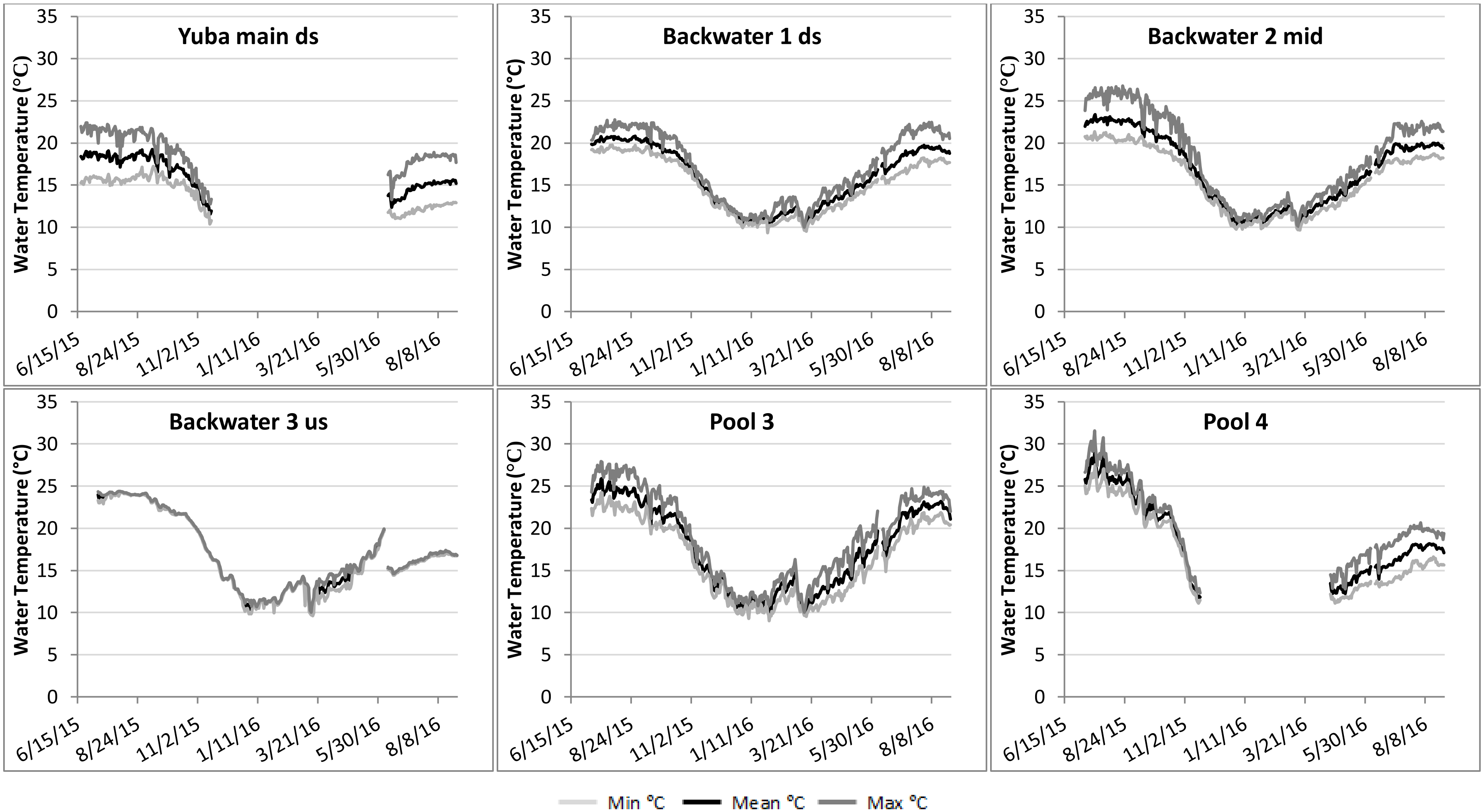

Figure 4. The mean, maximum, and minimum water temperature (°C) in the Yuba River at 6 temperature logger monitoring locations from 15 June 2015 to 31 August 2016. Temperatures were recorded in the Yuba main channel downstream of the Hallwood Project boundary, Backwater 1, 2 and 3, and pools 3 and 4, all within the Hallwood Project boundary.

Table 3. Summary of water quality (water temperature, dissolved oxygen, and turbidity) grab samples collected during pre-project monitoring. SC = side channel, MC = main channel, DS = downstream, US = upstream, N/C = not collected.

Date	Site	Time	Water Temp (°C)	DO (mg/L)	Turbidity (NTU)
5/9/2014	SC DS	11:03	17.2	8.69	N/C
5/9/2014	SC US	13:42	15.4	7.9	N/C
5/13/2014	MC DS	13:38	17.2	10.45	N/C
5/13/2014	MC US	10:22	13.8	10.7	1.7
8/28/2014	SC DS	12:08	19.2	8.24	N/C
8/28/2014	SC Mid	08:30	24	10.77	N/C
8/28/2014	SC US	09:00	15.8	8.03	N/C
8/29/2014	MC DS	12:31	15.7	9.95	N/C
8/29/2014	MC US	08:32	13.7	9.63	N/C
10/1/2014	SC DS	7:09	17.3	5.4	0.41
10/1/2014	SC DS	11:04	18.6	6.96	0.46
10/1/2014	SC DS	18:31	19.2	8.71	0.59
10/1/2014	SC DS	21:41	18.3	6.63	0.32
10/1/2014	MC DS	7:11	14.1	9.39	0.68
10/1/2014	MC DS	11:06	15.8	10.4	0.7
10/1/2014	MC DS	19:00	17.3	9.14	0.44
10/1/2014	MC DS	22:21	16.2	8.93	0.5
3/3/2016	MC DS	15:40	12.7	10.51	3.61
3/3/2016	MC US	10:00	10.2	11.49	2.45
3/11/2016	SC DS	07:25	11.3	8.02	4.91
3/11/2016	MC DS	07:08	10.8	9.15	5.53
4/7/2016	SC Mid	9:56	12.2	8.48	N/C
4/7/2016	SC US	7:45	11.4	8.01	0.95
4/8/2016	MC DS	15:15	14.0	9.36	2.75
4/8/2016	MC US	10:00	11.3	11.13	3.49
5/26/2016	MC DS	17:19	17.9	10.86	N/C
5/26/2016	MC US	09:25	12.8	10.79	N/C

Photo Points and Vegetation Mapping

A total of 15 photo point locations were established on 9 June 2016 within the Hallwood Project boundary (Figure 5; Appendix A). Additional photo points will be taken immediately prior to Project implementation. These will provide a qualitative measure of habitat structural changes and are required for regulatory compliance. All photographs were taken at the same height and in the four cardinal directions (i.e., North, South, East and West) at each sampling site, and the photo point location was recorded using a handheld GPS (Trimble Geo XT 6000 series). Qualitative changes in environmental conditions as a result of restoration activities will be made by comparing the photo series over time.

Vegetation and large woody material will be mapped following restoration and tracked over time to document changes in habitat for terrestrial organisms as well as in-channel structures that provide seasonal rearing habitat for juvenile salmonids or their predators. To investigate use of aquatic vegetation species by native and non-native fish species and compare invasive aquatic vegetation extent before and after Project implementation, we will perform spectral analysis on existing aerial photographs from several years prior to implementation and following implementation, following the methods described in Hestir et al. (2008). The resulting spatial data will be overlaid with bathymetry and fish survey data to investigate relationships between water depth, aquatic vegetation, and native and non-native fish distribution. This analysis will be conducted following Project implementation.

Vegetation Monitoring

Pre-project vegetation surveys were conducted by botanist Mehrey Vaghti on 11-13July 2016, and a report summarizing this data is included in Appendix B. Special-status plant surveys were also conducted as part of federal and state permitting compliance on 3 March, 20 April, and 12 May 2016 (Vaghti 2016). No special-status plants were observed during the survey.

Pre-project elderberry surveys were performed by CFS in August and September 2016. The pedestrian surveys covered the entire restoration area over a period of two days. The location of individual or groups of elderberry plants with ground-level stem diameter of 1 inch or greater within the restoration area were recorded using a handheld GPS unit (Trimble GeoXT Geoexplorer 6,000 series). A total of 277 elderberry plants with ground level stem diameter of 1 inch or greater were observed. While elderberry plants were distributed throughout the restoration area, the majority were along the toe of the north side of the Middle Training Wall. Following the high flows in spring 2017 and subsequent design updates, a total of 251 elderberry plants remained, 153 of which were within 20 feet of the grading footprint. More detailed descriptions of elderberry surveys, including distribution maps are available in the Hallwood Biological Assessment (CFS and cbec 2016a) and the USFWS Biological Opinion (USFWS 2017).

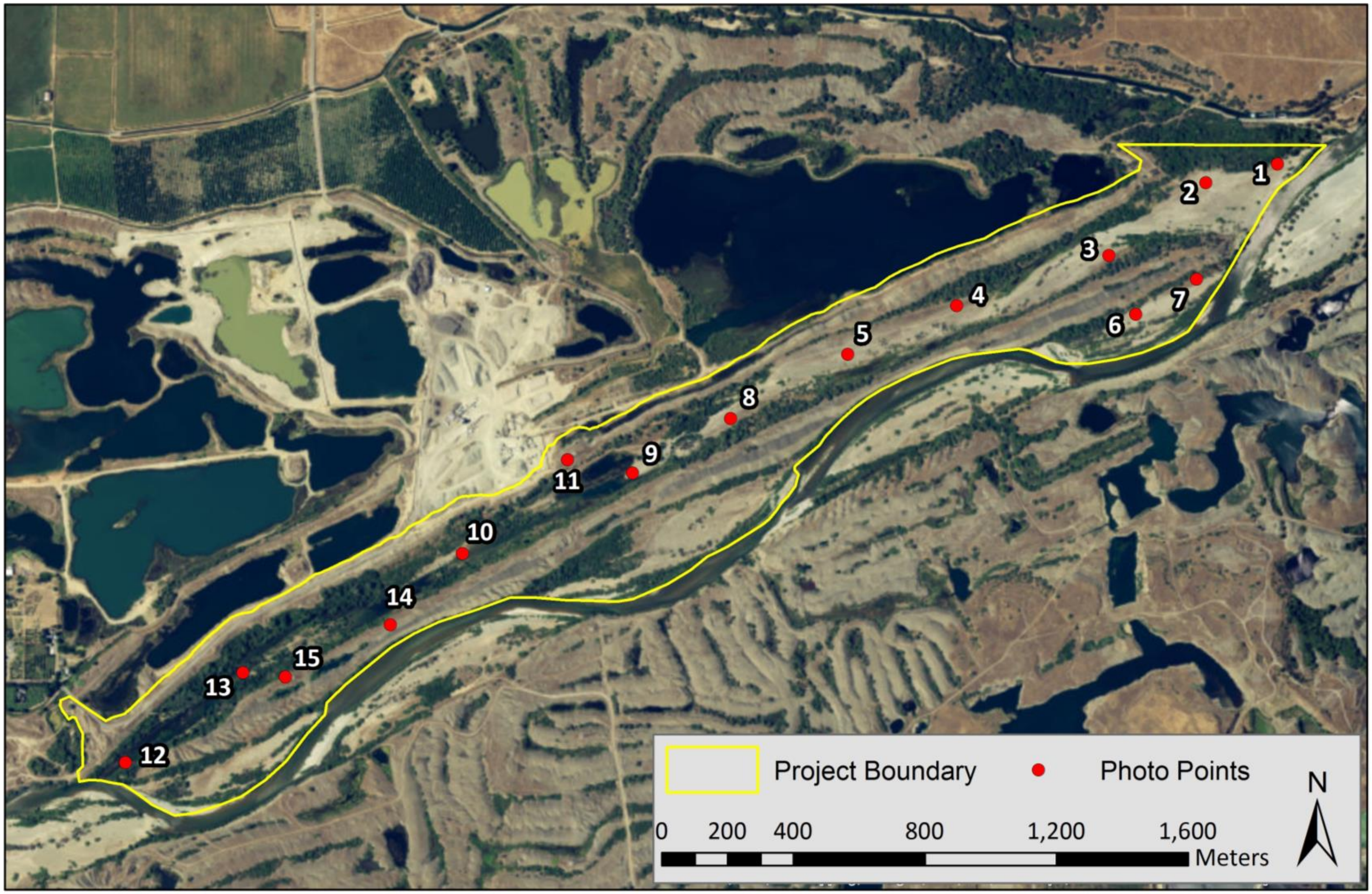

Figure 5. Pre-project photo point locations within the Hallwood Project boundary.

Fish Community Surveys

Snorkel surveys were conducted to monitor the abundance and composition of fish assemblages in both Project and main channel control sites. By monitoring fish communities throughout the rearing and holding period, we will be able to determine how restoration affects spatial and temporal distribution and density of native and non-native fish, with a focus on juvenile salmonids. Pre-project surveys were conducted in the spring and summer, coinciding with rearing for fall-run Chinook Salmon and holding for spring-run Chinook Salmon and CCV steelhead, respectively. All surveys were led by a biologist or senior technician with training and experience conducting snorkel surveys. Snorkel surveys were conducted to assess juvenile use of the restored Project site and unrestored, main channel control sites. Snorkeling methods were consistent with other studies (Edmundson et al. 1968, Hankin and Reeves 1988, Jackson 1992, McCain 1992, Dolloff et al. 1996, Cavallo et al. 2003). Fish were observed, identified and counted by size group as snorkelers proceeded in transects moving upstream. Counts were converted to densities (fish/m^2) using the transect length and a standard width of 2m per snorkeler to calculate total area sampled. Fish were categorized by species and size class (0 – 50 mm, 51 – 80 mm, 81 – 100 mm, 101 – 120 mm, 121 – 150 mm, 151 – 200 mm, 201 – 300 mm, and >301 mm). During snorkel surveys, two depth and velocity transects were recorded to characterize background conditions within each sample unit.

Snorkel surveys were performed in 2014 and 2016. In 2014, snorkel surveys were performed in May and August and in 2016 they were performed in March, April, and May (Table 4). Three locations within the Project site (upstream, middle, and downstream) and upstream and downstream main channel control locations were surveyed during each month (Figure 1). We were only able to survey the upstream and downstream main channel control locations in March 2016 due to high flows, which created unsafe sampling conditions in the main channel (Figure 2). The mean daily flow was lower when snorkel surveys were performed in 2014 compared to 2016 (Table 4).

Table 4. Snorkel survey dates, locations, mean daily flow in the Yuba River at Marysville (USGS Gage #114240000), and mean daily water temperature.

Date	Sites surveyed	Mean daily flow (cfs)	Mean daily water temperature (°C)
5/9/2014	upstream, middle, downstream Project	623	11.2
5/13/2014	upstream and downstream main channel	639	11.1
8/28/2014	upstream, middle, downstream Project	862	12.2
8/29/2014	upstream and downstream main channel	780	12.2
3/3/2016	upstream and downstream main channel	1230	9.2
4/7/2016	upstream, middle, downstream Project	3170	10.2
4/8/2016	upstream and downstream main channel	3360	10.3
5/26/2016	upstream, middle, downstream Project; upstream and downstream main channel	2110	11.3

Juvenile Chinook Salmon were observed at one or both of the control sites on all survey dates except in August 2014 (Table 5, Figure 6). Juvenile Chinook Salmon were only observed in the backwater complex in May 2016 (Table 5). Juvenile Chinook Salmon densities ranged from 0.00 to 0.68 fish per m^2, with the highest density observed at the upstream control site in March 2016 (Figure 6). Adult Chinook Salmon were observed at the upstream and downstream control sites in August 2014.

Juvenile *O. mykiss* were observed at one or both main channel sites on all survey dates except for in April 2016 (Table 5, Figure 6). Juvenile *O. mykiss* were observed at the upstream side channel site in May of 2014 and 2016 (Table 5). Juvenile *O. mykiss* density ranged from 0.00 to 2.25 fish per m^2, with the highest density observed at the upstream control site in May 2014. Overall, few salmonids were observed in the Project site, whereas salmonids were seasonally present in relatively high numbers in the main channel (Figure 6).

The fish species observed in the Yuba River main channel were primarily native while species observed in the Project site were a mixture of native and exotic species (Table 5). In the main channel, an average of 91% (±28% SD) of fish observed in each transect were native; in the Project site, an average of 69% (±47% SD) of fish were native. Sunfish were observed in the Project site but not the main channel, while Striped Bass and American Shad were observed in the main channel but not the Project site. Native fish species were observed in both the Project site and the main channel and included Chinook Salmon, *O. mykiss*, Sacramento Sucker, Sacramento Pikeminnow, California Roach, Tule Perch, and Sculpin (Table 5). Sacramento Pikeminnow and Sacramento Sucker were observed in relatively high abundance on several in both the main channel and project site (Table 5). Tule Perch was also observed in high abundance in May 2016 (Table 5). Other native species were relatively rare in both the main channel and the project site.

Table 5. Fish species and total number of fish observed during snorkel surveys at Hallwood and main channel control sites.

		Native								Non-native				
Date	Site	Chinook salmon (juvenile)	Chinook salmon (adult)	*O. mykiss*	Sacramento Sucker	Sacramento Pikeminnow	California Roach	Tule Perch	Sculpin	Western Mosquitofish	Striped Bass	Black Bass	Sunfish	American Shad
9-13 May 2014	US SC			8	1				1					
	Mid SC					15						9	56	
	DS SC					400								
	US MC	12		214										
	DS MC			10	28				1					400
28-29 Aug 2014	US SC									10				
	Mid SC											19	5	
	DS SC					5470				70			9	
	US MC		1	3										
	DS MC		3	23	169	525		20			8	4		
3 Mar 2016	US MC	564		15	3					1				
	DS MC	165												
7-8 Apr 2016	US SC													
	Mid SC				1		2			11				
	DS SC											1		
	US MC				1									
	DS MC	94												
26 May 2016	US SC			5			1416		1			1		
	Mid SC						12							
	DS SC	2			86	147	6	31				11	11	
	US MC	1		5			1							
	DS MC	61			17	20								45

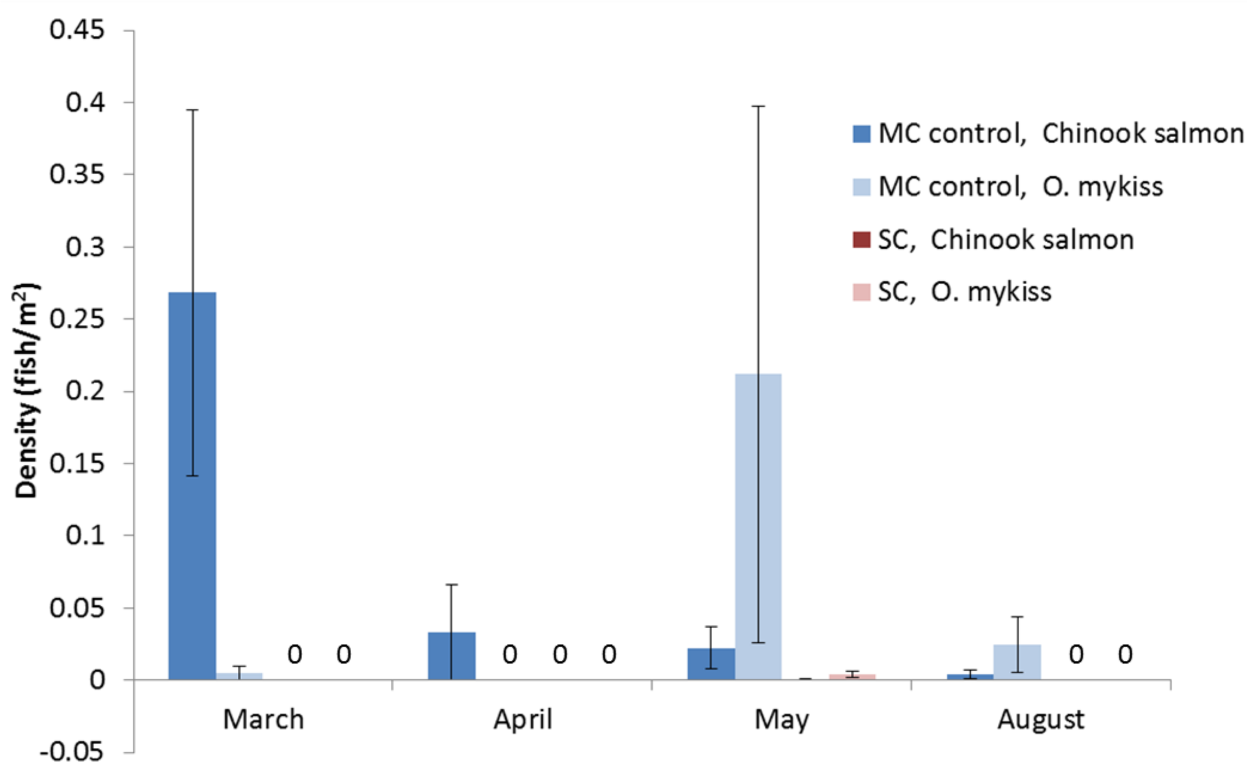

Figure 6. Chinook Salmon and *O. mykiss* observed in the Hallwood side channel (SC) and main channel control (MC Control) sites during 2014 and 2016 snorkel surveys.

Redd Surveys

Salmon redd surveys were conducted on 26 November 2014 along transects within the main channel and in areas of the remnant side channel with actively flowing water and connectivity with the main channel (Figure 7). Survey transects were conducted on foot and using aerial drone (Phantom 2 Vision +; DJI, inc.) to capture aerial images. For surveys conducted on foot, at each redd location the spatial coordinates were marked using a handheld GPS device (Trimble GeoXT 2012 6000 Series) and surveyors recorded the physical condition of redds, redd morphology, and the presence or absence of salmon. Redds currently occupied by fish and those with clean gravel were identified as new, whereas redds with algae covered substrate were considered old redds and their location recorded but morphological measurements were not taken. All spatial data associated with redd surveys were downloaded and subjected to quality control measures within one to seven days after collection. The survey progressed upstream from the downstream end of the site, the exit of the backwater, and covered six spawning tail outs/riffles (Figure 7). A total of 140 redds were observed, two of which were test redds.

On 20 November 2015, Chinook Salmon redds were opportunistically observed in the downstream end of the Project site while downloading temperature loggers. There were five redds, one of which was a test redd, observed near where the backwater flows into the Yuba River main channel (Figure 7). A female Chinook Salmon was observed in association with one of the redds.

Drone aerial images were also recorded on 20 November 2016 in four locations within the main channel adjacent to the Project site and at an unrestored main channel control site located upstream, near Hammon Bar, to document redd distribution prior to implementation (Figure 7). The locations within the Project area were chosen based on accessibility and the potential to support Chinook Salmon spawning. The riffles surveyed were within the main channel of the Yuba River at the upstream end, downstream end (including the downstream exit of the backwater), and two in the middle of the Project area (Figure 7). The control site spawning riffle, upstream of the Project site at the Hammon Grove river access, was a publicly accessible site where salmon spawning activity had been observed previously.

At each drone survey site, the drone was launched from the gravel bar and allowed to ascend to an appropriate height and then video recording was started. The drone was then flown over the potential spawning riffle with an attempt made to obtain footage which covered the entire potential spawning area. After covering the entire potential spawning area the video recording was stopped and then the drone was landed. The video footage was downloaded from the drone to a computer for analysis. The number of redds visible in the video footage at each potential spawning area were enumerated for each site. Redds were only counted if an obvious pot and tail spill were visible.

A total of 27 redds were observed within the main channel Project sites, and 17 redds were observed in the Hammon Bar control site (Table 6).

Table 6. The number of redds observed by site during the 2 December 2016 Hallwood drone redd survey.

Site	Number of Redds
Hallwood main channel (upstream)	13
Hallwood main channel (mid-upstream)	9
Hallwood main channel (mid-downstream)	0
Hallwood main channel (downstream)	5
Hammon Bar (control site)	17

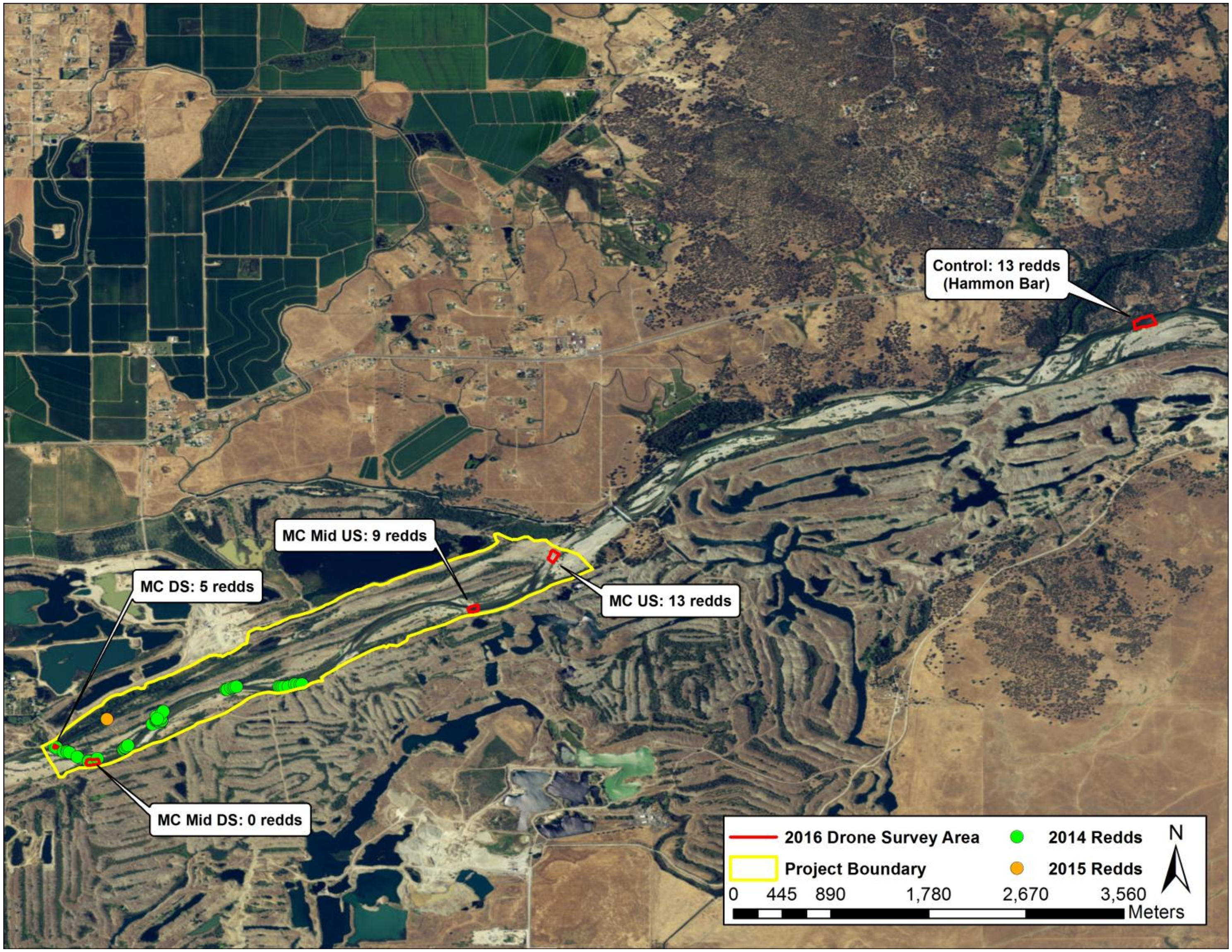

Figure 7. Redd map from 2015-2016 surveys.

Macroinvertebrates

A critical component of monitoring habitat function is gathering information on the macroinvertebrate community. Invertebrates are also important indicators of ecosystem health (Kearns and Karr 1994). In particular, the EPT Index uses three orders of aquatic insects (Ephemeroptera, Plecoptera, and Trichoptera) that are easily identified and is commonly used as an indicator of water quality (Lenat 1988). Macroinvertebrates are sensitive to environmental change and have been used by many studies to assess restoration success (e.g., Gray et al. 2002, Merz et al. 2004). Juvenile Chinook Salmon and steelhead primarily feed on a variety of terrestrial and aquatic invertebrates that enter the water column as drift, therefore monitoring drift invertebrate abundance provides a key metric of rearing habitat quality and juvenile salmon growth potential (Merz and Vanicek 1996, Merz 2002a, Merz 2002b, Sogard et al. 2012).

We collected benthic invertebrate samples using D-frame kick-net and Hess samplers to directly assess location-specific invertebrate prey standing crop, and used drift nets to assess prey density available to juvenile salmonids, which primarily feed from the water column (Gregory and Northcote 1993, Brewitt et al. *2*017). In 2014 and 2016, four replicate benthic macroinvertebrate samples were collected at four sampling sites, in the Main Channel (MC) upstream and downstream from the Project site, and in the upstream and downstream ends of the Side Channel (SC).

In 2014, samples were collected with a D-frame kick-net sampler with an attached polyvinyl chloride (PVC) frame with an internal area of 0.093 m^2 at its base, which was capable of sampling in water depths of up to 1m. The kick net was placed perpendicular to the benthic surface with the open-end facing upstream and the PVC frame in contact with the substrate. All substrate contained within the PVC frame to a depth of 5 cm was placed into the kick net, and the kick net was lifted vertically out of the water. The substrate sample was then placed into a white enamel pan, and invertebrates were carefully removed from the substrate by rinsing with a spray bottle and picking with forceps.

In 2016, samples were collected with a 330 mm i.d. X 400 mm high, stainless steel 368 µm nitex Hess Stream Sampler (bottom area opening = 0.086 m^2) with an attached 368 µm dolphin bucket. Although it is not capable of sampling in areas deeper than 40 cm, the Hess sampler design isolates the sample area, hinders contamination from drift and provides consistency in area/volume sampled and invertebrate size. Benthic invertebrate samples were taken to a substrate depth of approximately 15 cm below the benthic surface.

In both 2014 and 2016, macroinvertebrates suspended in the drift were collected using a drift sampler with 106 µm mesh. Drift nets were placed in areas where flow was greater than 0.2 m/s. In 2014, drift samples were collected from the Project site only; in 2016 samples were collected from both the Project site and the main channel. Invertebrate density (# individuals/m^3) was calculated by dividing the total number of invertebrates by the volume sampled, calculated according to the following formula:

volume (m^3) = sample time (s) * inundated net opening area (m^2) * velocity (m/s).

For both benthic and drift collection, all invertebrate samples were rinsed into 500 mL labeled bottles with 70-95% ethanol and transported to the laboratory and sorted under a light dissecting scope (e.g., 60X). Taxa were identified to species as possible; size classes and life stage were recorded. Individual organisms were grouped by type, further categorized by individual size classes (<2, 2 – 7 mm, 8 – 13 mm, 14 – 20 mm, and > 20 mm) and life stages (larva/nymph, pupa and adult), and enumerated for each type-size-life stage combination.

In addition to salmonid prey abundance, we assessed abundance of EPT taxa, which include invertebrates from the orders Ephemeroptera, Trichoptera, and Plecoptera. This group is frequently used as indicators of aquatic habitat quality due to their intolerance to poor water quality (Resh and Jackson 1993).

Benthic Macroinvertebrates

We collected a total of 21,556 individuals during benthic invertebrate sampling. Invertebrate density in benthic samples ranged from 1,570 to 66,512 invertebrates per m^2. The number of orders observed in benthic samples ranged from 11 (main channel 2016) to 13 (side channel 2014 and 2016; Table 7). Diptera had the highest mean density (n/m^2) in all years at all sample sites with the highest density observed in the side channel site in 2016 (3522 [8612 SD]; Table 7).

The density of Ephemeroptera, Plecoptera, Trichoptera (EPT) was relatively low compared to the density of all other taxa in the control and Project site in 2014 (Figure 8) and 2016 (Figure 8). In 2014, the density of EPT and all other taxa were not significantly different between the Project and control sites (p = 0.92; Figure 8). In addition, there was no significant difference in the relationship between density of EPT and all other taxa between the Project and control sites (interaction between site and taxa group, p = 0.94). The same results were obtained in 2016; the density of EPT and all other taxa were not significantly different between the Project and control sites (p = 0.99, Figure 9). Likewise, there was no significant difference in the relationship between density of EPT and all other taxa between the Project and control sites (interaction between site and taxa group, p = 0.97).

Table 7. Mean density [n · m^{-2} (SD)] of benthic macroinvertebrates sampled in 2014 and 2016 within the side channel (SC) and main channel control (MC). Note the sampling methodology changed from Kick Net in 2014 to Hess sampling in 2016. Orders listed include all unique taxa observed in both benthic and drift invertebrate samples.

Order	2014		2016	
	Project	Main channel control	Project	Main channel control
Amphipoda	544 (574)	212 (224)	1299 (1571)	57 (40)
Arachnid	72 (87)	782 (875)	235 (297)	20 (11)
Cladocera	81 (65)	47 (38)	558 (NA)	
Coleoptera	43 (NA)			12 (< 0.01)
Copepoda	312 (83)	39 (6)	419 (460)	99 (25)
Diptera	1362 (1791)	1780 (3851)	3522 (8612)	389 (639)
Ephemeroptera	43 (NA)	199 (295)	48 (30)	28 (22)
Gastropoda	164 (245)	106 (101)	194 (175)	12 (< 0.01)
Hemiptera	316 (370)		249 (218)	12 (NA)
Lepidoptera		19 (16)		
Odonata			12 (NA)	
Oligochaeta	154 (172)	292 (480)	895 (864)	99 (116)
Ostracoda	366 (NA)		279 (132)	
Plecoptera		54 (NA)		17 (8)
Trichoptera	36 (29)	218 (361)	52 (58)	12 (< 0.01)
Turbellaria	29 (22)	75 (77)	52 (58)	
Hymenoptera				
Isopoda				
Megaloptera				
Thysanoptera				

The benthic macroinvertebrate community composition in the control and Project sites varied in similarity by year and sampling methodology. We observed virtually no overlap in the invertebrate communities in 2014 between the control and Project sites indicating that the invertebrate communities were distinctly different between sites (Figure 10). In contrast, we observed substantial overlap in the community composition in 2016 between the control and Project sites suggesting that the communities were fairly similar (Figure 10). Because sampling methods changed between 2014 and 2016 it is difficult to assess if the observed differences in community structure are the result of annual variability (i.e., 2014 vs. 2016), variability due to sampling method (i.e., Hess vs. Kick Net), or some combination between the two.

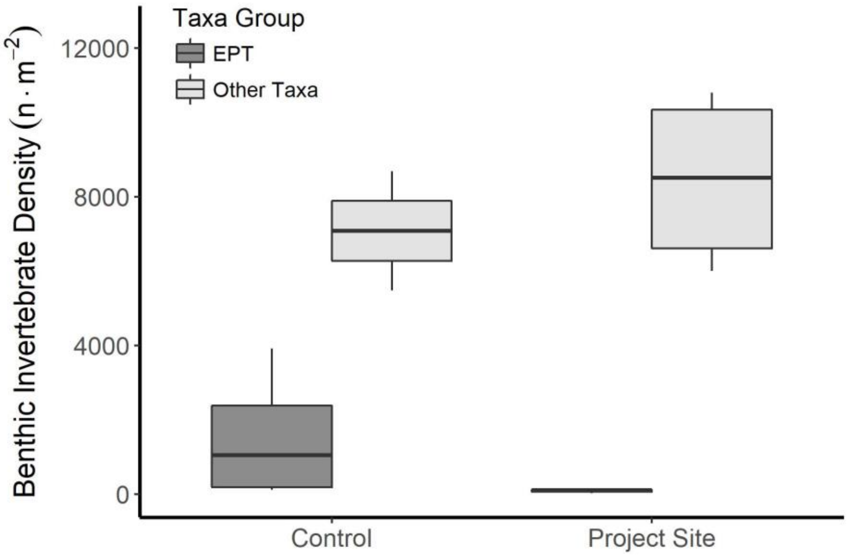

Figure 8. Box and whisker plot illustrates the distribution of benthic invertebrate densities observed at the main channel control and Project site in spring 2014. These samples were collected using a kick net. Note two outliers from the main channel control site ("Other taxa"; 22,753 and 16,591 n · m^{-2}) were excluded from this plot to improve data visualization.

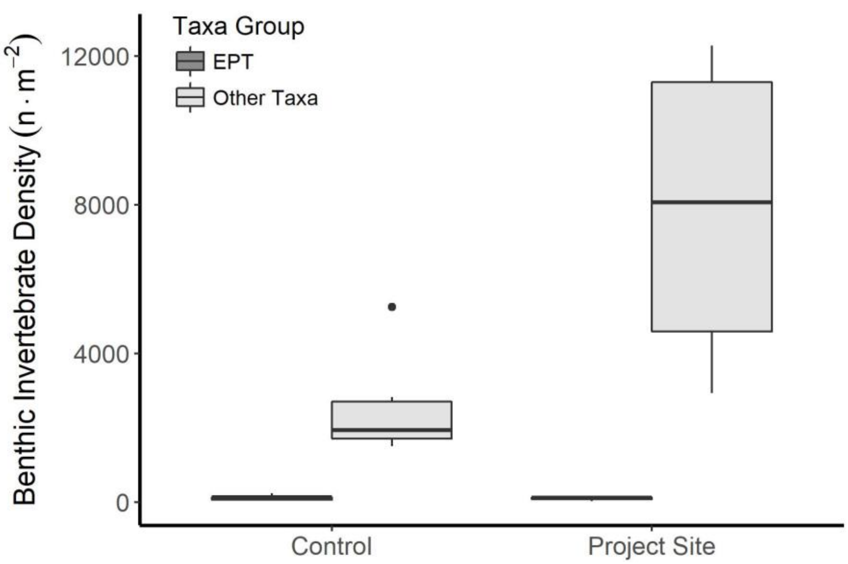

Figure 9. Box and whisker plot illustrates the distribution of benthic invertebrate densities observed at the main channel control and Project site in spring 2016. These samples were collected using a Hess sampler. Note two outliers from the Project site ("Other taxa" 66,372 and 32,767 n · m^{-2}) were excluded from this plot to improve data visualization.

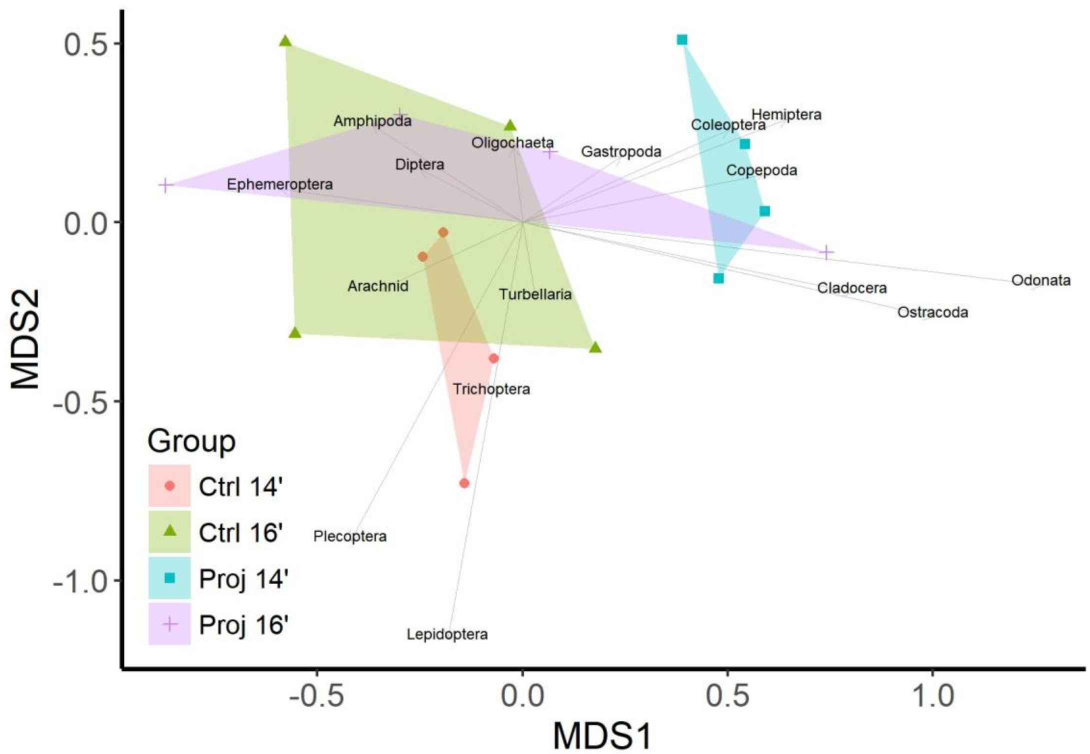

Figure 10. NMDS plot illustrating benthic sample community composition observed in the main channel control (Ctrl) and Project (Proj) site for 2014 and 2016 sampling years (14', 16').

Drift Invertebrates

We collected a total of 8,798 invertebrates during drift sampling. Invertebrate drift densities ranged from 0.76 to 53.43 invertebrates per m^3. Samples were collected in both the Project site and main channel control site in 2016. The number of orders observed in 2016 drift samples was greater in the main channel than the Project site (Table 8). Copepoda had the highest mean density in drift samples from the Project site in 2014 (3.31 per m^3 [2.64 SD]) and main channel control site in 2016 (0.57 per m^3 [0.2 SD]) while Oligochaeta had the highest mean density in the Project site in 2016 (0.59 per m^3 [0.91 SD]; Table 8). The invertebrate drift density was significantly different between the main channel control and Project site in 2016 (p = 0.015; Figure 11). The invertebrate communities sampled from the drift at the Project and main channel control sites were distinctly different (Figure 12). Densities from the main channel control site were within the range of those observed in the Sacramento River and the Yolo Bypass (Sommer et al. 2004), whereas densities from the Project site were relatively low. This may be attributed to the low flow velocities in the Project site compared to the main channel (Harvey et al. 2006), coupled with lower primary productivity in the backwater due to a predominance of relatively deep water with low light penetration to the benthic surface.

Table 8. Table summarizing the mean density [n · m^{-3} (SD)] of drift macroinvertebrates sampled in 2014 and 2016 within the Project site and main channel control site. Orders listed include all unique taxa observed in both benthic invertebrate sampling and drift invertebrate sampling.

	2014	2016	
Order	**Project**	**Project**	**Main channel control**
Amphipoda	0.61 (0.19)	0.08 (0.06)	0.07 (0.03)
Arachnid	0.15 (0.06)	0.11 (NA)	0.04 (0.02)
Cladocera	0.38 (0.5)	0.08 (0.05)	0.18 (0.18)
Coleoptera			0.02 (< 0.01)
Copepoda	3.31 (2.64)	0.25 (0.2)	0.57 (0.2)
Diptera	3 (4.24)	0.16 (0.12)	0.41 (0.71)
Ephemeroptera	0.06 (NA)		0.04 (0.03)
Gastropoda	0.12 (0.07)	0.11 (NA)	
Hemiptera			0.02 (< 0.01)
Lepidoptera	0.11 (0.11)		
Odonata			
Oligochaeta		0.59 (0.91)	0.09 (0.04)
Ostracoda	0.2 (0.02)		
Plecoptera			
Trichoptera	0.27 (0.26)		0.02 (NA)
Turbellaria	0.18 (NA)		
Hymenoptera	0.03 (NA)	0.03 (NA)	0.02 (0.02)
Isopoda			0.02 (NA)
Megaloptera			0.01 (NA)
Thysanoptera			0.02 (0.01)

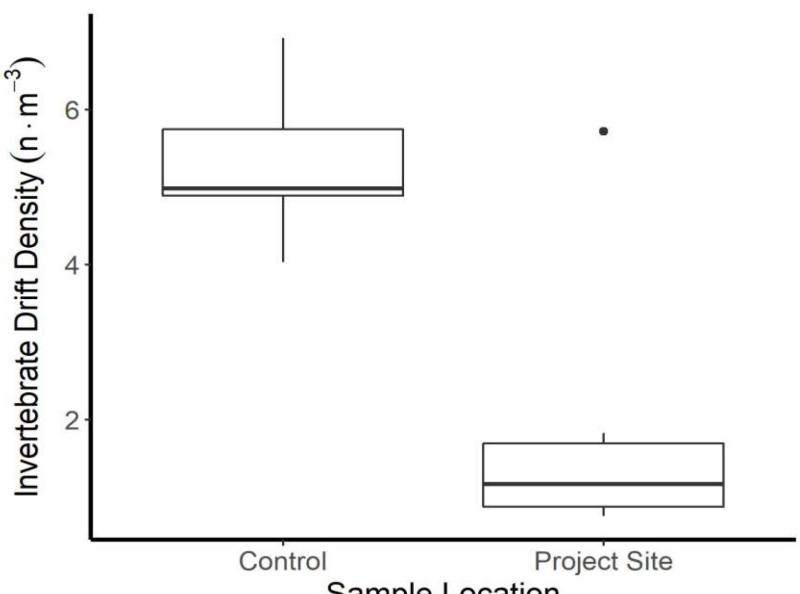

Figure 11. Box and whisker plot illustrates the distribution of macroinvertebrate densities observed in drift at the control and Project site in spring 2016. Data from 2014 is not included, as samples were only collected in the Project site in 2014.

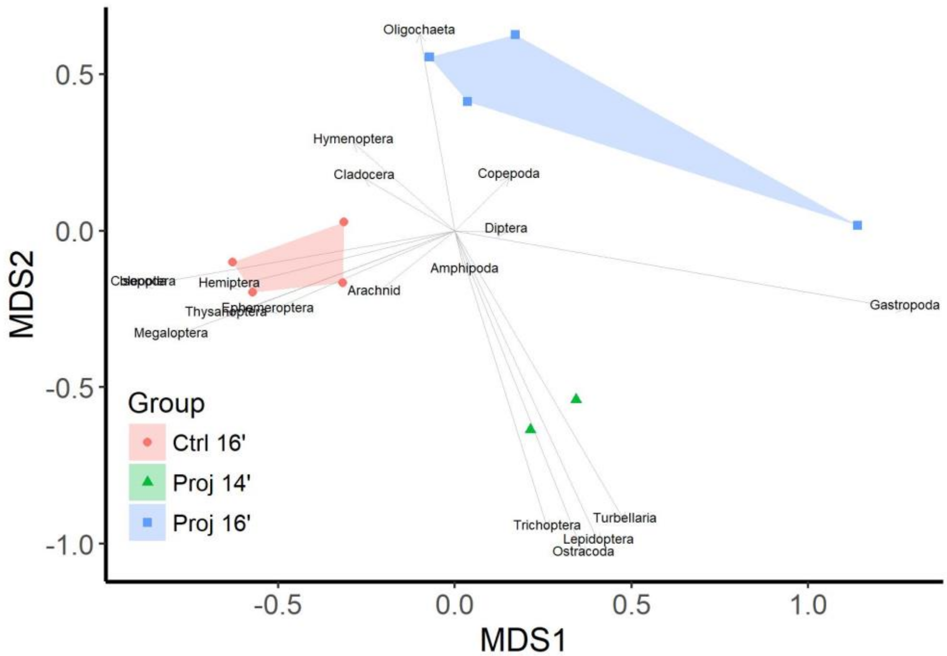

Figure 12. NMDS plot illustrating invertebrate community composition sampled from the drift in the control (Ctrl) and Project (Proj) sites for 2014 and 2016 sampling years (14', 16').

Juvenile Rearing and Growth

Previous studies have suggested that fish rearing in Central Valley off-channel habitats exhibit enhanced growth and survival as compared to those in the main channel (Sommer et al. 2001, Jeffres et al. 2008). However, these studies were conducted in low-elevation, expansive, managed floodplain systems that are geomorphologically and hydrologically quite different from the off-channel habitat in the Project site. The extent to which the enhanced growth observed in these studies is applicable to off-channel habitat in the upper reaches of the Sacramento River system is unknown.

In spring 2016, we PIT tagged juvenile salmon and allowed them to rear within the Project site and in an unrestored backwater habitat (Kino control site, Figure 1) before and after restoration to test the hypothesis that juvenile salmon rearing in restored off-channel habitats will exhibit greater growth rate and health condition than those that rear in unrestored backwater habitats. We released approximately 1000 PIT tagged fish at each location; outmigrating fish were recaptured at the downstream end of the backwater using a channel-spanning fyke net. The fykes were operated from 29 April to the 21 May (Figure 2). Traps were checked daily, and each captured salmon was scanned with at PIT tag reader, its size (fork length and weight) recorded, and a photo taken. Incidental catch (including all native and non-native fish species) were also recorded and measured to provide additional data on fish assemblages. PIT tagged fish were euthanized and placed into a small vial containing 100% ethanol, and all other fish were released downstream of the trap. Stomach contents were also analyzed following recapture to assess prey biomass and composition.

Otoliths were extracted from PIT tagged juvenile salmonids captured in the fyke net, cleaned, and then dried in vials from recaptured Chinook Salmon, prior to preparation. We followed methods for preparing salmonid otoliths for microstructure analysis, according to Neilson and Geen (1982). Right otoliths were mounted on microscope slides in Crystalbond™ (Aremco, Valley Cottage, NY) with the sulcus side facing up. Left otoliths were used when right otoliths were vaterite or damaged during preparation. Otoliths were polished using 1500 grit sandpaper followed by and 3 and 1 µm grit aluminum oxide lapping discs until central primordia and daily increments were visible under light microscopy.

Otolith microstructure was observed using a compound microscope (20X) mounted with a digital camera (Motic, Moticam 5). Daily increment widths were measured and counted along a 90° transect from the edge of the otolith toward the primordia using the image analysis software, Image Pro Premier version 9.2 Media Cybernetics (Rockville , Maryland).

To estimate mean daily growth rates we used the Fraser-Lee model of back-calculation, available in the R package FSA (Ogle 2016). This method estimates daily growth by predicting daily length of a fish over a particular time period based on final length and a series of daily otolith growth increment widths.

A total of 3,822 fish were captured in the fyke nets, including 2,365 fish at the Hallwood site and 1,457 fish at the Kino site (Table 9). Ten native taxa were observed; the most abundant native species were California Roach, Chinook Salmon, Sacramento Pikeminnow, Sacramento Sucker, and Tule Perch. Nine non-native species were observed; the most abundant non-native species were various sunfish species and hybrids (*Lepomis* spp.) and Warmouth. A higher proportion of native taxa was present at the Hallwood site compared to the Kino Control site (Table 9).

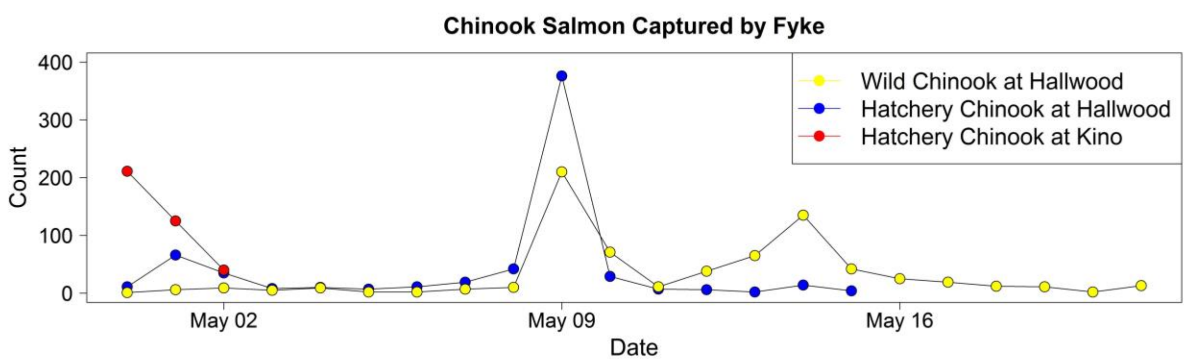

Figure 13. Wild and PIT tagged hatchery juvenile Chinook Salmon captured in the fyke nets at Hallwood and Kino (control) between 29 April and 21 May.

Table 9. Fish taxa captured via fyke at Hallwood Project site and Kino control site.

Status	Taxon	Hallwood (Project)	Kino (Control)	Total
Native	California Roach (*Hesperoleucus symmetricus*)	68		68
	Chinook Salmon (*Oncorhynchus tschawytscha)*	1352	376	1728
	Hardhead (*Mylopharodon conocephalus*)	1	14	15
	Pacific Lamprey (*Entosphenus tridentate)*	10		10
	Prickly Sculpin (*Cottus asper)*	1		1
	Rainbow trout/steelhead (*O. mykiss)*	3	1	4
	Sacramento Pikeminnow (*Ptychocheilus grandis)*	215	20	235
	Sacramento Sucker *(Catostomus occidentalis)*	354	12	366
	Speckled Dace (*Rhinichthys osculus)*	2		2
	Tule Perch (*Hysterocarpus traskii)*	125		125
	Unknown lamprey (*Lampetra sp*. or *Entosphenus tridentata*)	7		7
	Unknown sculpin (*Cottus* sp.)	29	6	35
	TOTAL NATIVES	**2167**	**429**	**2596**
Non-native	Black Crappie (*Pomoxis nigromaculatus*)		4	4
	Bluegill Sunfish (*Lepomis macrochirus)*	7	368	375
	Golden Shiner (*Notemigonus crysoleucas)*	1	2	3
	Green Sunfish (*Lepomis cyanellus)*		34	34
	Largemouth Bass *(Micropterus salmoides)*	1	3	4
	Mosquitofish (*Gambusia affinis)*		1	1
	Pumpkinseed (*Lepomis gibbosus)*	1	1	2
	Redear Sunfish (*Lepomis microlophus)*	35	372	407
	Warmouth (*Lepomis gulosus*)		97	97
	Unknown black bass (*Micropterus sp,)*		6	6
	Unknown sunfish (*Lemomis sp.)*	153	140	293
	TOTAL NON-NATIVES	**198**	**1028**	**1226**
	GRAND TOTAL	**2365**	**1457**	**3822**

Approximately 1,000 PIT-tagged juvenile hatchery Chinook Salmon from Feather River Hatchery were released into each site on 29 April. The juvenile salmon were allowed to rear in these backwater habitats until they volitionally moved downstream and were captured in a fyke net. The outmigration pattern of juvenile Chinook Salmon (i.e. capture) varied temporally among the two sites (Figure 13). At Kino, all juvenile Chinook Salmon captures occurred over the first three days, with 376 recaptures out of the 985 PIT-tagged fish released (Figure 13). No wild juvenile Chinook Salmon were captured at Kino. In contrast, at Hallwood outmigration was protracted, with a peak for PIT-tagged hatchery salmon occurring on 9 May (Figure 13). Wild juvenile Chinook Salmon were also captured at Hallwood and had outmigration peaks on 9 and 14 May (Figure 13). At Hallwood, 647 fish were recaptured out of the 1,000 PIT-tagged fish released and 705 wild Chinook Salmon were also captured in the fyke. The maximum residence time of an individual PIT-tagged fish at the Hallwood site was 16 days. Wild juvenile Chinook Salmon were captured in the Hallwood fyke-net trap on the last day of trap operation, suggesting that wild juvenile Chinook Salmon were rearing in the Hallwood site at least until late May.

Abiotic conditions of the Hallwood and Kino sites likely contributed to differences in observed outmigration patterns and apparent survival, based upon the relative proportion of recaptures in the fyke. The Kino control site had warmer water temperatures and lower dissolved oxygen compared to the Hallwood site (Figures 14, 15). During the course of the experiment, water temperatures averaged 14.7°C (±0.8°C SD) in the Hallwood site, which is within the bioenergetics thermal optimum for juvenile Chinook Salmon growth (Myrick and Cech 1998, Marine and Cech 2004). In contrast, Kino control site water temperatures averaged 19.7°C (±2.1°C) with high temperatures above 24°C (Figure 14), which is considered lethal to salmonids if there is prolonged exposure. DO levels were higher on average in the Hallwood site compared to the Kino control site, also indicating poorer water quality at Kino (Figure 16). Some of the differences in abiotic conditions between the two experimental sites may be due to decreased main channel connectivity at the Kino control site compared to the Hallwood site. The unfavorable abiotic conditions likely contributed to shorter juvenile salmon residence time and lower successful outmigration at the Kino control site relative to the Hallwood site. However, at both sites successful outmigration rates were relatively low (65% for Hallwood and 38% for Kino control).

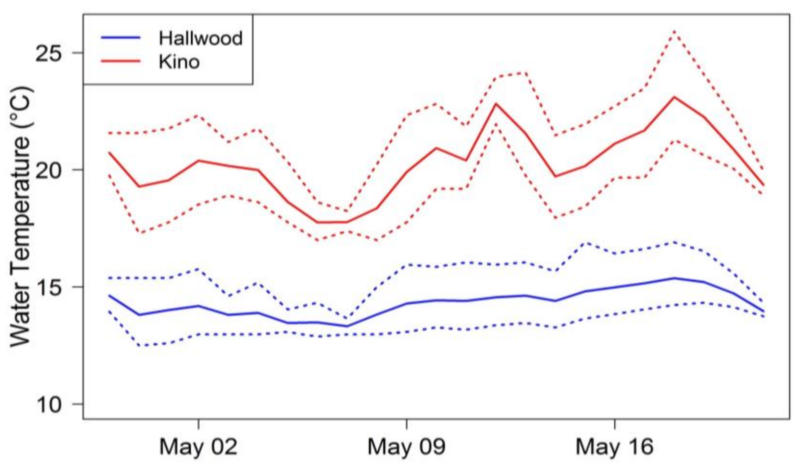

Figure 14. The minimum, mean, and maximum water temperatures observed at Hallwood and Kino for the duration of the study period (29 April to 21 May).

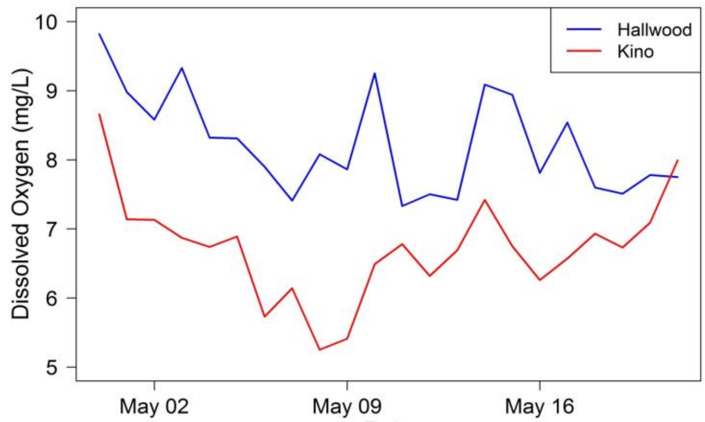

Figure 15. Dissolved oxygen (mg/L) levels at Hallwood and Kino for the duration of the study period (29 April to 21 May).

In the Hallwood site, PIT tagged hatchery juvenile Chinook Salmon grew an average of 0.31 mm per day with a maximum observed growth of 0.65 mm per day based on otolith analysis (Figure 16). Other studies have observed faster growth rates of juvenile Chinook Salmon in off-channel habitats. In the Yolo Bypass, juvenile Chinook Salmon were observed to average 0.93 mm per day growth (Katz et al. 2013) and in off-channel areas of the San Joaquin River juvenile Chinook Salmon had mean daily growth rates between 0.76 and 1.10 mm/day (Zeug et al. 2019). However, other studies have reported juvenile Chinook Salmon growth rates within large California rivers to be more similar to those observed in this study. For example, Sommer et al. (2001) report that juvenile Chinook Salmon in the Sacramento River mainstem grew 0.43 to 0.52 mm/day, and Jeffres et al (2008) report growth rates of 0.19 to 0.57 mm/day in the Cosumnes River mainstem.

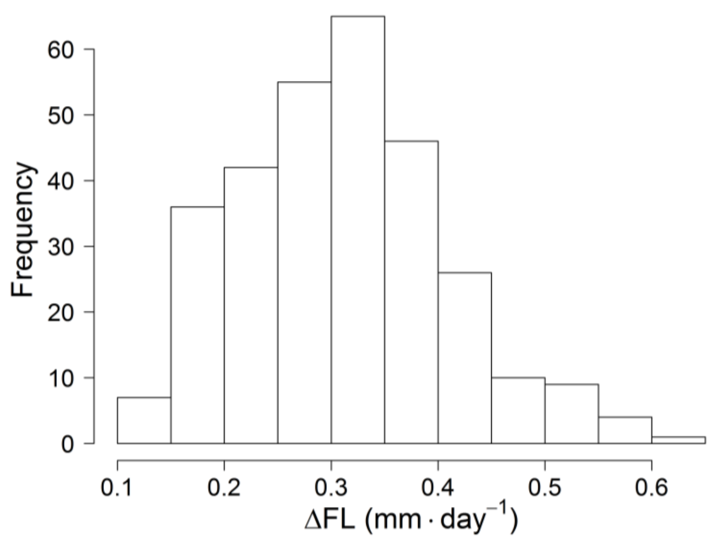

Figure 16. Otolith derived growth rates of PIT tagged hatchery juvenile Chinook Salmon in the Hallwood site. Growth rates could not be calculated from the Kino (control) site because all fish that outmigrated were captured within the first three days of release.

We examined the stomach contents of 37 PIT-tagged Chinook Salmon from the Hallwood site between 7 and 15 May. Fourteen of these stomachs were empty; the remaining stomachs contained insects, crustaceans, arachnids, and oligochaetes (Table 10). The majority of observed prey items were small dipteran larvae, with only 5 total prey items >7mm in length. These data suggest that macroinvertebrate prey availability may be a factor limiting growth potential in the Hallwood backwater.

After Project implementation, we will replicate the experiment and compare successful outmigrant rates, rearing duration, growth, health condition, and diet of juvenile salmon before and after restoration.

Table 10. Prey taxa observed in the stomachs of PIT-tagged Chinook Salmon captured in the Hallwood fyke trap.

Group	Taxon	Count
Arachnida	Hydracarina	6
	Arachnida sp.	1
Crustacea	Cladocera	2
	Gammaridae	1
Insecta	Baetidae	1
	Calliphoridae	4
	Chironomidae	20
	Coleoptera	1
	Diptera	35
	Ephemeroptera	8
	Hemiptera	2
	Homoptera	1
	Hydropsychidae	1
	Neuroptera	1
	Odonata	1
	Psychodidae	7
	Pyralidae	1
	Simuliidae	3
	Insect exoskeleton	27
Oligochaeta	Oligochaeta sp.	1

Detecting Predation on Juvenile Salmonids

Predation on threatened and endangered species by non-native piscivorous fishes is hypothesized to be a major driver of population declines and a potential limitation to their recovery (Baerwald et al. 2012, Lindley et al. 2003). Tagging studies are often used to estimate predation losses, but the fate of tagged fish often cannot be reliably identified as predation events and the effects of tagging on fish behavior can increase the probability they will be consumed. Another approach is to directly examine the diet of potential predators to identify predation events. In this study, we used a combination of tagged salmon and direct observation of potential predator stomach contents to examine the effect of predators on the survival of juvenile salmonids.

This study occurred in conjunction with the juvenile rearing and growth experiment described above. After PIT-tagged juvenile salmonids were released into the Hallwood and Kino sites, native and non-native piscivorous fish were collected from both sites several times a week using beach seines. They were scanned with a PIT-tag reader to determine whether they consumed tagged juvenile salmonids. Then, their stomach contents were extracted using gastric lavage, a non-lethal sampling method (Haley 1998, Koehler et al. 2006). Prior to handling, captured fish were anesthetized with AQUI-S 20E and the fish were weighed to the nearest 0.01 g and measured to the nearest 1 mm FL. A small syringe fitted with an 8-mm diameter rubber tube was inserted into the fish's esophagus. The syringe was used to gently empty the stomach contents from the fish into a 106 µm sieve, and the fish was returned to freshwater to recover. The predator was then released back into the system from which it was collected. The stomach contents were washed into a Whirlpac™ and preserved with 100% ethanol. Stomach contents were examined and organisms identified with a light dissecting microscope to the smallest taxonomic resolution.

Seining effort was standardized between the two locations, allowing for comparison of predator abundance, size, and species composition at the Project and control sites before and after restoration. The two sites were each seined once a week for three weeks (weeks of 1 May, 8 May, and 15 May) to attempt to capture predators and examine them for predation on PIT-tagged juvenile Chinook Salmon. We captured a total of 1,829 fish during seining efforts; species composition of samples from each site is summarized in Table 11. As with the fyke net sampling, the proportion of native species observed during seining efforts was greater at the Hallwood site as compared to the Kino control site (Tables 9 and 11).

As detailed in above section (Juvenile Rearing and Growth), at the control site there were 376 recaptures in the fyke out of the 985 PIT-tagged salmon released and at Project site 647 salmon were recaptured out of the 1,000 PIT-tagged salmon released. The fate of PIT-tagged salmon not recaptured is unknown. They potentially either died (from predation or other cause) or remained in the backwater and left after the experiment had ended. As noted, non-PIT tagged juvenile Chinook Salmon were captured in the Project site fyke on its last day of operation in late May.

Table 11. Fish taxa captured via seine at Hallwood Project site and Kino control site.

Status	Taxon	Hallwood (Project)	Kino (Control)	Total
Native	California Roach	90		90
	Chinook Salmon	234		234
	Hardhead		8	8
	Sacramento Pikeminnow	58	1	59
	Sacramento Sucker	69	3	72
	Speckled Dace	1		1
	Tule Perch	22		22
	Unknown Sculpin	2	1	3
Non-native	Black Crappie		1	1
	Bluegill Sunfish	19	231	250
	Golden Shiner	1	6	7
	Green Sunfish	1	9	10
	Largemouth Bass	27	22	49
	Mosquitofish	45	7	52
	Redear Sunfish	20	232	252
	Warmouth		4	4
	Unknown Sunfish	29	686	715
	Total fish observed	**618**	**1211**	**1829**

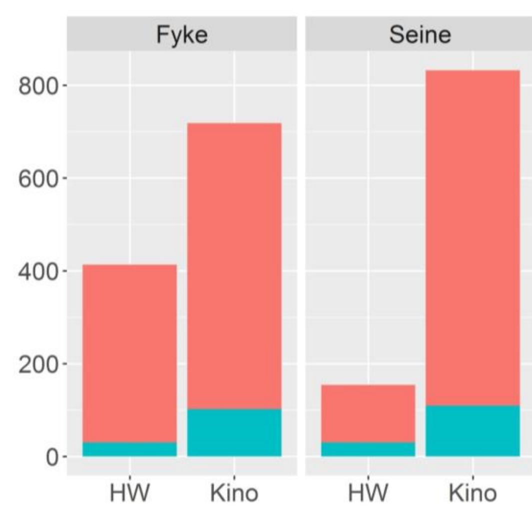

Figure 17. The number of piscivorous fish captured by seine and fyke at Hallwood Project and Kino (control) sites that, based on piscivorous fish fork length, are able (blue bars) or not able (red bars) to consume a juvenile Chinook Salmon with a fork length greater than 50 mm.

The abundance of warm-water piscivorous fishes was markedly different between the Project and control sites. The piscivorous fish species captured included the following non-native species: Largemouth Bass, Warmouth, and several other sunfish species (and hybrids); and two native species: Sacramento Pikeminnow and Hardhead. We captured over 260% more warm-water piscivorous fishes capable of consuming Chinook Salmon of the size that we released into the backwater (i.e., FL > 150mm) in the Kino control site compared to the Hallwood Project site (Figure 17).

We obtained stomach contents from four piscivorous fish species: 13 Largemouth Bass, nine Redear Sunfish (*Lepomis microlophus*), five hybrid *Lepomis*, and one Sacramento Pikeminnow. One Largemouth Bass stomach was empty. The taxonomic identity and total number of prey items observed for each piscivorous species is summarized in Table 12. Stomach contents revealed that a large proportion of the diet of non-native fish inhabiting the Hallwood Project and Kino control sites is composed of invertebrates. Many invertebrate prey taxa overlapped with those observed in Chinook Salmon stomach contents. In particular, crustaceans and small insects such as dipteran larva were prominent in both Chinook Salmon and non-native species' diets, suggesting the potential for niche overlap and competitive interactions across fish species, particularly considering the high abundances of non-native species observed in both locations (Tables 9, 11).

Figure 18. Largemouth Bass with its stomach contents from gastric lavage. The red circles are PIT tags from juvenile Chinook Salmon released at the site. The inset photo shows a relatively small Largemouth Bass in the process of consuming a juvenile Chinook Salmon.

Table 12. Prey items observed in piscivorous fish stomach contents during seining at Hallwood Project and Kino control sites. Numbers in parentheses after predator species names indicate the number of individuals from which stomach contents were collected.

		Hallwood				Kino Control		
Group	Taxon	Sunfish sp. (1)	Largemouth Bass (6)	Redear Sunfish (2)	Sacramento Pikeminnow (1)	Sunfish sp. (4)	Largemouth Bass (7)	Redear Sunfish (7)
Vertebrates	Chinook Salmon						8	
	Redear Sunfish						1	
	Sacramento Sucker		3					
	Warmouth		1					
	Salmonid scales		1					
	Unidentified eggs		2			995		2338
	Unidentified fish scales					103		73
	Unidentified vertebrae		1				2	
Invertebrates	Anisoptera		1					
	Chironomidae		8	1			3	54
	Chydoridae		2					1
	Copepoda							4
	Corbicula							1
	Culicidae						1	
	Cyprinidae		1					
	Diptera		1		1			
	Ephemeridae			1				
	Gammaridae	18		3	1	3		7
	Gastropoda	18		14		1		
	Hyalellidae					1		
	Hydracarina					1		
	Ostracod	1						
	Physidae			3				
	Planorbidae	9						1
	Procambarus clarkia		1				3	
	Thysanoptera		1					
	Zygoptera		1					
	TOTAL	46	24	22	2	1104	18	2479

Although there was only limited evidence of piscivory in fish stomachs (Table 12), examining the stomach contents from specific individuals revealed remarkable rates of predation. For example, one Largemouth Bass had eight PIT-tags in its digestive system (Figure 18). Anecdotally, we directly observed warm-water fishes with FL less than 150mm predating on juvenile salmon in the fyke trap (Figure 18 inset). The high number of invasive predators and competitors were likely factors that contributed to the decreased residence time and increased mortality rates for juvenile Chinook Salmon in the control site compared to the Project site.

CONCLUSION

Currently, Project site environmental conditions provide marginal habitat for juvenile salmonids. Project site temperatures become stressful in late May or early June, and invertebrate prey densities were relatively low compared to the main channel. Juvenile salmon growth rates were low to moderate. Juvenile salmon were observed in the Project site during snorkel and seining surveys and fyke trapping. Non-native piscivorous fish were also abundant, including large-bodied predators that may exert high predation pressure on juvenile salmonids; several predation events were observed during seining and fyke trapping. Non-native competitors such as sunfish were also abundant at the Project site. We observed substantial diet overlap between non-native fish species and juvenile salmonids indicating a potential for competitive interactions, particularly given the relatively low drift invertebrate density.

Optimizing depth and flow velocities and increasing habitat extent and complexity following restoration are predicted to improve temperature conditions, increase invertebrate prey production and availability as drift, reduce non-native predator and competitor fish species abundance by reducing suitable habitat for these species, and provide enhanced growth opportunities and rearing duration for rearing juvenile salmonids.

Post-project monitoring following restoration will be conducted for at least 2 years, and should be conducted for 5 or more years to capture a range of environmental conditions. Longer-term monitoring of physical and biological habitat features over time and continued fish use of the restored habitat is recommended to determine the long-term sustainability of the site and whether additional actions are needed to maintain and improve off-channel habitat function.

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APPENDIX A. PRE-PROJECT PHOTO POINTS

Pre-Project Photo Points

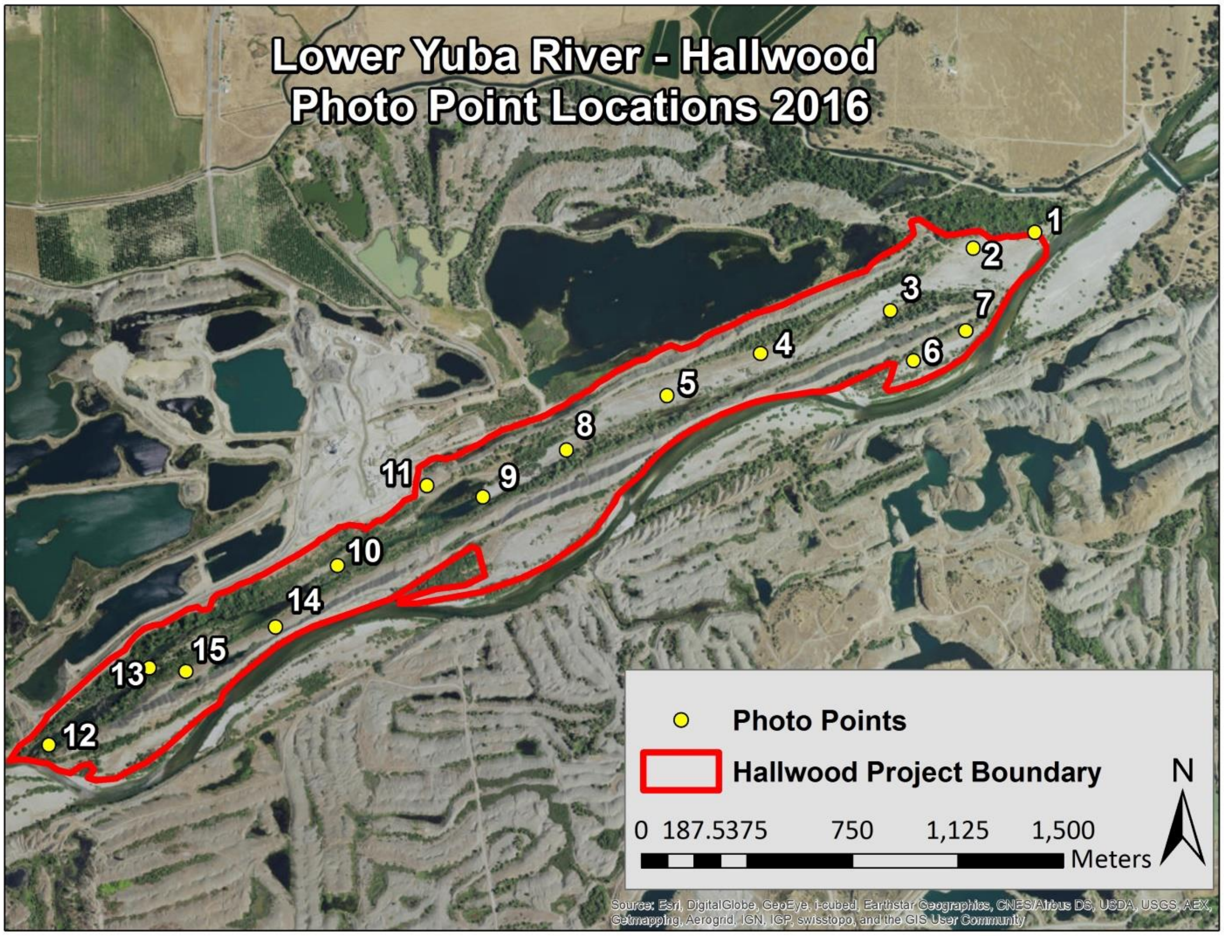

Figure 19: Photo point 1 North.

Figure 20: Photo point 1 South

Figure 21: Photo point 2 North

Figure 22: Photo point 2 South

Figure 23: Photo point 1 East

Figure 24: Photo point 1 West.

Figure 25: Photo point 2 East

Figure 26: Photo point 2 West

Figure 27: Photo point 3 North

Figure 28: Photo point 3 South

Figure 29: Photo point 4 North

Figure 30: Photo point 4 South

Figure 31: Photo point 3 East

Figure 32: Photo point 3 West

Figure 33: Photo point 4 East

Figure 34: Photo point 4 West

Figure 35: Photo point 5 North

Figure 36: Photo point 5 South

Figure 37: Photo point 6 North

Figure 38: Photo point 6 South

Figure 39: Photo point 5 East

Figure 40: Photo point 5 West

Figure 41: Photo point 6 East

Figure 42: Photo point 6 West

Figure 43: Photo point 7 North

Figure 44: Photo point 7 South

Figure 45: Photo point 8 North

Figure 46: Photo point 8 South

Figure 47: Photo point 7 East

Figure 48: Photo point 7 West

Figure 49: Photo point 8 East

Figure 50: Photo point 8 West

Figure 51: Photo point 9 North

Figure 52: Photo point 9 South

Figure 53: Photo point 10 North

Figure 54: Photo point 10 South

Figure 55: Photo point 9 East

Figure 56: Photo point 9 West

Figure 57: Photo point 10 East

Figure 58: Photo point 10 West

Figure 59: Photo point 11 North

Figure 60: Photo point 11 South

Figure 61: Photo point 12 North

Figure 62: Photo point 12 South

Figure 63: Photo point 11 East

Figure 64: Photo point 11 West

Figure 65: Photo point 12 East

Figure 66: Photo point 12 West

Figure 67: Photo point 13 North

Figure 68: Photo point 13 South

Figure 69: Photo point 14 North

Figure 70: Photo point 14 South

Figure 71: Photo point 13 East

Figure 72: Photo point 13 West

Figure 73: Photo point 14 East

Figure 74: Photo point 14 West

Figure 75: Photo point 15 North

Figure 76: Photo point 15 South

Figure 77: Photo point 15 East

Figure 78: Photo point 15 West

APPENDIX B. PRE-PROJECT VEGETATION SURVEYS

DRAFT

Hallwood Side Channel and Floodplain Restoration Project

Pre-Project Vegetation Sampling

2016 Collected Data Summary Report

November 13, 2016

Prepared For Cramer Fish Sciences, Inc. by Mehrey Vaghti

Table of Contents

Executive Summary

Vegetation survey data from 6 plots were collected at the control site on July 13, 2016. The project site was surveyed July 11-13, 2016 and 15 plots were completed. A total of 11 vegetation alliances were documented across both sites. Eighty-six species were recorded across both sites including 42 native species, 30 introduced species, and 14 plants of unknown origin (those not identified to species level).

Natural regeneration of native woody plants was very limited at both the control and project sites. All recruitment was native; 4 oaks seedlings were recorded at the project site, while 35 wetland seedlings were recorded at the control site.

No special status plants species were recorded.

Introduction

The goal of the Hallwood Side Channel and Floodplain Restoration Project is to improve juvenile rearing habitat quality and ecosystem function by enhancing a disconnected side channel and adjacent floodplain areas to increase connectivity with the main channel along the Yuba River below Daguerre Point Dam. The project scope includes construction activities that will significantly impact the existing physical attributes of the site.

The Project is located on private lands owned by Teichert Materials and Western Aggregates on the north bank of the Yuba River just downstream of Daguerre Point Dam and approximately 8 miles upstream of Marysville, near the community of Hallwood in an area known as the Yuba Goldfields. Within the Project Area the Yuba River is laterally constrained by tall linear cobble embankments (aka training walls) constructed by hydraulic dredges, with an additional large linear cobble embankment (Middle Training Wall) located in the middle of the flood corridor running the length of the project.

Methods

The removal of dredger tailings and the construction of secondary channels and appropriate floodplain elevation are the primary restoration actions. Surveys of riparian vegetation before and after the restoration actions aim to answer the following effectiveness and validation questions: (1) Was there an increase in native vegetation in the project area, and was the cover of non-native invasive plant species reduced or prevented; and (2) Does restoring floodplains recover ecosystem processes that affect the success of natural native plant regeneration?

A Before-After-Control-Impact (BACI) study design (Eberhardt 1976) was used to improve the probability of detecting changes in vegetation patterns due to the project implementation. This approach utilized a paired series of Control-Impact sites, subjected to a series of Before-After replicated measurements. Robust statistical assessment is possible because of the spatial and temporal replication. Permanent plots were placed at a downstream control site and at the project site (Figure 1). Data from the control site provide measures of baseline variation over the project period. The control site was qualitatively stratified by floodplain position and existing vegetation types. The project site was stratified using existing LiDAR data of vegetation height crossed with modeled post-project flood recurrence interval (Figures 4a-c).

To address the effectiveness and validation questions the following metrics were collected: native species richness; effective number of native species, native species cover, naturalized species cover, and number of species recruits. Two vegetation data collection methods, further described below, were utilized to obtain the desired metrics. All sampling sites were surveyed using a Trimble GeoXT (GeoExplorer 2008 series) global positioning system (GPS) unit. A 100 m^2 (10 m x 10 m) sampling plot was centrally located within each polygon selected for sampling. This is smaller than the standard for riparian shrub and tree vegetation but allows for increased replication across the project area (CNPS/CDFG 2009).

The California Native Plant Society/California Department of Fish and Game (CNPS/CDFG) Protocol for Combined Vegetation Rapid Assessment and Relevé Sampling (2009; attached) was applied to all sites. This protocol follows methods of vegetation community sampling developed by the CNPS and CDFG to meet the standards developed by the Federal Geographic Data Committee (Jennings et al. 2009). The CNPS/CDFG (2009) sampling protocol also collects habitat data for the California Wildlife-Habitat Relationships (CWHR) system (Mayer and Laudenslayer, Jr. 1988). CWHR is a comprehensive database providing several tools including a standardized habitat classification scheme and a community-level matrix model associating over 650 wildlife species to these standard habitats and rating suitability for reproduction, cover, and feeding. Habitat data are used to create and refine predictive models of California wildlife for conservation and restoration applications.

All plots were marked with GPS locations, photographs and descriptions. All plant species were identified and absolute cover by stratum (tree, shrub, sapling, seedling, herb, non-vascular) was estimated ocularly. The relative cover of the following surface covers was estimated oculary: open water; basal area stems; litter; bedrock; boulder; stone; cobble; gravel; and fines. These data were entered into a CNPS/CDFG Relevé/Rapid Assessment Database, a customized Access (Microsoft 2002) database; nomenclature followed Baldwin et al. (2012). Additionally, a 16 m^2 (4 m x 4 m or 2 m x 8 m depending on stand extent) recruitment subplot was placed in the anchor corner of each relevé. A 1 m^2 grid was laid and all woody seedlings were mapped with location, species and diameter class. Plant species that could not be identified in the field were collected and reexamined later with magnification.

Data were transferred to an Excel (Microsoft 2010) database for tabulation and the creation of tables and charts. Data were aggregated by sampling location (control vs. project site). For each site, frequency and average cover (where present) were tabulated for all recorded species. Wetland determinations were taken from the 2012 U.S. Department of Agriculture Wetland Indicator Status online database for the Arid West region, which references Lichvar and Kartesz (2009); species considered obligate (OBL) or facultative wetland (FACW) were included in the "wetland" metric. Naturalized species of concern were identified using the California Invasive Plant Council inventory and are described as "invasive non-native plants that threaten wildlands" that: 1) are not native to, yet can spread into, wildland ecosystems, and that also 2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes (Cal-IPC 2006)

For each plot, a preliminary alliance and association determination was made using the key to vegetation types in *A Manual of California Vegetation* (Sawyer et al. 2009). An alliance is a classification unit of vegetation defined by one or more diagnostic species in the uppermost layer or layer with highest cover; alliances reflect regional to subregional physical gradients (Sawyer et al., 2009). An association is a vegetation classification unit defined by a diagnostic species, a characteristic range of species composition, physiognomy and discrete habitat conditions; associations reflect local physical gradients (Sawyer et al. 2009).

Data from the recruitment subplots were tabulated and summarized.

Results

Vegetation survey data from 6 plots were collected at the control site on July 13, 2016. The project site was surveyed July 11-13, 2016 and 15 plots were completed.

Special Status Species

Pre-project special status species surveys identified 19 plant species with the potential to be present at the project site. Table 1 lists these plants, their status listing, habitats and flowering time. None of these special status plants were recorded during pre-project vegetation monitoring.

Regeneration

Natural regeneration of native woody plants was very limited at both the control and project sites; recruitment was recorded at one plot for each site (Table 2). All recruitment was native; 4 oaks seedlings were recorded at the project site, while 35 wetland seedlings were recorded at the control site (*Salix melanopsis* and *Populus fremontii*).

Vegetation Community

A total of 11 vegetation alliances were documented across both sites: these are given in Table 3. Eighty-six species were recorded across both sites including 42 native species, 30 introduced species, and 14 plants of unknown origin (those not identified to species level). A complete species list with average cover, frequency and wetland status is given in Table 4.

The project site supported a diversity of native riparian and upland tree and shrub species, though young sapling trees were lacking. The majority of diversity was driven by herbaceous species which included 97% of introduced species. Table 5 lists introduced species at both sites identified by the California Invasive Plant Council as invasive. The following species have an invasive rating of "high:" *Bromus tectorum*, *Centaurea solstitialis*, *Myriophyllum aquaticum*, and *Rubus armeniacus*.

Discussion

A full discussion will be provided in the final Hallwood Side Channel and Floodplain Restoration Project Report.

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Figure 1 – Control Site and Project Site Sampling Locations

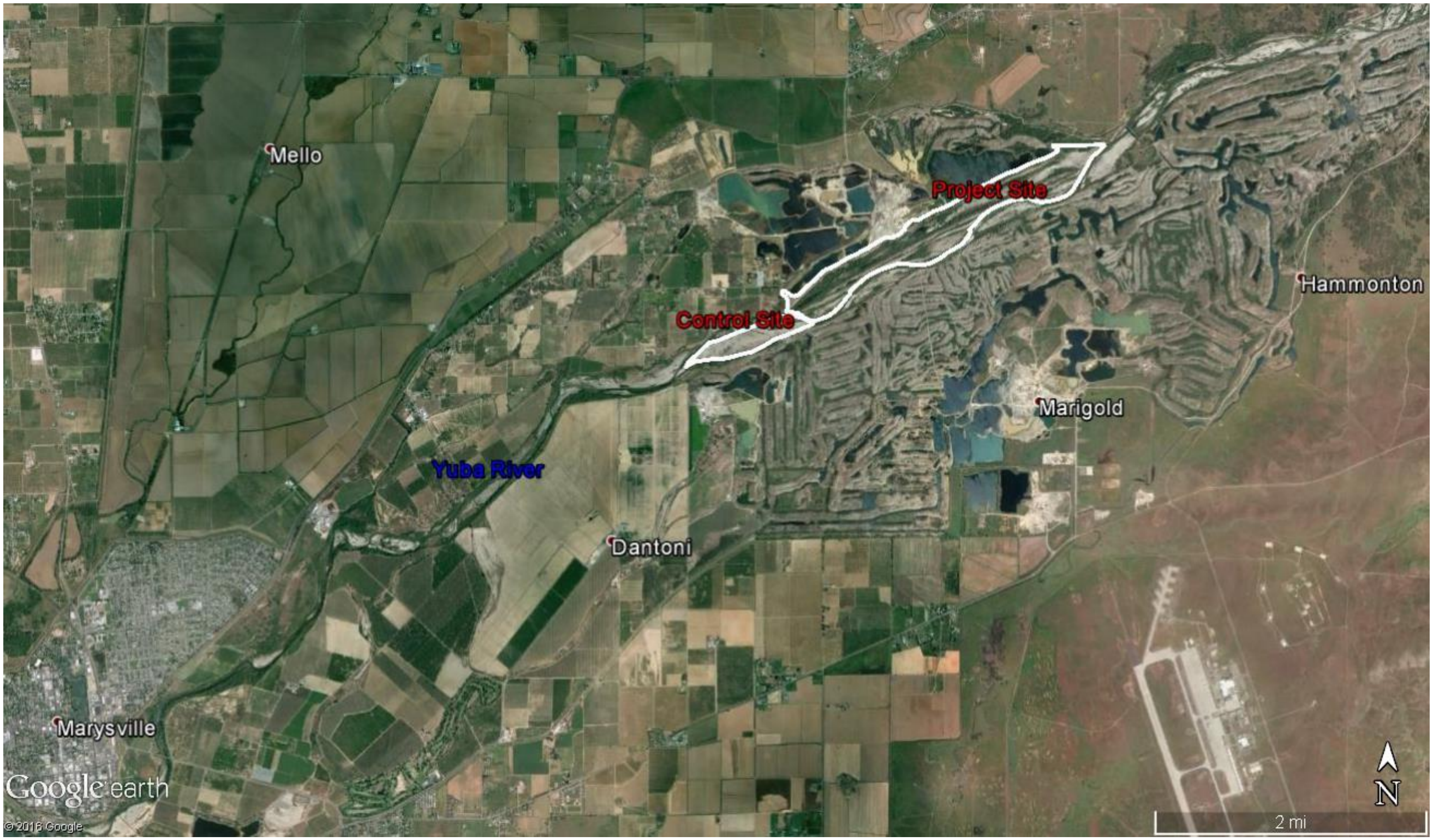

Figure 2 – Control Site Vegetation Sampling Detail

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Figure 3 – Project Site Sampling Overview

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Figure 4a – Project Site Vegetation Sampling Detail (Upstream)

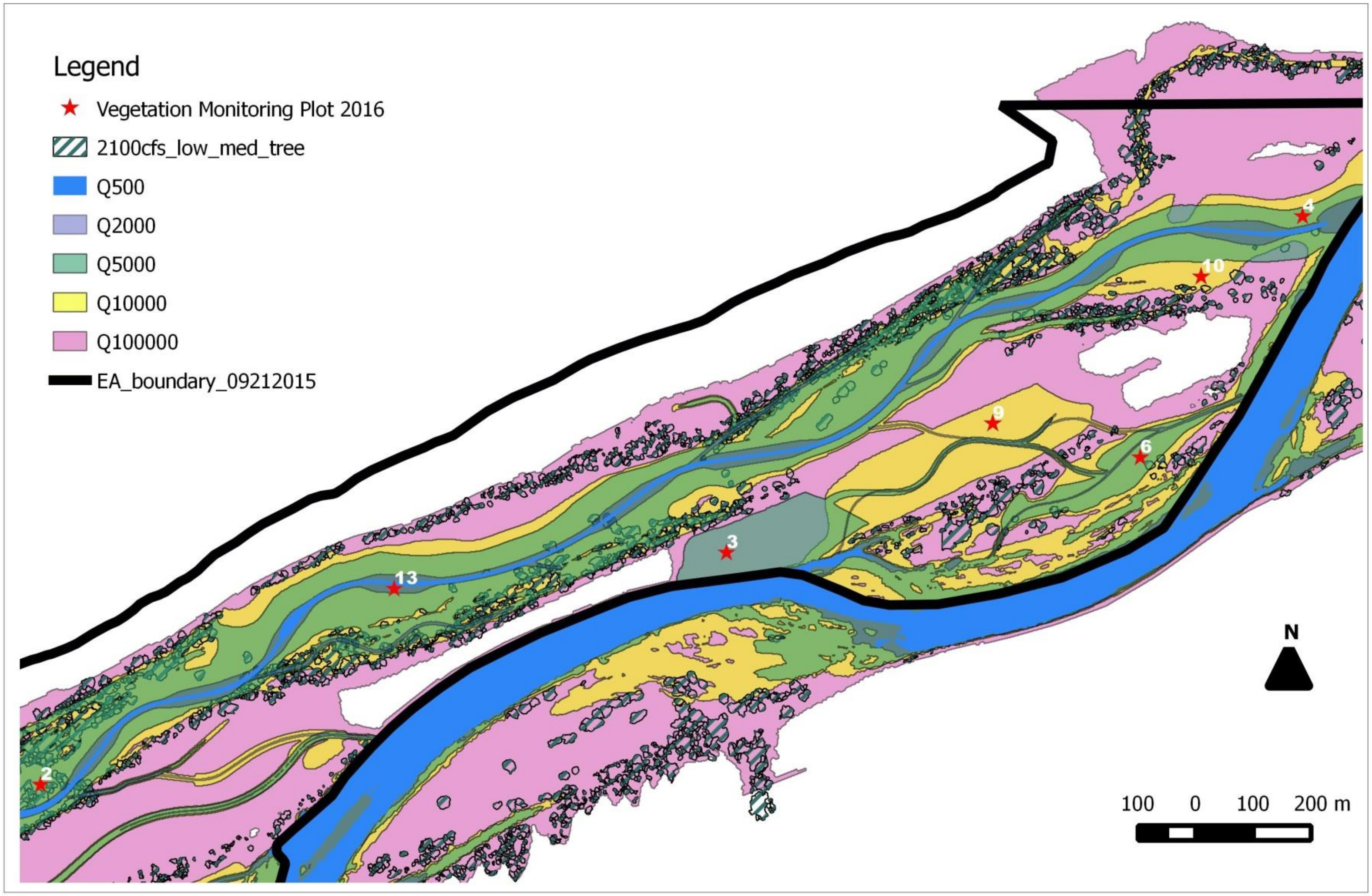

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Figure 4b – Project Site Vegetation Sampling Detail (Middle)

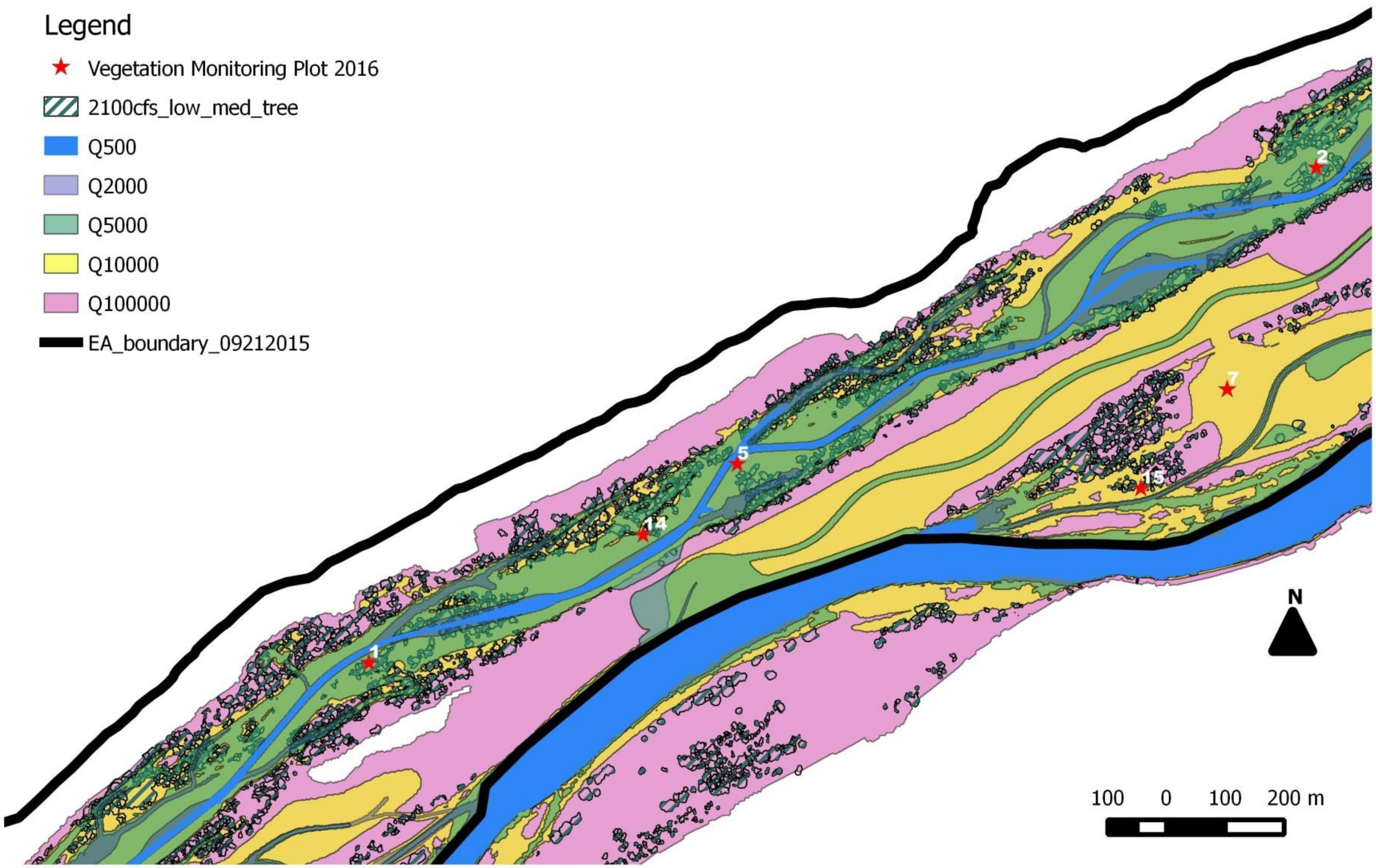

Figure 4c – Project Site Vegetation Sampling Detail (Downstream)

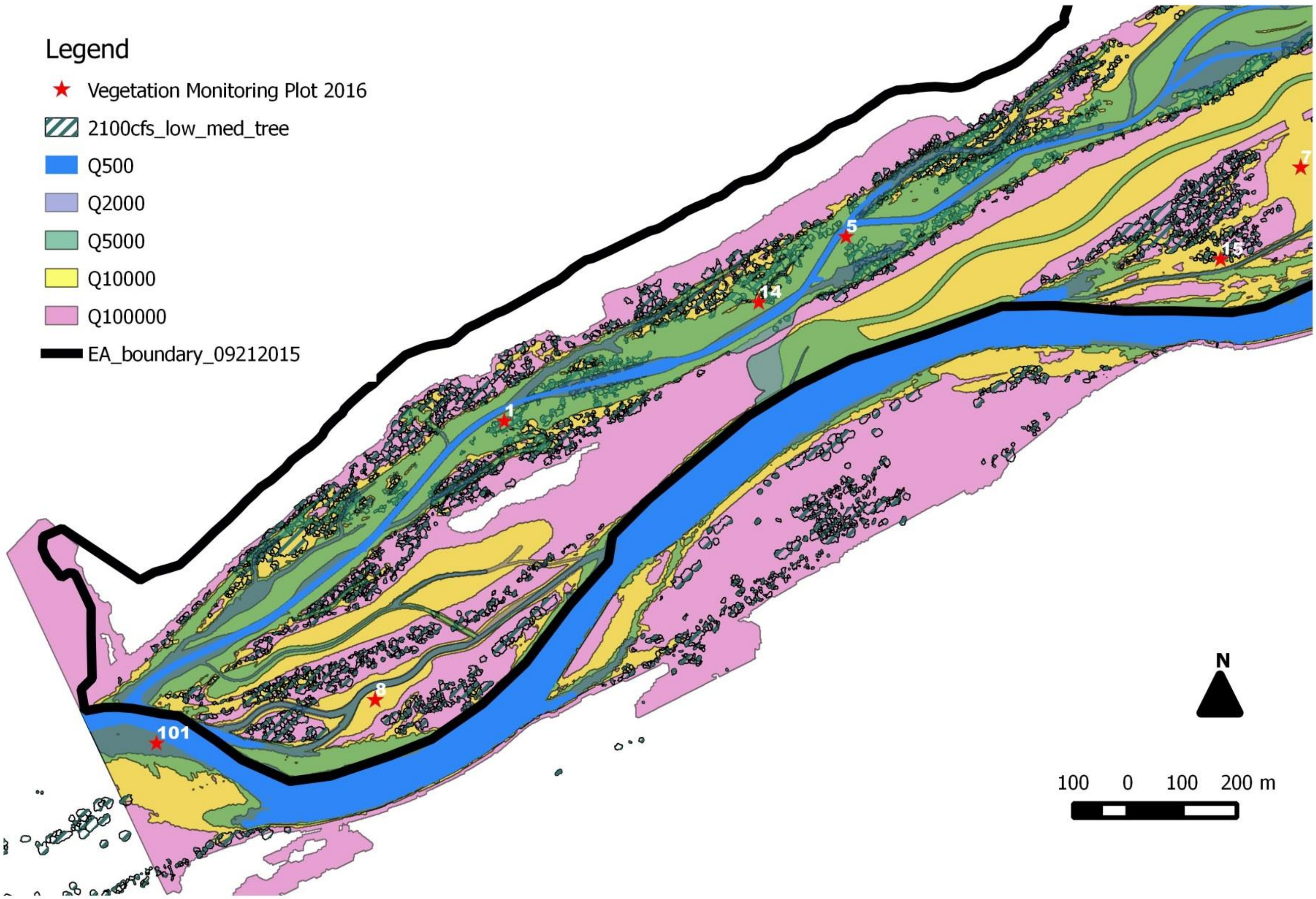

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Table 1. Special Status Plant Species with the Potential to Occur at the Project Site

Family	Scientific Name	Common Name	Listing	Habitat	Flowering
Fabaceae	*Astragalus pauperculus*	depauperate milk-vetch	CNPS 4.3	open, vernally moist volcanic clay	mar-may
Fabaceae	*Astragalus tener var. ferrisiae*	Ferris' milk-vetch	CNPS 1B.1	Alkaline flats, vernally moist meadows	mar-june
Azollaceae	*Azolla microphylla*	Mexican mosquito fern	CNPS 4.2	ponds, ditches	
Themidaceae	*Brodiaea sierrae*	sierra foothills brodiaea	CNPS 4.3	ultramafic, foothill, dry meadow	june-july
Onagraceae	*Clarkia biloba ssp. brandegeeae*	Brandegee's clarkia	CNPS 4.2	foothill woodland	june-july
Ranunculaceae	*Delphinium recurvatum*	recurved larkspur	CNPS 1B.2	Poorly drained, fine, alkaline soils in grassland	mar-june
Campanulaceae	*Downingia pusilla*	dwarf downingia	CNPS 2B.2	vernal pools, seasonal wetlands	mar-may
Liliaceae	*Fritillaria agrestis*	stinkbells	CNPS 4.2	grasslands	mar-june
Asteraceae	*Hesperevax caulescens*	hogwallow starfish	CNPS 4.2	drying vernal pools	mar-june
Juncaeae	*Juncus leiospermus var. ahartii*	Ahart's dwarf rush	CNPS 1B.2	vernal pool margins	mar-may
Campanulaceae	*Legenere limosa*	legenere	CNPS 1B.1	vernal pools, seasonal wetlands	may-june
Phrymaceae	*Mimulus glaucescens*	shield-bracted monkeyflower	CNPS 4.3	serpentine seeps	mar-may
Lamiaceae	*Monardella venosa*	veiny monardella	CNPS 1B.1	wet meadows	mar-june
Asteraceae	*Packera layneae*	Layne's butterweed	CNPS 1B.2	serpentine 300-900m	apr-june
Caryophyllaceae	*Paronychia ahartii*	Ahart's paronychia	CNPS 1B.1	drying vernal pools	mar-june
Boraginaceae	*Plagiobothrys glyptocarpus var. modestus*	Cedar Crest popcornflower	CNPS 3	seeps	apr-may
Asteraceae	*Pseudobahia bahiifolia*	Hartweg's golden sunburst	FE, CE, CNPS 1B.1	grassland, open woodland, clay soil	mar-may
Alismataceae	*Sagittaria sanfordii*	Sanford's arrowhead	CNPS 1B.2	ponds, ditches	may-oct
Araceae	*Wolffia brasiliensis*	Brazilian watermeal	CNPS 2B.3	ponds, ditches	apr-dec

Table 2 – 2016 Pre-Project Recruitment Summary for Both Sites

			Control	Project
			Summer 2016 (n = 1)	Summer 2016 (n = 1)
Recruitment	**Total Seedlings**		35	4
	Recruitment Richness		2	2
	Wetland		100.0%	0.0%
	Native		100.0%	100.0%
	Naturalized*		0.0%	0.0%
	Standard Deviation		50.0%	50.0%
	Populus fremontii	FACW	8.6%	
	Quercus douglasii	none		50.0%
	Quercus wislizeni	none		50.0%
	Salix melanopsis	OBL	91.4%	
	Standard Deviation		41.4%	0.0%

* denotes non-native species naturalized in California

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Table 3 – Vegetation Alliances and Associations for the Control and Project Sites

Alliance	Association	Common Name	Number of Plots	
			Control	Project
Alnus rhombifolia ‡	*(none)*	white alder		1
Avena fatua ‡	*(none)*	wild oats		2
Baccharis pilularis ‡	*Baccharis pilularis / Festuca myuros*	coyote bush / rattail fescue		1
Brickellia californica	*(none)*	California brickellbush		1
Festuca myuros	*(none)*	rattail fescue	2	3
Lupinus albifrons ‡	*(none)*	silver bush lupine	1	
Open water				2
Populus fremontii ‡	*(none)*	Fremont cottonwood		1
Quercus wislizeni ‡	*Quercus wislizeni - Q. douglasii / Bromus diandrus* ‡	interior live oak - blue oak / ripgut brome		1
Salix lasiolepis ‡	*Salix lasiolepis / Festuca myuros*	yellow willow / rattail fescue		2
Salix melanopsis	*(none)*	dusky willow	3	
Trichostema lanceolatum	*Trichostema lanceolatum / Festuca myuros*	vinegarweed / rattail fescue		1

‡ indicates alliance or association currently described in Sawyer et al. (2009)

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Table 4 – Vegetation Community Summary for the Control and Project Sites

Stratum	Origin	Scientific Name	Common Name	Wetland Status	Control Ave. % Cover	Control Count (n=6)	Project Ave. % Cover	Project Count (n=15)
Tree	Native	*Alnus rhombifolia*	white alder	FACW			75.0	1
		Pinus sabiniana	California foothill pine				10.0	1
		Populus fremontii	Fremont cottonwood	FACW			25.0	1
		Quercus douglasii	blue oak				15.0	1
		Quercus wislizeni	interior live oak				35.0	1
		Salix gooddingii	Goodding's willow	FACW			15.0	1
		Salix lasiolepis	arroyo willow	FACW			10.0	1
Shrub	Native	*Aristolochia californica*	California dutchman's pipe				0.2	2
		Baccharis pilularis	coyotebrush				5.0	2
		Brickellia californica	California brickellbush	FACU			1.4	3
		Lupinus albifrons	silver lupine		25.0	1	0.2	1
		Rubus ursinus	California blackberry	FACU	1.0	1	6.5	2
		Salix exigua	narrowleaf willow	FACW	10.0	1	4.4	3
		Salix lasiolepis	arroyo willow	FACW	35.0	1	50.0	2
		Salix melanopsis	dusky willow	OBL	35.0	3	5.3	3
		Toxicodendron diversilobum	Pacific poison oak				3.5	2
		Trichostema lanceolatum	vinegarweed	FACU	0.2	1		
		Vitis californica	California wild grape	FACU			20.0	1
	Introduced	*Rubus armeniacus*	Himalayan Blackberry		0.2	1	3.4	3
Sapling	Native	*Populus fremontii*	Fremont cottonwood	FACW	0.2	1		
		Salix laevigata	red willow	FACW	0.2	1		
Seedling	Native	*Populus fremontii*	Fremont cottonwood	FACW	0.2	1		
		Quercus douglasii	blue oak				0.2	1
		Quercus wislizeni	interior live oak				0.2	1
		Salix melanopsis	dusky willow	OBL	0.2	1		
Non-vasc		*Algae*					10.0	1
		Moss					4.8	4
Herb	Native	*Acmispon americanus*	Spanish clover		0.2	1	0.6	5
		Artemisia douglasiana	Douglas' sagewort	FAC			0.2	1
		Carex aquatilis	water sedge	OBL			0.2	1
		Cyperus eragrostis	tall flatsedge	FACW	0.2	1		

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Table 4 (cont.) – Vegetation Community Summary for the Control and Project Sites

Stratum	Origin	*Scientific Name*	Common Name	Wetland Status	Control Ave. % Cover	Control Count (n=6)	Project Ave. % Cover	Project Count (n=15)
Herb	Native	*Dichelostemma capitatum*	bluedicks	FACU	0.2	2	0.7	4
		Elodea canadensis	elodea	OBL			2.0	1
		Epilobium brachycarpum	tall annual willowherb		0.2	2	0.2	3
		Equisetum hyemale	scouringrush horsetail	FACW	5.0	1	5.0	1
		Eriogonum	buckwheat		0.6	2	0.2	5
		Eriophyllum lanatum var. grandiflorum	common woolly sunflower				0.2	1
		Eschscholzia caespitosa	tufted poppy		0.2	1	0.2	2
		Euthamia occidentalis	western goldentop	FACW	0.2	1		
		Galium aparine	stickywilly	FACU			0.2	2
		Juncus acuminatus	tapertip rush	OBL			0.2	1
		Juncus balticus	baltic rush				0.2	1
		Juncus effusus	common rush	FACW			0.2	1
		Leersia oryzoides	rice cutgrass	OBL			0.2	1
		Lotus argophyllus	silver bird's-foot trefoil				0.2	1
		Lycopus americanus	American water horehound	OBL	0.2	2	3.0	1
		Mentzelia laevicaulis	smoothstem blazingstar				0.2	2
		Phoradendron macrophyllum	Colorado Desert mistletoe				0.2	1
		Polypogon monspeliensis	annual rabbitsfoot grass	FACW	0.2	1		
		Stachys ajugoides	bugle hedgenettle	OBL	0.2	1	0.2	1
		Trichostema lanceolatum	vinegarweed	FACU			5.1	2
		Xanthium strumarium	rough cocklebur	FAC	0.2	1		
	Introduced	*Aira caryophyllea*	silver hairgrass	FACU	0.2	1	0.6	2
		Avena fatua	wild oat		0.5	3	2.3	8
		Brachypodium distachyon	purple false brome		0.2	2	0.7	7
		Brassica nigra	black mustard		0.2	2	0.2	4
		Bromus diandrus	ripgut brome		8.0	1	4.2	6
		Bromus hordeaceus	soft brome	FACU			0.2	1
		Bromus madritensis	compact brome		1.5	2	1.0	11
		Bromus tectorum	cheatgrass				0.2	1
		Carduus pycnocephalus	Italian plumeless thistle				0.2	3
		Centaurea solstitialis	yellow star-thistle				1.4	4

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Table 4 (cont.) – Vegetation Community Summary for the Control and Project Sites

Stratum	Origin	*Scientific Name*	Common Name	Wetland Status	Control Ave. % Cover	Control Count (n=6)	Project Ave. % Cover	Project Count (n=15)
Herb	Introduced	*Chondrilla juncea*	rush skeletonweed				0.2	1
		Cynodon dactylon	Bermudagrass	FACU	5.1	2	1.6	2
		Eleocharis pachycarpa	black sand spikerush	OBL			0.2	1
		Erodium botrys	longbeak stork's bill	FACU	15.0	1	0.6	2
		Festuca myuros	rattail fescue	FACU	15.8	5	11.2	9
		Hypochaeris	cat's ear				0.2	1
		Hypochaeris glabra	smooth cat's ear		0.5	3	0.4	4
		Lactuca serriola	prickly lettuce	FACU	0.2	1	0.2	1
		Logfia gallica	narrowleaf cottonrose		0.2	3	0.3	6
		Myriophyllum aquaticum	parrot feather watermilfoil	OBL			0.5	3
		Plantago lanceolata	narrowleaf plantain	FAC			0.2	1
		Pseudognaphalium luteoalbum	false cudweed	FAC	0.2	2		
		Rumex conglomeratus	clustered dock	FACW	0.2	1		
		Setaria viridis	Green bristle grass		0.2	1		
		Torilis arvensis	spreading hedgeparsley				0.2	1
		Trifolium hirtum	rose clover		0.2	1	0.7	3
		Verbascum sp.	mullein		0.2	1		
		Verbena bonariensis	purpletop vervain	FACW	0.2	1		
		Vicia sativa	garden vetch	FACU			0.2	1
	Unknown	*Bidens*	beggarticks		0.2	2	0.2	1
		Forb					0.2	1
		Ludwigia sp.	water primrose				0.2	1
		Lupinus sp.	lupine				0.2	4
		Melilotus sp.	sweetclover		0.2	1		
		Orthocarpus sp.					0.2	1
		Paspalum sp.	crowngrass		0.2	1		
		Poaceae	unknown Poaceae		0.2	2		
		Polygonum	knotweed		1.1	2		
		Polypogon	rabbitsfoot grass				0.2	1
		Sorghum sp.	sorghum		0.2	1	0.2	1
		Trifolium sp.	clover		0.2	2		

Table 5 - Invasive Naturalized Plants (Cal-IPC 2006) Recorded at the Control and Project Sites

Scientific Name	Common Name	Rating	Impact	Invasiveness	Distribution	Habitats of Concern & Comments	Presence	
							Control	Project
Avena barbata	slender oat	Moderate	Moderate	Moderate	Severe	Coastal scrub, grasslands, oak woodland, forest. Very widespread, but impacts more severe in desert regions.	x	x
Brassica nigra	black mustard	Moderate	Moderate	Moderate	Severe	Widespread. Primarily a weed of disturbed sites, but can be locally a more significant problem in wildlands.	x	x
Bromus diandrus	ripgut brome	Moderate	Moderate	Moderate	Severe	Dunes, scrub, grassland, woodland, forest. Very widespread, but monotypic stands uncommon.	x	x
Bromus hordaceus	soft chess	Limited	Moderate	Limited	Severe			x
Bromus tectorum	cheatgrass	High	Severe	Moderate	Severe			x
Carduus pycnocephalus	Italian thistle	Moderate	Moderate	Moderate	Severe	Forest, scrub, grasslands, woodland. Very widespread. Impacts may be variable regionally		x
Centaurea solstitialis	yellow starthistle	High	Severe	Moderate	Severe	Grasslands, woodlands, occasionally riparian		x
Chondrilla juncea	kkeletonweed	Moderate	Moderate	Moderate	Moderate	Grasslands. Very invasive in other western states, but currently limited in distribution in CA.		x
Cynodon dactylon	Bermuda grass	Moderate	Moderate	Moderate	Moderate	Riparian scrub in southern CA. Common landscape weed, but can be very invasive in desert washes.	x	x
Festuca myuros	rattail fescue	Moderate	Moderate	Moderate	Severe		x	x
Hypochaeris glabra	smooth cat's ear	Limited	Limited	Moderate	Moderate	Scrub and woodlands. Widespread. Impacts appear to be minor. Some local variability.	x	x
Myriophyllum aqauticum	parrot-feather	High	Severe	Moderate	Limited	Freshwater aquatic habitats		x
Polypogon monspeliensis	rabbitfootgrass	Limited	Limited	Limited	Moderate		x	
Rubus armeniacus	Himalayan blackberry	High	Severe	Severe	Severe	Riparian areas, marshes, oak woodlands	x	x
Torilis arvensis	hedge parsley	Moderate	Limited	Moderate	Severe	Expanding range. Appear to have only moderate ecological impacts.		x
Trifolium hirtum	rose clover	Limited	Limited	Moderate	Moderate		x	x

Attachment A – CNPS Combined Vegetation Rapid Assessment & Relevé Protocol

CALIFORNIA NATIVE PLANT SOCIETY / DEPARTMENT OF FISH AND GAME PROTOCOL FOR COMBINED VEGETATION RAPID ASSESSMENT AND RELEVÉ SAMPLING FIELD FORM (September, 10 2009)

Introduction
This protocol describes the methodology for both the relevé and rapid assessment vegetation sampling techniques as recorded in the combined relevé and rapid assessment field survey form dated September 10, 2009. The same environmental data are collected for both techniques. However, the relevé sample is plot-based, with each species in the plot and its cover being recorded. The rapid assessment sample is based not on a plot but on the entire stand, with 12-20 of the dominant or characteristic species and their cover values recorded. For more background on the relevé and rapid assessment sampling methods, see the relevé and rapid assessment protocols at www.cnps.org.

Selecting stands to sample:
To start either the relevé or rapid assessment method, a stand of vegetation needs to be defined. A stand is the basic physical unit of vegetation in a landscape. It has no set size. Some vegetation stands are very small, such as alpine meadow or tundra types, and some may be several square kilometers in size, such as desert or forest types. A stand is defined by two main unifying characteristics:

1) It has compositional integrity. Throughout the site, the combination of species is similar. The stand is differentiated from adjacent stands by a discernable boundary that may be abrupt or indistinct.
2) It has structural integrity. It has a similar history or environmental setting that affords relatively similar horizontal and vertical spacing of plant species. For example, a hillside forest originally dominated by the same species that burned on the upper part of the slopes, but not the lower, would be divided into two stands. Likewise, sparse woodland occupying a slope with very shallow rocky soils would be considered a different stand from an adjacent slope with deeper, moister soil and a denser woodland or forest of the same species.

The structural and compositional features of a stand are often combined into a term called homogeneity. For an area of vegetated ground to meet the requirements of a stand, it must be homogeneous (uniform in structure and composition throughout). Stands to be sampled may be selected by evaluation prior to a site visit (*e.g.*, delineated from aerial photos or satellite images), or they may be selected on site during reconnaissance to determine extent and boundaries, location of other similar stands, etc.. Depending on the project goals, you may want to select just one or a few representative stands of each homogeneous vegetation type for sampling (*e.g.*, for developing a classification for a vegetation mapping project), or you may want to sample all of them (*e.g.*, to define a rare vegetation type and/or compare site quality between the few remaining stands).
For the rapid assessment method, you will collect data based on the entire stand.

Selecting a plot to sample within in a stand (for relevés only):
Because many stands are large, it may be difficult to summarize the species composition, cover, and structure of an entire stand. We are also usually trying to capture the most information as efficiently as possible. Thus, we are typically forced to select a representative portion to sample. When sampling a vegetation stand, the main point to remember is to select a sample that, in as many ways possible, is representative of that stand. This means that you are not randomly selecting a plot; on the contrary, you

are actively using your own best judgment to find a representative example of the stand. Selecting a plot requires that you see enough of the stand you are sampling to feel comfortable in choosing a representative plot location. Take a brief walk through the stand and look for variations in species composition and in stand structure. In many cases in hilly or mountainous terrain look for a vantage point from which you can get a representative view of the whole stand. Variations in vegetation that are repeated throughout the stand should be included in your plot. Once you assess the variation within the stand, attempt to find an area that captures the stand's common species composition and structural condition to sample.

Plot Size

All relevés of the same type of vegetation to be analyzed in a study need to be the same size. Plot shape and size are somewhat dependent on the type of vegetation under study. Therefore, general guidelines for plot sizes of tree-, shrub-, and herbaceous communities have been established. Sufficient work has been done in temperate vegetation to be confident the following conventions will capture species richness:

Herbaceous communities: 100 sq. m plot
Shrublands: 400 sq. m plot
Forest and woodland communities: 1000 sq. m plot

Plot Shape

A relevé has no fixed shape, though plot shape should reflect the character of the stand. If the stand is about the same size as a relevé, you need to sample the entire stand. If we are sampling streamside riparian or other linear communities, our plot dimensions should not go beyond the community's natural ecological boundaries. Thus, a relatively long, narrow plot capturing the vegetation within the stand, but not outside it would be appropriate. Species present along the edges of the plot that are clearly part of the adjacent stand should be excluded. If we are sampling broad homogeneous stands, we would most likely choose a shape such as a circle (which has the advantage of the edges being equidistant to the center point) or a square (which can be quickly laid out using perpendicular tapes).

Definitions of fields in the protocol

Relevé or Rapid Assessment (Circle One).

LOCATIONAL/ENVIRONMENTAL DESCRIPTION

Polygon/Stand #: Number assigned either in the field or in the office prior to sampling. It is usually denoted with a four-letter abbreviation of the sampling location and then a four-number sequential number of that locale (*e.g.* CARR0001 for Carrizo sample #1). The maximum number of letters/numbers is eight.

Air photo #: The number given to the aerial photo in a vegetation-mapping project, for which photo interpreters have already done photo interpretation and delineations of polygons. If the sample site has not been photo-interpreted, leave blank.

Date: Date of the sampling.

Name(s) of surveyors: The full names of each person assisting should be provided for the first field form for the day. On successive forms, initials of each person assisting can be recorded. Please note: The person recording the data on the form should circle their name/initials.

GPS waypoint #: The waypoint number assigned by a Global Positioning System (GPS) unit when marking and storing a waypoint for the sample location. Stored points should be downloaded in the office to serve as a check on the written points and to enter into a GIS.

For relevé plots, take the waypoint in the southwest corner of the plot or in the center of a circular plot.

GPS name: The name/number assigned to each GPS unit. This can be the serial number if another

number is not assigned.
Datum: (NAD 83) The standard GPS datum used is NAD 83. If you are using a different datum, denote it here.
Bearing, left axis at SW pt (note in degrees) of Long or Short side: For square or rectangular plots: from the SW corner (=GPS point location), looking towards the plot, record the bearing of the axis to your left. If the plot is a rectangle, indicate whether the left side of the plot is the long or short side of the rectangle by circling "long" or "short" side (no need to circle anything for circular or square plots). If there are no stand constraints, W/E should run along the short side while N/S should run along the long side of the rectangle.
UTM coordinates: Easting (UTME) and northing (UTMN) location coordinates using the Universal Transverse Mercator (UTM) grid. Record using a GPS unit.
UTM zone: Universal Transverse Mercator zone. Zone 10 is for California west of the 120th longitude, zone 11 is for California east of 120th longitude
Error: ± The accuracy of the GPS location, when taking the UTM field reading. Please denote the units of feet (ft), meters (m), or positional dilution of precision (pdop). If your GPS does not determine error, insert N/A in this field.
Is GPS within stand? Yes / No Circle"Yes" to denote that the GPS waypoint was taken directly within or at the edge of the stand being assessed for a rapid assessment, or circle "No" to denoted the waypoint was taken at a distance from the stand (such as with a binocular view of the stand).
If No, cite from waypoint to stand, distance (note in meters) & bearing (note in degrees): An estimate of the number of feet or meters (please circle appropriate), the compass bearing from the waypoint of GPS to the stand.
Elevation: Recorded from the GPS unit or USGS topographic map. Please denote feet (ft) or meters (m).
Photograph #s: Write the name or initials of the camera owner, JPG/frame number, and direction of photos (note the roll number if using film). *Take four photos in the main cardinal directions (N, E, S, W) clockwise from the north, from the GPS location.* If additional photos are taken in other directions, please note this information on the form.
Stand Size: Estimate the size of the entire stand in which the sample is taken. As a measure, one acre is about 4000 square meters, or 208 feet by 208 feet.
Plot Size: If this is a relevé, circle the size of the plot.
Plot Shape: Denote the length and width of the plot and include measurement units (i.e., ft or m). If it is a circular plot, enter radius (or just check).
Exposure: (Enter actual º and circle general category): Read degree slope from compass (or estimate), using degrees from north, adjusted for declination. Average the reading over entire stand, even if you are sampling a relevé plot, since your plot is representative of the stand. "Variable" may be selected if the same, homogenous stand of vegetation occurs across a varied range of slope exposures. Select "all" if stand is on top of a knoll that slopes in all directions or if the same, homogenous stand of vegetation occurs across all ranges of slope.
Steepness: (Enter actual º and circle general category): Read degree aspect from a compass or clinometer (or estimate). Make sure to average the reading across entire stand even if you are sampling in a relevé plot.
Topography: First assess the broad (macro) topographic feature or general position of the stand in the surrounding watershed, that is, the stand is at the bottom, lower (1/3 of slope), middle (1/3 of slope), upper (1/3 of slope), or at the top. Circle all of the positions that apply. Then, assess the local (micro) topographic features or the lay of the area (*e.g.*, surface is flat or concave). Circle only one of the microtopographic descriptors.
Geology: Geological parent material of site. If exact type is unknown, use a more general category

(*e.g.*, igneous, metamorphic, sedimentary). *See code list for types.*
Soil Texture: Record soil texture that is characteristic of the site (*e.g.*, coarse loamy sand, sandy clay loam). *See soil texture key and code list for types.*
Upland or Wetland/Riparian (circle one): Indicate if the stand is in an upland or a wetland. Note that a site need not be officially delineated as a wetland to qualify as such in this context (*e.g.*, seasonally wet meadow).
% Surface cover (abiotic substrates). It is helpful to imagine "mowing off" all of the live vegetation at the base of the plants and removing it – you will be estimating what is left covering the surface. **The total should sum to 100%.** Note that non-vascular cover (lichens, mosses, cryptobiotic crusts) is not estimated in this section.

> **% Water**: Estimate the percent surface cover of running or standing water, ignoring the substrate below the water.
> **% BA Stems**: Percent surface cover of the plant basal area, *i.e.*, the basal area of stems at the ground surface. Note that for most vegetation types BA is 1-3% cover.
> **% Litter**: Percent surface cover of litter, duff, or wood on the ground.
> **% Bedrock**: Percent surface cover of bedrock.
> **% Boulders:** Percent surface cover of rocks > 60 cm in diameter.
> **% Stone:** Percent surface cover of rocks 25-60 cm in diameter.
> **% Cobble:** Percent surface cover of rocks 7.5 to 25 cm in diameter.
> **% Gravel:** Percent surface cover of rocks 2 mm to 7.5 cm in diameter.
> **% Fines:** Percent surface cover of bare ground and fine sediment (e.g. dirt) < 2 mm in diameter.

% Current year bioturbation: Estimate the percent of the sample or stand exhibiting soil disturbance by fossorial organisms (any organism that lives underground). Do not include disturbance by ungulates. Note that this is a separate estimation from surface cover.
Past bioturbation present? Circle "Y" (yes) if there is evidence of bioturbation from previous years.
% Hoof punch: Note the percent of the sample or stand surface that has been punched down by hooves (cattle or native grazers) in wet soil.
Site history, stand age, and comments: Briefly describe the stand age/seral stage, disturbance history, nature and extent of land use, and other site environmental and vegetation factors. Examples of disturbance history: fire, landslides, avalanching, drought, flood, animal burrowing, or pest outbreak. Also, try to estimate year or frequency of disturbance. Examples of land use: grazing, timber harvest, or mining. Examples of other site factors: exposed rocks, soil with finetextured sediments, high litter/duff build-up, multi-storied vegetation structure, or other stand dynamics.
Type / level of disturbance (use codes): List codes for potential or existing impacts on the stability of the plant community. Characterize each impact each as L (=Light), M (=Moderate), or H (=Heavy). For invasive exotics, divide the total exotic cover (e.g. 25% Bromus diandrus + 8% Bromus madritensis + 5% Centaurea melitensis = 38% total exotics) by the total % cover of all the layers went added up (e.g. 15% tree + 5% low tree + 25% shrub + 40% herbs = 85% total) and multiply by 100 to get the % relative cover of exotics (e.g. 38% total exotics/85% total cover = 45% relative exotic cover). L = 0-33% *relative* cover of exotics; M =34-66% relative cover, and H = > 66% relative cover. *See code list for impacts.*

II. HABITAT AND VEGETATION DESCRIPTION *per California Wildlife-Habitat Relationships (CWHR)*

For CWHR, identify the size/height class of the stand using the following tree, shrub, and/or herbaceous categories. These categories are based on functional life forms.
Tree DBH: Record tree size classes when the tree canopy closure exceeds 10 percent of the total cover (except in desert types), or if young tree density indicates imminent tree dominance. Size class is based on the average diameter at breast height (dbh) of each trunk (standard breast height is 4.5ft/137cm).

You can record tree size class by circling the main size class(es), When marking the main size class, make sure to estimate the mean diameter of all trees over the entire stand, and weight the mean if there are some larger tree dbh's. The "**T6 multi-layered**" dbh size class contains a multi-layered tree canopy (with a size class T3 and/or T4 layer growing under a T5 layer and a distinct height separation between the classes) exceeding 60% total cover. Stands in the T6 class need also to contain at least 10% cover of size class 5 (>24" dbh) trees growing over a distinct layer with at least 10% combined cover of trees in size classes 3 or 4 (>11-24" dbh).

Shrub (mark one)**:** Record shrub size classes when shrub canopy closure exceeds 10 percent (except in desert types). You can record shrub size class by circling the class that is predominant in the survey. Shrub size class is based on the average amount of crown decadence (dead standing vegetation on live shrubs when looking across the crowns of the shrubs).

Herb (mark one)**:** Record herb height when herbaceous cover exceeds 2 percent. You can record herb class by the size class that is predominant in the survey (**H1 or H2**). *This height class is based on the average plant height at maturity.*

Overall cover of vegetation

Provide an estimate of cover for the following categories below (based on functional life forms). Record a specific number for the total aerial cover or "bird's-eye view" looking from above for each category, estimating cover for the living plants only. Litter/duff should not be included in these estimates. The porosity of the vegetation should be taken into consideration when estimating percent cover (how much of the sky can you see when you are standing under the canopy of a tree, or how much light passes through the canopy of the shrub layer?). To come up with a specific number estimate for percent cover, first use to the following CWHR cover intervals as a reference aid to get a generalized cover estimate: <2%, 2-9%, 10-24%, 25-39%, 40-59%, 60-100%. While keeping these intervals in mind, you can then refine your estimate to a specific percentage for each category below.

% Total Non-Vasc cover: The total cover of all lichens and bryophytes (mosses, liverworts, hornworts) on substrate surfaces including downed logs, rocks and soil, but not on standing or inclined trees.

% Total Vasc Veg cover: The total cover of all vascular vegetation taking into consideration the porosity, or the holes, in the vegetation. This is an estimate of the absolute vegetation cover, disregarding overlap of the various tree, shrub, and/or herbaceous layers and species.

%Overstory Conifer/Hardwood Tree: The total foliar cover (considering porosity) of all live tree species (>5 m tall) that are specifically in the overstory or are emerging, disregarding overlap of individual trees. Estimate conifer and hardwood covers separately. Please note: These cover values should not include the coverage of recruits of overstory tree species (the only place that seedlings and saplings should be considered is in the species list in the "U" stratum category).

%Low-Medium Tree: The total foliar cover (considering porosity) of all live understory low to medium height tree species, disregarding overlap of individual trees and shrubs. This category only includes tree species that typically do not make up the overstory canopy. Please note: These cover values should not include the coverage of recruits of overstory tree species (the only place that seedlings and saplings should be considered is in the species list in the "U" stratum category).

%Shrub: The total foliar cover (considering porosity) of all live shrub species disregarding overlap of individual shrubs.

%Herbaceous: The total cover (considering porosity) of all herbaceous species, disregarding overlap of individual herbs.

Modal height for conifer/hardwood tree, shrub, and herbaceous categories: Provide an estimate of height for each category listed. Record an average height value per each category by estimating the mean height for each group. Please use the following height intervals to record a height class: 01=<1/2m, 02=1/2-1m, 03=1-2m, 04=2-5m, 05=5-10m, 06=10-15m, 07=15-20m, 08=20-35m, 09=35-50m, 10=>50m.

Species list and coverage
For rapid assessments, list the 10-20 species that are dominant or that are characteristically consistent throughout the stand. These species may or may not be abundant, but they should be constant representatives in the survey. When different layers of vegetation occur in the stand, make sure to list species from each stratum. As a general guide, make sure to list at least 1-2 of the most abundant species per stratum.
For relevés, list all species present in the plot, using the second species list page if necessary.
For both sample types, provide the stratum where:

> **T= Overstory tree.** A woody perennial plant that has a single trunk.
> **U= Understory tree**. Trees species that grow under the overstory trees. Note: this also includes seedlings and saplings of trees that may be in the overstory.
> **S = Shrub.** A perennial, woody plant that is multi-branched and doesn't die back to the ground every year.
> **H= Herb.** An annual or perennial that dies down to ground level every year.
> **N= Non-vascular**. Includes mosses, liverworts, hornworts, and algae.

Be consistent and don't break up a single species into two separate strata. The only time it would be appropriate to do so is when you have a tree that is in the overstory (T) and it is also recruiting in the understory (U).

If a species collection is made, it should be indicated in the collection column with a "C" (for collected). If the species is later keyed out, the data sheet needs to be updated with the proper species name. If the specimen is then thrown out, the "C" in the collection column should be erased. If the specimen is kept but is still not confidently identified, add a "U" to the "C" in the collection column (CU = collected and unconfirmed). In this case the unconfirmed species epithet should be put in parentheses [e.g *Hordeum (murinum)*]. If the specimen is kept and is confidently identified, add a "C" to the existing "C" in the collection column (CC = Collected and confirmed). Use Jepson Manual nomenclature. Provide the % absolute aerial cover for each species listed. When estimating, it is often helpful to think of coverage in terms of the following cover intervals at first:

> <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, >75%.

Keeping these classes in mind, then refine your estimate to a specific percentage. All species percent covers may total over 100% because of overlap. For rapid assessments, make sure that the major non-native species occurring in the stand also are listed in the space provided in the species list with their strata and % cover. For relevés, all nonnative species should be included in the species list.
Unusual species: List species that are locally or regionally rare, endangered, or atypical (*e.g.*, range extension or range limit) within the stand. This species list will be useful to the Program for obtaining data on regionally or locally significant populations of plants. Include the percent cover of snags (standing dead) of trees and shrubs. Note their species, if known, in the "Stand history, stand age and comments" section.

INTERPRETATION OF STAND

Field-assessed vegetation alliance name: Name of alliance or habitat following the most recent CNPS classification system or the Manual of California Vegetation (Sawyer J.O., Keeler-Wolf T., and Evens, J. 2009). Please use scientific nomenclature, *e.g., Quercus agrifolia* forest. An alliance is based on the dominant or diagnostic species of the stand, and is usually of the uppermost and/or dominant height stratum. A dominant species covers the greatest area. A diagnostic species is consistently found in some vegetation types but not others. Please note: The field-assessed alliance name may not exist in present classification, in which case you can provide a new alliance name in this field. If this is the case, also make sure to state that it is not in the MCV under the explanation for "Confidence in alliance identification."

Field-assessed association name (optional): Name of the species in the alliance and additional dominant/diagnostic species from any strata, as according to CNPS classification. In following naming conventions, species in differing strata are separated with a slash, and species in the uppermost stratum are listed first (*e.g., Quercus douglasii/Toxicodendron diversilobum*). Species in the same stratum are separated with a dash (*e.g., Quercus lobata-Quercus douglasii)*. Please note: The field-assessed association name may not exist in present classification, in which you can provide a new association name in this field.

Adjacent Alliances: Identify other vegetation types that are directly adjacent to the stand being assessed by noting the dominant species (or known type). Also note the distance away in meters from the GPS waypoint and the direction in degrees aspect that the adjacent alliance is found (e.g., *Amsinckia tessellata* 50m, 360°/N *Eriogonum fasciculatum* 100m, 110°).

Confidence in Identification: (L, M, H) With respect to the "field-assessed alliance name", note whether you have L (=Low), M (=Moderate), or H (=High) confidence in the interpretation of this alliance name.

Explain: Please elaborate if your "Confidence in Identification" is low or moderate. Low confidence can occur from such things as a poor view of the stand, an unusual mix of species that does not meet the criteria of any described alliance, or a low confidence in your ability to identify species that are significant members of the stand.

Phenology: Indicate early (E), peak (P) or late (L) phenology for each of the strata.

Other identification problems or mapping issues: Discuss any further problems with the identification of the assessment or issues that may be of interest to mappers. Note if this sample represents a type that is likely too small to map, and if so, how much of the likely mapping unit would be comprised of this type. For example: "this sample represents the top of kangaroo rat precincts in this general area, which are surrounded by vegetation represented by CARR000x; this type makes up 10% of the mapping unit."

DRAFT

Simplified Key to Soil Texture

(Adapted from Brewer and McCann 1982)

Place about three teaspoons of soil in the palm of your hand. Take out any particles ≥ 3 mm in size.

A. Does soil remain in ball when squeezed in your hand palm?

Yes, soil does remain in a ball when squeezed............…... **B**

No, soil does not remain in a ball when squeezed.....................…..................................... **sand**

SAND Sand (class unknown)

Very coarse texture……………………………….………COSA Coarse sand

Moderately coarse texture…………………….…………… MESN Medium sand

Moderately fine texture……………………………………….. FISN Fine sand

B. Add a small amount of water until the soil feels like putty. Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger. Does soil make a ribbon?

Yes, soil makes a ribbon; though it may be very short...**C**

No, soil does not make a ribbon..…...............................**loamy sand**

Very gritty with coarse particles…..COLS Coarse, loamy sand

Moderately to slightly gritty with medium to fine particles........ .MELS Medium to very fine, loamy sand

C. Does ribbon extend more than one inch?

Yes, soil extends > 1 inch..**D**

No, soil does not extend > 1 inch..Add excess water

Soil feels gritty or not smooth………...………………..…............. **sandy loam or loam**

LOAM Loam (class unknown)

Very gritty with coarse particles…..MCSL Moderately coarse, sandy loam

Moderately gritty with medium to fine particles........................MESA Medium to very fine, sandy loam

Slightly gritty ....MELO Medium loam

Soil feels very smooth...…...............**silt loam**

MESIL medium silt loam

D. Does ribbon extend more than 2 inches?

Yes, ribbon extends more than 2 inches, and does not crack if bent into a ring..........................**E**

No, soil breaks when 1–2 inches long; cracks if bent into a ring………………...Add excess water

Soil feels gritty or not smooth...**sandy clay loam or clay loam**

Moderately to very gritty………………………………………... MFSA Moderately fine sandy clay loam

Slightly gritty or not smooth…………………………………… MFCL Moderately fine clay loam

Soil feels very smooth..…...**silty clay loam or silt**

Moderately fine texture………………………………………....MFSL Moderately fine silty clay loam

Very fine texture………………………………………………….. MESI Medium silt

E. Soil makes a ribbon 2+ inches long; does not crack when bent into a ring................Add excess water

Soil feels gritty or not smooth...**sandy clay or clay**

Moderately to very gritty……………………………………… FISA Fine sandy clay

Slightly gritty or not smooth………………………………….. FICL Fine clay

CLAY Clay (class unknown)

Soil feels very smooth...…..….........**silty clay**

FISC Fine silty clay

UNKN = UNKNOWN PEAT = PEAT MUCK = MUCK

June 23, 2008

GEOLOGY CODE
IGTU Igneous (type unknown)
MIIG Mixed igneous
ULTU Ultramafic (type unknown)
VOLC General volcanic extrusives
ANDE Andesite
ASHT Ash (of any origin)
BASA Basalt
DIAB Diabase
OBSI Obsidian
PUMI Pumice
PYFL Pyroclastic flow
RHYO Rhyolite
VOFL Volcanic flow
VOMU Volcanic mud
INTR General igneous intrusives
DIOR Diorite
GABB Gabbro
GRAN Granitic (generic)
MONZ Monzonite
PERI Peridotite
QUDI Quartz diorite
METU Metamorphic (type unknown)
MIME Mixed metamorphic
GREE Greenstone
BLUE Blue schist
FRME Franciscan melange
GNBG Gneiss/biotite gneiss
HORN Hornfels
MARB Marble
PHYL Phyllite
SCHI Schist
SESC Semi-schist
SLAT Slate
ULTU Ultramafic (type unknown)
SERP Serpentine
SETU Sedimentary (type unknown)
BREC Breccia (non-volcanic)
CACO Calcareous conglomerate
CALU Calcareous (origin unknown)
CASA Calcareous sandstone
CASH Calcareous shale
CASI Calcareous siltstone
CHER Chert
CONG Conglomerate
DOLO Dolomite
FANG Fanglomerate
LIME Limestone
MISE Mixed sedimentary
SAND Sandstone
SHAL Shale
SILT Siltstone
CLAL Clayey alluvium
DUNE Sand dunes
GLTI Glacial till, mixed origin, moraine
GRAL Gravelly alluvium
LALA Large landslide (unconsolidated)
LOSS Loess
MIAL Mixed alluvium
SAAL Sandy alluvium
SIAL Silty alluvium
MIRT Mix of two or more rock types
OTHE Other than on list

ROCK SIZE
Boulder > 60 cm diameter
Stone 25 cm to 60 cm
Cobble 7.5 cm to 25 cm
Gravel 2 mm to 7.5 cm
Fines < 2 mm

DISTURBANCE CODES
01 Development
02 ORV activity
03 Agriculture
04 Grazing
05 Competition from exotics
06 Logging
07 Insufficient population/stand size
08 Altered flood/tidal regime
09 Mining
10 Hybridization
11 Groundwater pumping
12 Dam/inundation
13 Other
14 Surface water diversion
15 Road/trail construction/maint.
16 Biocides
17 Pollution
18 Unknown
19 Vandalism/dumping/litter
20 Foot traffic/trampling
21 Improper burning regime
22 Over collecting/poaching
23 Erosion/runoff
24 Altered thermal regime
25 Landfill
26 Degrading water quality
27 Wood cutting
28 Military operations
29 Recreational use (non ORV)
30 Nest parasitism
31 Non-native predators
32 Rip-rap, bank protection
33 Channelization (human caused)
34 Feral pigs
35 Burros
36 Rills
37 Phytogenic mounding
38 Sudden Oak Death