Working Version 4

NAPA RIVER RESTORATION

Basis of Design: Oakville to Oak Knoll Reach

Prepared for
County of Napa

November 2019

Working Version 4

NAPA RIVER RESTORATION

Basis of Design: Oakville to Oak Knoll Reach

Prepared for
County of Napa

November 2019

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900
esassoc.com

Bend	Oakland	San Diego
Camarillo	Orlando	San Francisco
Delray Beach	Pasadena	Santa Monica
Destin	Petaluma	Sarasota
Irvine	Portland	Seattle
Los Angeles	Sacramento	Tampa

OUR COMMITMENT TO SUSTAINABILITY | ESA helps a variety of public and private sector clients plan and prepare for climate change and emerging regulations that limit GHG emissions. ESA is a registered assessor with the California Climate Action Registry, a Climate Leader, and founding reporter for the Climate Registry. ESA is also a corporate member of the U.S. Green Building Council and the Business Council on Climate Change (BC3). Internally, ESA has adopted a Sustainability Vision and Policy Statement and a plan to reduce waste and energy within our operations. This document was produced using recycled paper.

TABLE OF CONTENTS

Napa River Restoration
Basis of Design: Oakville to Oak Knoll Reach

Page

List of Figures

List of Tables

1. INTRODUCTION

In 2011 a team led by the California Land Stewardship Institute (CLSI), ESA PWA (now ESA), and the Napa County Resource Conservation District (NRCD) published a conceptual plan to restore the Napa River between Oakville Cross Road Bridge and Oak Knoll Avenue Bridge. In 2012 Napa County Water Conservation and Flood Control District (Flood District) hired a team led by ESA to advance the conceptual design to final design. This document is the Basis of Design (BoD) for the final restoration design and is considered a living document that will be updated to reflect technical analyses conducted at the refined concept-, 30% design-, and final design-level for each construction Grouping. The Basis of Design provides the rationale, assumptions, and design criteria for the proposed project restoration elements (channel widening, floodplain restoration, biotechnical stabilization, in-stream habitat features, gravel augmentation, etc). After completion of each construction grouping, design criteria can be used to test restoration effectiveness and whether restoration actions function as anticipated and meet the project goals. In adopting this transparent approach to our design we are acknowledging the somewhat experimental nature of restoration design and facilitating the process of learning lessons and adaptively managing this and other projects in future.

1.1 Summary of Historical Conditions

Before developing potential restoration actions it is helpful to consider the historic trajectory of the Napa River; to look at its evolution from historic to contemporary conditions. We recognize that the watershed has changed irreversibly (through urbanization, increases in runoff, and reductions in coarse sediment supply) and that true 'restoration' to those conditions is neither realistic nor sustainable. However, historic conditions provide a valuable source of information on how parts of the system can function when undisturbed, which specific geomorphic processes have been degraded or lost, and most importantly which restoration actions may supplement or increase degraded or lost processes that have led to the general decline in aquatic and terrestrial habitat along the project reach.

The San Francisco Estuary Institute undertook a significant project to understand the historical ecology of the Napa River Valley, the compendium of physical, social, and temporal factors that are responsible for contemporary conditions (SFEI, 2012). Historically, the Napa River in the Oakville to Oak Knoll area was characterized by a dynamic anabranching channel network within a broad alluvial valley of riparian and wetland habitats. Prior to Euro-American settlement, the Napa River was system of distributary channels and sloughs, weaving through seasonally wet meadows with pockets of freshwater marsh. In contrast to today's river which in most reaches has a single, deeply entrenched channel that flows onto the floodplain less than once every 10 years, the pre-European Napa River was characterized by a large number of smaller, shallower channels that spilled onto the floodplain much more frequently. Many of the basin's tributaries dissipated into wetlands which slowed the rise of flood waters and metered sediment transport and erosion processes in the main stem Napa River. Water entering the wetlands also recharged

groundwater aquifers which in turn maintained river base flows during the dry season. Compared with current conditions the riparian corridor was much more connected to its floodplain, with much more extensive, gentler and more complex transitions between aquatic, wetland and upland habitat.

With such a complex fresh water system, the Napa River was once ideal for supporting a wide diversity of aquatic species including anadromous salmonids. It is estimated the basin once supported approximately 8,000 Steelhead trout and 4,000 Coho salmon (USFWS, 1968). Historical abundance of Chinook salmon is less certain, however based on historical channel form, hydrology, ecology, and proximity to the Sacramento River and San Joaquin River Delta, the Napa River likely supported a sustainable population of Chinook salmon (Stillwater Sciences, 2002). In addition, the riparian corridor and floodplain supported a wide array of flora and fauna.

1.2 Summary of Existing Conditions

In 2002 the Napa River was listed as impaired for salmonids, and a Limiting Factors Report was prepared by Stillwater Sciences (Stillwater Sciences, 2002). The Limiting Factors Report provides a helpful summary of the causes of degradation on the river, and points to potential actions to reverse in-stream habitat degradation. Land use practices related to the development of the Napa Valley over the past 150 years have altered the physical characteristics of the Napa River landscape. In particular, four significant changes have impacted channel morphology and in-stream habitat conditions in the Napa River (SFEI, 2012):

- Urbanization of the watershed has increased impervious surface area and runoff. More runoff per unit area now reaches the tributaries of the Napa River than was historically the case.
- The drainage efficiency of Napa River's tributaries has been significantly increased. Runoff that would previously have infiltrated, ponded on the surface, or been slowly conveyed to the river through wetlands is now conveyed directly to the mainstem by a system of channelized tributaries that have been extended with stormwater channels, agricultural ditches, and tile drains.
- The Napa River has been narrowed and confined with the construction of agricultural berms. Secondary channels have been cut-off from the channel which results in a single thread, deepened, and more hydraulically efficient channel with a higher risk of erosion.
- At the same time, coarse sediment from the tributaries has been trapped behind dams, undersized culverts, and armored banks. Thus while the River has more water and more energy to erode and move sediment, it has less coarse sediment entering the channel than before, creating a 'hungry water' situation where the channel erodes sediment from the mainstem to compensate.

The result of these changes is channel incision and a deeply entrenched mainstem river channel with the following characteristics:

- Increased erosive energy and reduced coarse sediment load has led to erosion of the bed and bank of the river, and the loss of bed features such as bars, riffles, and short pools that are vital to salmonid spawning and rearing. In addition, flattening of the equilibrium channel gradient in response to increased flow and reduced sediment supply has created long flat glides with low water quality that harbor predators to juvenile salmonids.

- Increased erosive energy and a deeper channel have led to bank erosion, causing property damage, degrading the narrow riparian tree corridor, and generating excessive fine sediment that embeds spawning gravel in the channel bed.
- Channel incision has disconnected the channel from its historic floodplain and secondary channels, removing high flow refugia and a source of food for juvenile fish.
- Channel incision and groundwater drawdown has led to an aging and non-regenerating riparian canopy along the river corridor.

This page intentionally left blank

2. PROJECT DESIGN OBJECTIVES AND CRITERIA

The goal of the river and floodplain restoration project is to reverse habitat degradation and reduce bank erosion to the maximum extent practical, consistent with the surrounding watershed drivers, project funding, the wishes of the property owners, the need to maintain existing levels of flood control, and the relevant environmental and planning regulations. We propose that the project goals can be achieved through the implementation of the following restoration elements:

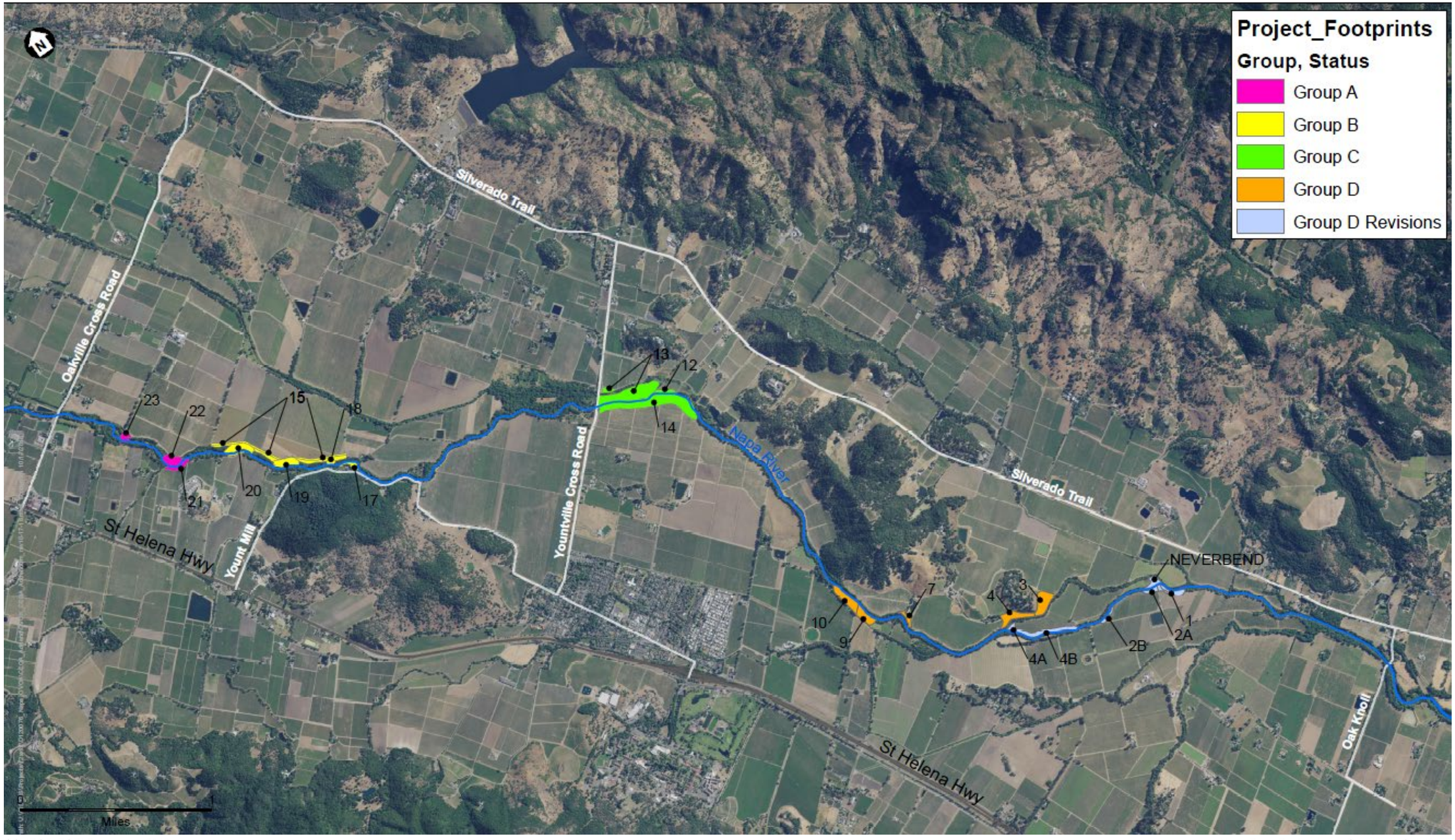
This page intentionally left blank

TABLE 1
PROJECT DESIGN OBJECTIVES & CRITERIA

Restoration Element	Action	Physical Objective	Biological Objective	Landowner Objective	Design Criteria
Bank Stabilization (BS)	**Stabilize actively eroding banks with biotechnical methods (replacing rip rap where appropriate)**	Reduce bank angles	Provide stable slopes for regeneration of riparian forest	Reduced bank erosion, reduce damages to property and infrastructure	Cut to 3:1 or flatter where bank-top constraints permit. Use living native plant materials (vegetated soil lifts, brush mats, etc) where shear stresses permit (using similar approach to Fischenich, 2001). Where shear stresses exceed resistance of purely biotechnical methods and/or where infrastructure is at risk use rock with native vegetation (e.g. rock with willow pole plantings).
		Reduce bank erosion	Reduce infilling of spawning gravel, and improve substrate conditions for BMIs		
		Remove rip rap	Improved bank edge habitat		
Channel Widening (CW)	**Widen selected reaches ("restoration nodes") to create inset floodplain benches and secondary channels**	Reduce flow velocity on edge of channel	Provide high flow velocity refugia for juvenile salmonids	Out of bank flows will be slower and less damaging to inundated vines and infrastructure	Where bank-top constraints permit, floodplain nodes should be on average 10 times wider than the depth between historic floodplain and channel thalweg (based on reference conditions in the project vicinity and hydraulic modeling). Nodes should be longer than 500 feet where feasible (based on reference conditions in the project vicinity). Shorter features should still function as alcoves and refugia, but are not expected to achieve the full range of geomorphic functions. Grading should minimize impacts to mature native trees both on the historic floodplain and on the channel edge (creating tree islands). Floodplain benches should have significant areas that inundate on an annual basis preferably between January and April (emergence and initial rearing), with the majority of the bench inundating two years out of three. Based on experience from the Rutherford Reach, floodplain benches should be approximately 2-6 feet above the thalweg, with heterogeneity to provide a range of inundation depths across a wide range of flow conditions and water years, but hydraulic modeling should be used to confirm design elevations. Benches should have variable widths around the design average to create convergent and divergent flow conditions and sustain riffle-pool maintenance. Where feasible wider sections should coincide with existing riffle crests. Benches may integrate mature tree preservation with creation of constrictions. Flow velocities on the majority of the floodplain should be lower than 2 feet/sec during the Q1.5 year flow, with velocities in the secondary channels lying between mainstem and floodplain velocities to promote heterogeneity and create feeding lanes. Banks should be cut to 3:1 or flatter where bank-top constraints permit. Use living native plant materials (willow baffles, fascines, etc) where shear stresses permit (using similar approach to Fischenich, 2001). Where shear stresses exceed resistance of purely biotechnical methods use vegetated rock.
		Induce gravel deposition in channel	Provide in-channel spawning and rearing habitat, and improve substrate conditions for BMIs		
		Induce fine sediment deposition on floodplains	Reduce infilling of spawning gravel, and improve substrate conditions for BMIs		
		Reduce bank erosion	Reduce infilling of spawning gravel, and improve substrate conditions for BMIs	Reduce bank erosion	
		Inundate floodplain and secondary channel areas	Create floodplain rearing opportunities for juvenile salmonids		
		Reduce bank angles	Provide stable slopes for regeneration of riparian forest		
		Set back agricultural berms and develop standardized replacement berms	Expand riparian corridor including transitional and upland habitats	Standardization of berm elevations and inundation frequencies. More stable engineered berms.	Where flood control berms are set back the design height of the setback berms will be coordinated to provide more uniform flood protection throughout the restoration site. In the Rutherford Reach, JSA and NHC have confirmed that the empirical equation for berm elevation provided in the Modeling Technical Memorandum is the guiding design criteria for berm height (NHC, 2006). ESA will confirm the calculated berm elevations for consistency with the berm elevations used in the post-project hydraulic model. Other berm dimensions are based on the Preliminary Design for rolling berms, with 3:1 and 8:1 side slopes on the river side and vineyard side, respectively. The top widths will vary from 15 to 25 feet wide, depending on specific landowners' use. Berms will also be designed according to recommendations from the Geotechnical Report prepared by A3Geo (separate document).
Instream Habitat (IH)	**Add in-channel large wood**	Break up uniform glides and create complex hydraulics, increase geomorphic complexity, sort sediment	Create shelter for juvenile and adult salmonids, create feeding lanes, create complex habitat and clean spawning gravel		Density of in-channel wood shall range from one (1) piece of large wood every 20 feet to one (1) every 240 feet. The minimum diameter shall be 1.5 feet. The maximum dimensions of a large wood structure are 6-foot structure height and encroachment length 1/3 of the channel width. Encroachment length and height may be reduced depending on final stability calculations and impacts on base flood elevation. Where feasible logs should be stabilized using bank embedment and ballast boulders, with cable used only where structures cannot be stabilized using this approach. Anchoring of the structures should consider the effects of buoyancy, hydrodynamic pressure, debris impact, and channel scour and be stable during an event with a 25-year recurrence interval. Generally, log structures will be located to function in conjunction with bench and channel geomorphic features. For example, logs with intact rootwads may be oriented to maintain pools through inducing high scour zones, or low profile logs may be oriented to trap sediment and direct base flows.
	Add in-channel roughness boulders (boulder clusters)	Break up uniform glides and create complex hydraulics, sort sediment, induce bed aggradation	Create shelter for juvenile and adult salmonids, create feeding lanes, create complex habitat and clean spawning gravel		Generally, boulder clusters will be located to function in conjunction with floodplain bench and channel geomorphic features. For example boulder clusters may be oriented to trap sediment and locally raise bed elevations. Roughness boulders may be placed along the channel margin to redirect flows and enhance alternating bar accumulation.

TABLE 1
PROJECT DESIGN OBJECTIVES & CRITERIA

Restoration Element	Action	Physical Objective	Biological Objective	Landowner Objective	Design Criteria
Augment Channel Bed (GA)	**Augment channel with gravel to raise bed elevation**	Locally reverse channel incision and increase channel complexity, raise channel bed for fish passage and riffle creation through discrete and limited (one-time) additions of gravel	Increase the area of spawning gravel; create substrate for BMIs to support native fish; cover clay hard pan reaches; break up long glides to reduce predation of native fish by non natives.		Gravel should be sized to be suitable for Chinook salmon and Steelhead (D_{50} ~42 mm) spawning activities (Raleigh et al. 1986, Sommer et al., 2001, Moyle, 2002). Gravel placement must not cause increased flooding at structures or where landowners are not willing to accept locally increased inundation of surrounding land. Gravel placement must not cause burial or backwatering of similar lengths of existing high quality habitat. Target sites that have sufficient potential gradient to aerate water and create good temperature / water quality / rearing or spawning conditions but that lack substrate (e.g. add gravel to steep sites with clay substrate). Increase gradient of flat glides where this will not drown out upstream habitat (e.g. downstream of knickpoints) and where the reach can be widened to make the steeper bed sustainable (i.e. achieve a steeper equilibrium gradient than under existing conditions). Narrow over-widened glides to increase flow concentration and velocity where steepening would drown out upstream habitat The channel dimensions shall be sized to provide the desired bar inundation frequency to promote macro invertebrate productivity. Where riffle-pool-bar formation and maintenance is desired, slopes shall be limited to less than 2%. As needed, gravel placement shall be stabilized using roughness boulders or grade control structures.
Floodplain Restoration (FR)	**Mass grading to lower floodplain elevations.**	Reconnect channel and floodplain areas	Provide partial treatment of agricultural runoff, provide wetland areas	Improved quality of runoff	Retain runoff from agricultural ditches for 48-72 hours (complying with vector control requirements). Wetlands should be planted with emergent wetland vegetation.
		Reduce in-channel flow velocity by expanding channel and floodplain cross sections	Induce deposition of coarse substrate and maintenance of riffle pool features.		
Vegetation Management (VM)	**Remove invasive and non-native plants**		Create conditions for native vegetation to become more abundant/healthy and improve habitat for native fauna.	Remove Pierce's Disease host plants and other undesirable plant	Remove non-native vegetation while preserving existing native vegetation.
Site Revegetation (SR)	**Revegetate areas disturbed during construction**	Reduce surface and bank erosion, increase bank stability	Increase shaded riparian area, reduce fine sedimentation		Establish an appropriate cover, diversity and canopy structure of native plants
Managed Retreat (MR)	**Set acceptable river corridor limits**	Allow river to naturally widen to corridor edge to reduce confinement	Reduce fine sedimentation and bed erosion, create space for floodplains and riparian corridor	Provide landowners with long term planning envelope for growing and infrastructure	Limit of planned retreat to be identified with landowner with goal of ultimate bank top width to depth ratio of at least 10:1 where practical



SOURCE: ESRI Basecamp, 2018

Napa River Restoration – Oakville to Oak Knoll

Figure 1
Proposed Project Overview

This page intentionally left blank

3. FINAL DESIGN DESCRIPTIONS

3.1 Introduction

The following section provides a description of the restoration elements proposed at each of four construction groupings (A through D) of which there are a total of 23 individual restoration sites (Figure 1). Detailed 65% design plans for Group D – Sites 10, 9, 7, 4, 4a, 4b, 3, 2a, 2b,1 & Neverbend are provided in Appendix A. Design plans for sites already completed, Group A Sites 23, 22, and 21, Group B – Sites 15, 17, 18, 19 & 20 , and Group C Site 14 and Group C Sites 12 & 13, are provided in Appendix B, C, D, and E, respectively.

This BoD focuses on key structural restoration elements of the project such as channel widening, floodplain restoration, and the addition of large wood and boulder features that will support habitat forming geomorphic processes and fish passage. Secondary components of the project include biotechnical stabilization, vegetation management, and site revegetation will be integrated at each site where structural restoration elements are proposed. A complete table of existing conditions and proposed restoration elements is provided in Table 2 and a detailed description of structural restoration elements at each of the four construction groupings follows.

3.2 Ecohydrology

Watershed-scale processes (rainfall/runoff) determine the timing, duration, and frequency of in-channel flows and ultimately the availability and condition of aquatic habitat. Because salmonids and other aquatic organisms of the Napa River have habitat needs that vary by life cycle and are dependent on these watershed processes, the Napa River Restoration Oakville to Oak Knoll Restoration project team has integrated an ecohydrologic component to restoration design. When combined with hydraulic model predictions, this approach provides a statistical and physical check on the location, activation, and function of proposed design features based on historic hydrologic data. Although predicting future flows is an imperfect science, the statistical analysis of stream flow records for determining habitat impacts (ecohydrology) can be extremely useful in designing restoration features that require specific flows before habitat benefits are realized. The ecohydrologic analysis supporting each design is provided in the restoration site descriptions below.

TABLE 2
EXISTING CONDITIONS AND PROPOSED RESTORATION ELEMENTS

Project Site	Project Footprint (Acres)	Restored Area (Acres)	Existing Conditions / Project Need	Proposed Restoration Elements*
Constructed in 2015/2016				
23	1.4	1.3	Limited off-channel habitat, existing high-flow secondary channel, extensive Arundo donax, rock slope protection, vegetated gravel bar	CW, BS, IH, VM, SR
22	2.9	2.7	Extensive Arundo donax, disconnected high-flow channel, established cottonwood and willows on flood bench	FR, BS, IH, CM, SR
21	1.6	1.2	Eroding channel bank, minimal in-stream refugia	CW, BS, IH, VM, SR
Constructed in 2016				
14	16.9	11.8	Actively eroding banks, existing flood control berm, dominated by glide habitat, discrete stands of large trees (oaks, bays, walnuts)	CW, FR, BS, IH, VM, SR
Constructed in 2017/2018				
13	16.18	13.9	Island vineyard between Napa river and side channel, limited flood terrace and floodplain connection	CW, FR, BS, IH, VM, SR, GA
12	1.35	1.35	Entrenched & confined channel, limited floodplain connection, discrete stands of large trees	CW, BS, IH, VM, SR
Constructed in 2019				
20 (East)	5.21	1.89	Highly entrenched, established riparian corridor	CW, FR, BS, IH, VM, SR
20 (West)	1.6	1.1	Vineyard and vineyard road to be relocated and riparian corridor established over time	FR, MR
19	2.28	1.96	Highly entrenched, established riparian corridor	FR, BS, IH, VM, SR
18	1.27	1.06	Highly entrenched, established riparian corridor	CW, BS, VM, SR
17	1.41	0.51	Existing residence on inside bend terrace	CW, FR, BS, IH, VM, SR
15	7.99	1.15	Vineyard and vineyard road to be relocated and riparian corridor established over time	MR
65% Design Level – Construction in 2020/2021				
10	5.7	4.2	Existing setback berm and high flow swale, intermittent stands of large trees, channel contains active gravel bars and sediment deposition associated with channel vegetation	FR, CW, BS, IH, VM, SR
9	4.6	2.9	Upstream – Fallow field between floodplain berm and river channel. Includes recently planted native riparian trees established by the landowner Downstream – Narrow band of established trees at top of bank that overhang a severely entrenched channel with limited complex habitat & refugia	CW, FR, BS, IH, VM, SR
7	1.9	1.8	Vineyard irrigation pond and access road, narrow band of established trees along top of overly steepened and armored channel bank, limited floodplain connection	CW, BS, VM, SR
4	5.2	4.5	Existing wetland complex disconnected from Napa river	FR, VM, SR
4a	1.0	0.7	Highly entrenched, established riparian corridor, bifurcation node at tributary channel connection	FR, VM, SR
4b	4.7	0.0	Vineyard and vineyard road to be relocated and riparian corridor established over time	FR, VM, SR

TABLE 2
EXISTING CONDITIONS AND PROPOSED RESTORATION ELEMENTS

Project Site	Project Footprint (Acres)	Restored Area (Acres)	Existing Conditions / Project Need	Proposed Restoration Elements*
3	6.1	4.4	Fallow (unplanted) field along bypass channel, banks exhibit intermittent stands of large trees, Limited connection between floodplain and Napa river	FR, CW, BS, IH, VM, SR
2a	2.0	0.8	Highly entrenched, active Chinook spawning site, gravel recruitment limited	CW, BS, IH, VM, SR
2b	2.0	1.6	Highly entrenched, active Chinook spawning site, gravel recruitment limited	CW, BS, IH, VM, SR
1	2.9	2.0	Highly entrenched, active Chinook spawning site, gravel recruitment limited	CW, BS, IH, RV, VM, SR
Neverbend	3.6	1.5	Highly entrenched, active Chinook spawning site, gravel recruitment limited, confluence node from tributary channel	CW, FR, IH, VM, SR

* CW-Channel Widening, FR-Floodplain Restoration, BS-Biotechnical Stabilization, IH-Instream Habitat, MR-Managed Retreat, VM-Vegetation Management, SR-Site Revegetation, GA-Gravel Augmentation

3.3 Group A

OVOK Construction Group A is located downstream of the Oakville Cross Road and is composed of Restoration Sites 23, 22, and 21 (Figure 1). Site 23 is designed as a stand-alone restoration action while Site 22 and 21 are an integrated restoration action intended to function in concert with one another to alleviate ongoing bank erosion and establish improved habitat conditions.

3.3.1 Ecohydrology

For Group A Sites 23, 22, and 21, ESA paired a Hydrologic Engineering Center – Ecosystem Functions Model (HEC-EFM) statistical analysis with a 2D hydraulic model of the proposed grading to guide the placement of habitat structures and design of off channel habitat features (secondary channel and alcoves). Various durations were analyzed (1-day, 14-day, & 21-day) to determine the exceedance probabilities for each month of the year. Statistics were computed from daily stream flow records for the St. Helena gage (USGS #11456000) between 1960 and 2012. A 14-day duration and 50% probability of exceedance was selected as a minimum project design criteria that supports spawning and rearing habitat for Chinook and Steelhead while still balancing the costs associated with grading, off-haul and disposal. Under this scenario, the computed design flows would be expected to occur every other year in the months of January, February, March, and April for at least 14-days. Alternatively, the probability of not activating for at least 14-days in any sequential January, February, March, and April is approximately 6%. It should be noted that more frequent but shorter duration activation flows will occur at each restoration site and activate restoration features for durations shorter than 14-days. For Group A Sites 23, 22, and 21 the discharge exceeded on average every other year for 14-days in January, February, March, and April is 35 cubic feet per second (cfs), 55 cfs, 50 cfs, and 25 cfs, respectively (Figure 2).

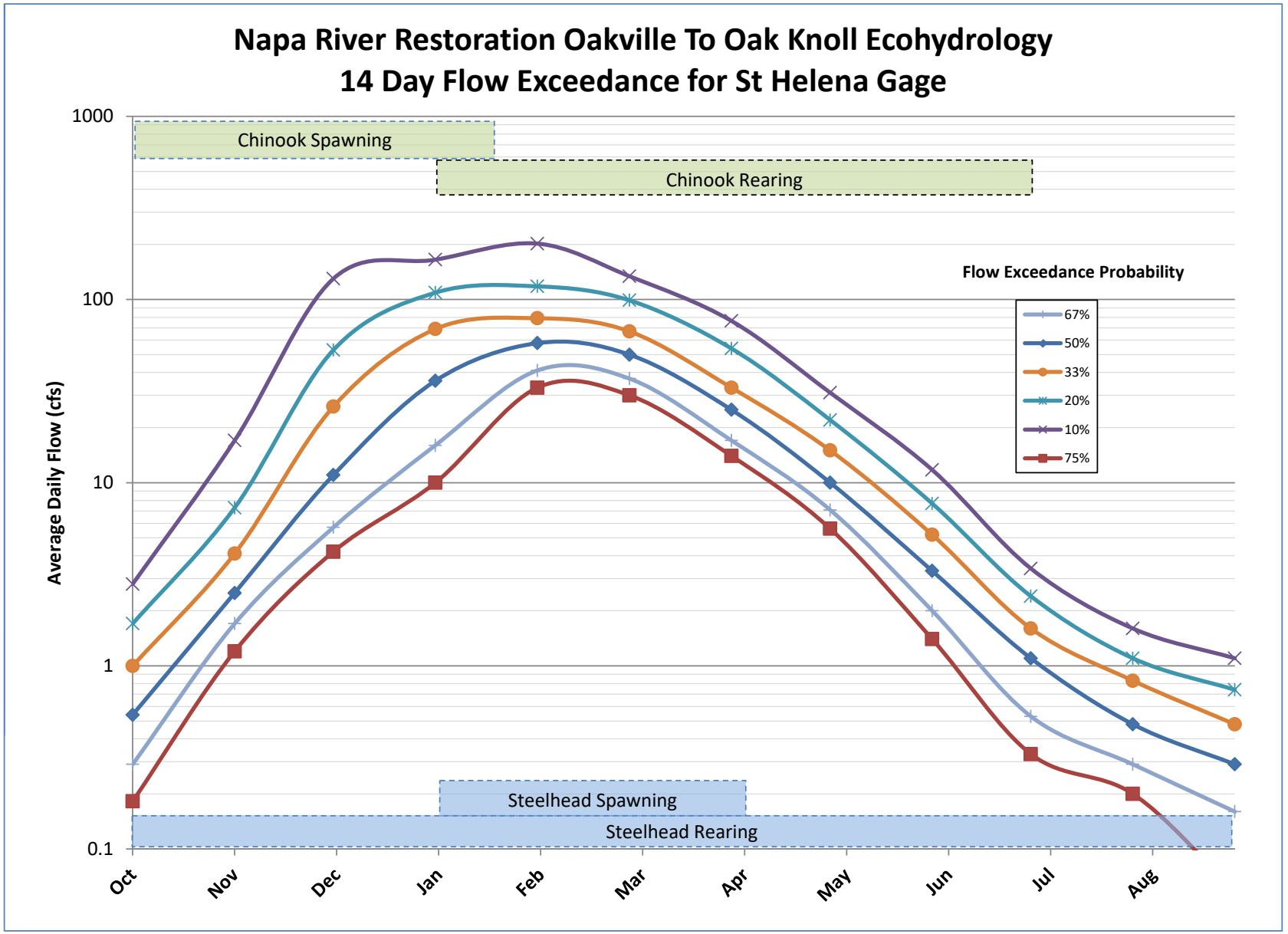


Figure 2
Group A Sites 23, 22, and 21 HEC-EFM Results

HEC-EFM results were evaluated with a 2D model (SRH-2D) to verify side channel and restoration structure activation for 30 cfs, 50 cfs, 100 cfs, 200 cfs, and 5,500 cfs (2-year) flow scenarios. 2D models such as SRH-2D account for the non-uniformity of natural channels and can predict horizontal and split flow hydraulics to ascertain complex main channel-side channel interactions. Model results for Group A Sites 23, 22, and 21 are presented in the restoration site design descriptions below.

3.3.2 Site 23

Restoration Site 23 is on the inside of a river bend, downstream of a relatively wide area of the channel (Appendix C). An existing high flow side channel exists approximately 30 feet to the east of the main channel and until recently was densely vegetated with Arundo donax. The existing high flow channel is located approximately 6 feet above the channel invert and does not stay activated for extended periods. An existing boulder revetment on the right channel bank has created localized scour and provides velocity refugia at low flows.

Channel Widening

A secondary channel and alcove will be graded on the left bank from Station 3+80 to Station 0+45. (Sheet 9, Appendix C). The alcove will be designed in a manner that ensures the meander bend at this location will not take a shorter and straighter course and will provide quiescent backwater habitat during high-flow events (>Q1.5). The active channel will be expanded by lowering the existing high flow channel so it activates during typical extended winter flow conditions to provide off-channel rearing habitat. As indicated above, the estimated activation design discharge for the secondary channel is between 30 and 50 cfs. Model predicted depth for the 30 cfs and 50 cfs ecohydrology flows are shown in Figure 3. Results of the modeling indicate the secondary channel is active and providing off-channel rearing habitat at depths of between 0.5 and 1.0 feet for the 30 cfs and 50 cfs events. The proposed secondary channel grading will expand the active channel by approximately 3,400 ft^2. The expanded flow area in the secondary channel will help to reduce overall channel shear stress near the existing riffle crest and promote deposition and maintenance of the existing main stem riffle. Model predicted velocity for the approximate 2-year flow event (5,500 cfs) is provided in Figure 4 and indicates an expansive quiescent backwater zone of low velocity for high-flow refugia in the alcove area. Velocity in the alcove feature ranges between 0 and 3 feet per second (ft/s).

Add Large Wood

A total of four large wood structures will be installed at Site 23 including opposing flow forcing structures in the secondary channel to promote local pool formation and two habitat structures along the main stem Napa River to provide immediate complex summer and winter/spring rearing habitat (Sheet 10, Appendix C). A complete list of proposed restoration elements, their targeted habitat, and geomorphic function is provided in Table 3.

Figure 3 – Site 23 Proposed SRH-2D Model Predicted Depths for A) 30 cfs and B) 50 cfs

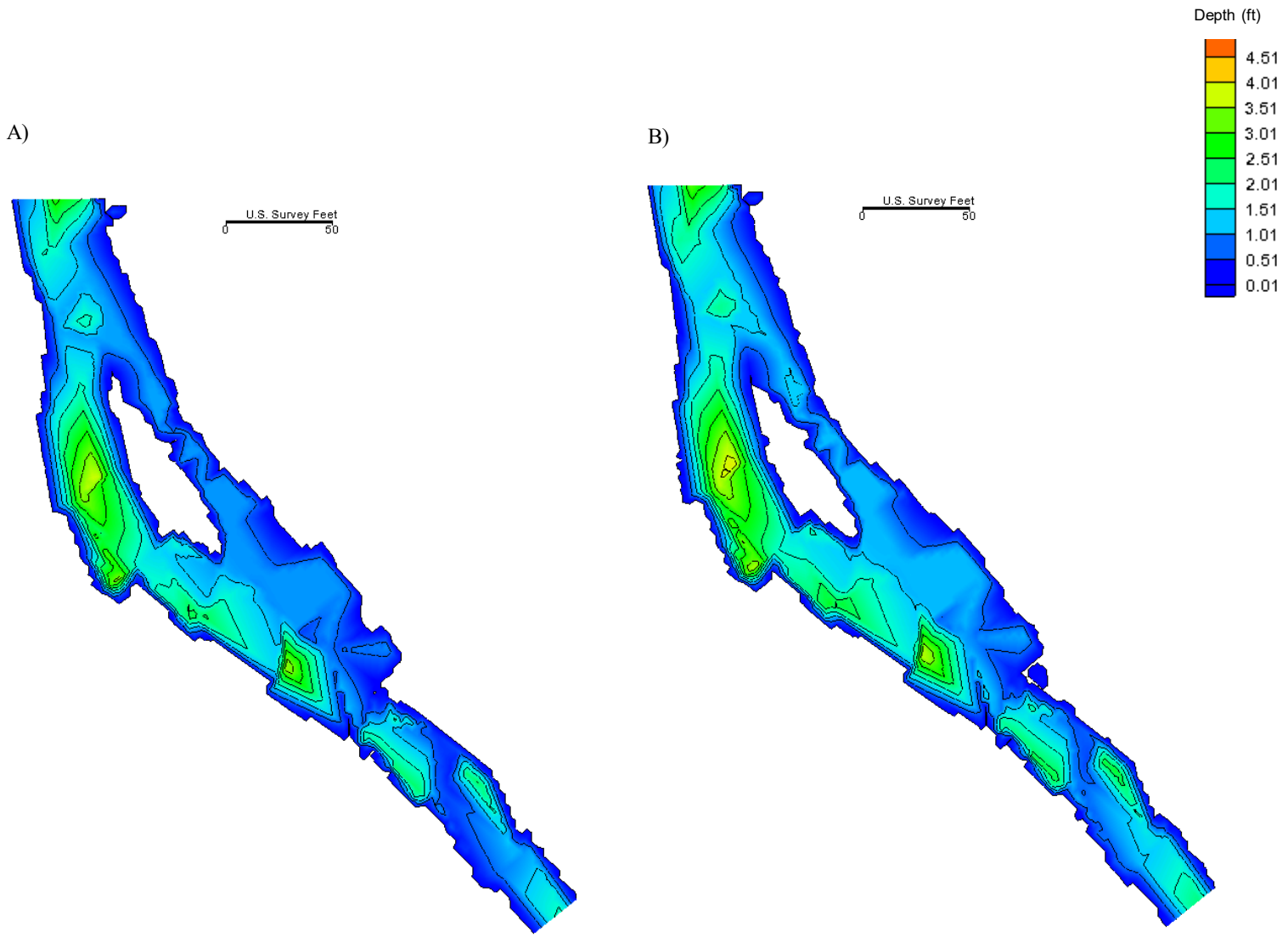
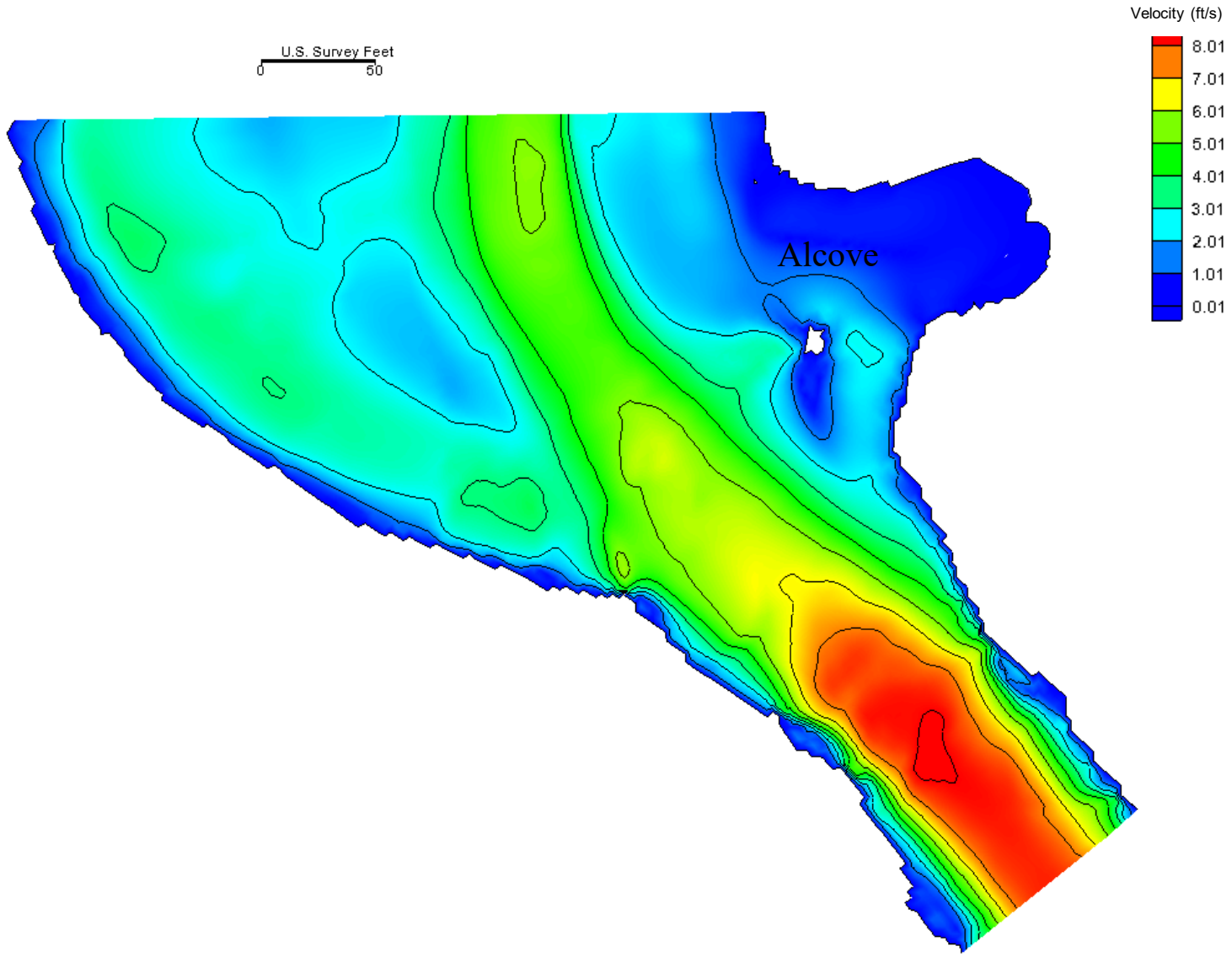


Figure 4 – Site 23 SRH-2D Model Predicted Velocity for 5,500 cfs (2-year event)



3.3.3 Sites 21 and 22

Restoration Site 21 is an actively eroding bank on the outside of a meander bend and consists of 20- to 25-foot tall nearly vertical channel banks. The top of bank is lined with an extensive but narrow band of trees. Most of the top of bank trees are significantly undermined and on a trajectory to fall into the Napa River as outer bank erosion continues. Portions of the bank are armored with scrap metal, rock, and construction debris for scour protection. Restoration Site 22 is opposite of Site 21 on the inside bend of the channel. Site 22 consists of a topographically complex but disconnected high flow channel. Large native cottonwoods are located throughout the site however much of the vegetation is dominated by invasive plants (Arundo, Himalayan blackberry, vinca, etc.). An existing riffle is located just downstream of the confluence with Doak Creek (Station 406+25, Sheet 8, Appendix C) although the majority of Sites 21 and 22 can be described as glide and pool habitat. Winter and spring rearing habitat is confined to the main channel.

Channel Widening & Floodplain Restoration

The proposed design includes extensive channel widening and floodplain restoration to decrease overall channel shear stress and promote the maintenance and formation of riffle and pool features. The right bank (Site 21) will be stabilized from Station 400+00 to Station 407+00 (approximately) by laying the bank back to a slope between 3:1 and 4:1. Brush mats would be installed along the right bank to stabilize the bank in areas of higher velocity. An overbank floodplain bench and secondary channel network would be graded through Site 22 with up to 5 mainstem-secondary channel connection points. The proposed design would lower the existing high flow channel at Site 22 to create a larger seasonally inundated floodplain and channel network. As indicated above, the estimated activation design discharge for the secondary channel is between 30 and 50 cfs. Model predicted depth for the 30 cfs ecohydrology flow is shown in Figure 5. Results of the modeling indicate the secondary channel is active and providing off-channel rearing habitat at depths of between 0.5 and 1.5 feet for the 30 cfs event. The existing flood berm and vineyard access road would be set back to support floodplain restoration activities and would be rebuilt to maintain current flood level protection. A high flow (>Q5) swale would be installed between the new set-back berm and existing top of bank trees at Site 22 to increase flood conveyance. In combination with the channel widening and bank set-back at Site 21, the high flow connection will reduce channel shear stress and alleviate outer bend erosion at Site 21.

Within the existing Site 22 floodplain, old growth cottonwoods and significant trees would be preserved as tree island features. The design also includes installation of floodplain roughness features (brush mattress, willow baffles, native pole planting, and biotechnical streambank stabilization.

Add Large Wood and Boulders

At Sites 21 and 22 a total of 20 large wood structures and 17 roughness boulders will be placed to influence channel morphology and provide immediate complex habitat for salmonids (Sheet 12 & 14, Appendix C). A complete list of proposed restoration elements, their targeted habitat, and geomorphic function is provided in Table 3. A total of 5 habitat structures would be installed at the upstream extent of Site 21 to capture and store coarse substrate and provide high flow refugia for salmonids. At Site 22 an

apex log structure would be installed at the entrance to the secondary channel to initiate flow separation during larger flow events and maintain the secondary channel geometry. Opposing flow forcing structures would be installed within the secondary channel to provide both complex winter and spring rearing habitat and to influence geomorphic processes. The combination of flow forcing structures and widened floodplain benches immediately downstream will establish local constriction and expansion zones responsible for riffle-pool formation and maintenance. A total of 13 large wood habitat structures would be installed as discrete habitat units along the secondary channel and main stem Napa River to immediately increase available complex habitat. Structures along the secondary channel target winter and spring rearing periods as demonstrated by the modeling results in Figure 6 while structures along the mainstem would provide complex habitat during winter, spring, and summer rearing periods.

A total of 17 roughness boulders would be placed along the mainstem Napa River to recruit spawning gravels, promote deposition, and introduce hydraulic variability to existing pools and glides.

Figure 5 – Site 22 & 21 Proposed SRH-2D Model Predicted Depths for 30 cfs

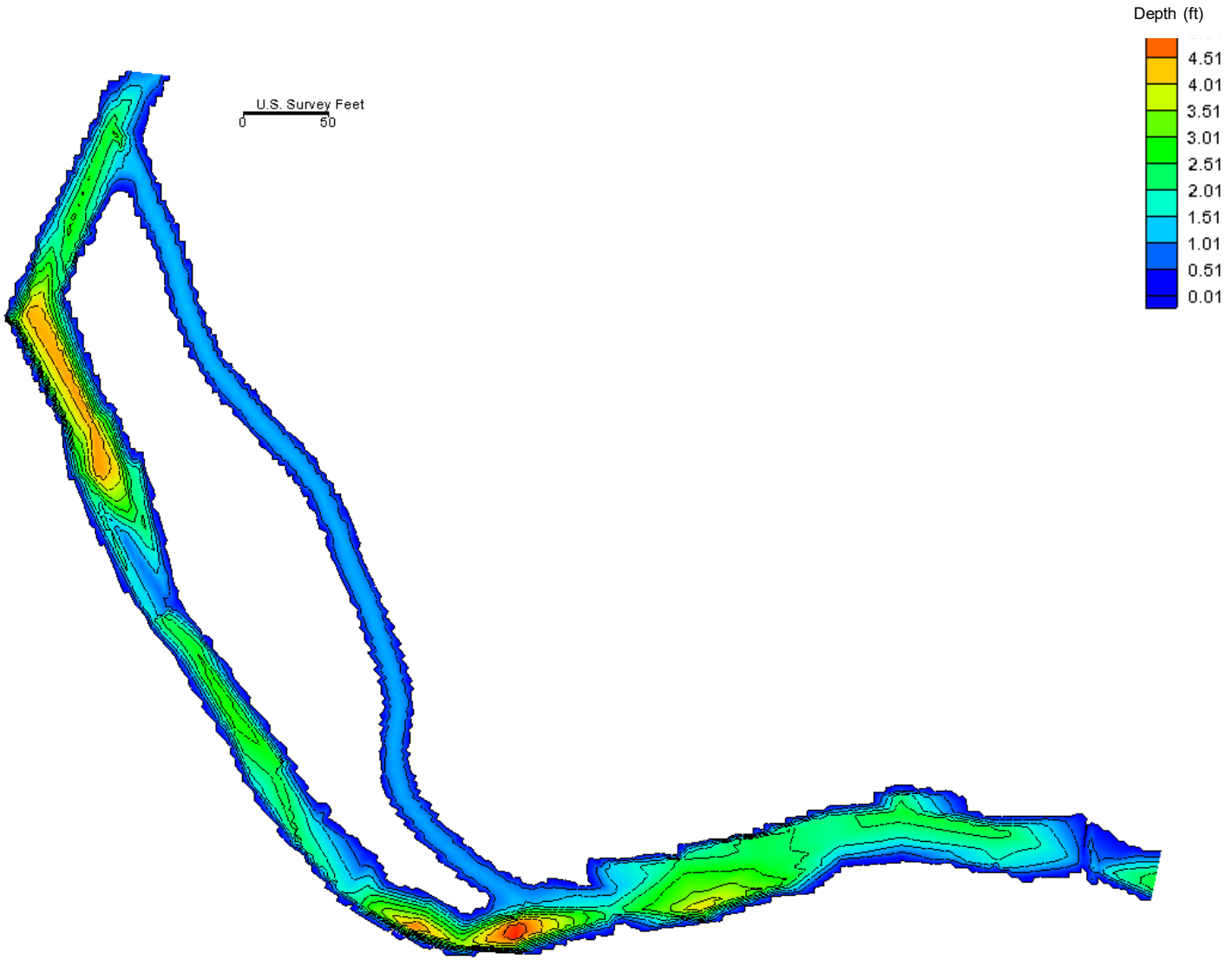


TABLE 3
GROUP A SITES 23, 22, AND 21 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
23	1+80 – 2+80	Alcove		X		X				
23	0+45 – 3+80	Secondary Channel		X	X			X	X	
23	1+95	Flow Forcing LWS			X		X	X	X	
23	1+95	Flow Forcing LWS			X		X	X	X	
23	0+70	Habitat LWS	X	X	X		X		X	
23	1+35	Habitat LWS	X	X	X		X		X	
23	1+30	Willow Baffle		X		X			X	
23	1+00	Willow Baffle		X		X			X	
23	3+33 – 2+52	Brush Mat								X
23	2+52 – 1+86	Vegetated Soil Lift								X
23	1+52 – 0+34	Vegetated Soil Lift								X
22	5+20	Apex Log Structure	X		X			X	X	
22	5+20 – 0+20	Secondary Channel		X	X	X		X	X	
22	3+05	Flow Forcing LWS			X		X	X	X	
22	3+05	Flow Forcing LWS			X		X	X	X	
22	2+40	Flow Forcing LWS			X		X	X	X	
22	2+40	Flow Forcing LWS			X		X	X	X	
22	4+06	Habitat LWS		X	X		X		X	
22	3+60	Habitat LWS		X	X		X		X	
22	4+06	Habitat LWS		X	X		X		X	
22	3+60	Habitat LWS		X	X		X		X	
22	2+85	Habitat LWS		X	X		X		X	
22	1+65	Habitat LWS		X	X		X		X	
22	1+06	Habitat LWS		X	X		X		X	
22	0+78	Habitat LWS	X	X	X		X		X	
22	1+40	Habitat LWS	X	X	X		X		X	
22	2+80	Habitat LWS	X	X	X		X		X	
22	0+45	Live LWS		X	X		X		X	
22	5+20	Roughness Boulders	X		X	X			X	
22	4+00	Roughness Boulders	X		X	X			X	
22	1+60	Roughness Boulders	X		X	X			X	
22	4+20	Willow Baffles		X		X			X	
22	2+00	Willow Baffles		X		X			X	
22	0+80	Willow Baffles		X		X			X	
22	0+65	Willow Baffles		X		X			X	
22	4+82 – 4+20	Vegetated Soil Lift								X
22	5+45 – 4+25	Brush Mat								X
22	4+04 – 3+77	Brush Mat								X
22	1+83 – 1+31	Brush Mat								X
22	1+83 – 0+10	Vegetated Soil Lift								X
21	407+20	Habitat LWS		X		X				
21	407+15	Habitat LWS		X		X				

TABLE 3
GROUP A SITES 23, 22, AND 21 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
21	407+10	Habitat LWS		X		X				
21	407+10	Habitat LWS		X		X				
21	407+05	Habitat LWS		X		X				
21	405+05	Log Revetment								X
21	404+62	Log Revetment								X
21	404+02	Log Revetment								X
21	403+51	Log Revetment								X
21	405+34	Roughness Boulders	X		X	X			X	
21	404+81	Roughness Boulders	X		X	X			X	
21	404+29	Roughness Boulders	X		X	X			X	
21	403+80	Roughness Boulders	X		X	X			X	
21	403+23	Roughness Boulders	X		X	X			X	
21	402+79	Roughness Boulders	X		X	X			X	
21	402+37	Roughness Boulders	X		X	X			X	
21	405+75 – 405+21	Brush Mat								X
21	405+21 – 404+90	Vegetated Soil Lift								X
21	404+90 – 404+80	Brush Mat								X
21	404+80 – 404+50	Vegetated Soil Lift								X
21	404+50 – 404+16	Brush Mat								X
21	404+16 – 403+86	Vegetated Soil Lift								X
21	403+86 – 403+70	Brush Mat								X
21	403+70 – 403+35	Vegetated Soil Lift								X
21	403+35 – 402+36	Brush Mat								X

3.4 Group B

OVOK Group B is located upstream of the California Department of Fish and Wildlife Napa River Ecological Reserve along the Napa River. Group B is composed of Restoration Sites 15, 17, 18, 19 and 20 and are part of an integrated design intended to function and holistically enhance conditions within the reach. Based on the project size, grading volume, and construction period limitations, Group B is scheduled for construction in 2019 based on available funding.

Restoration Sites 15, 17, 18, 19 and 20 include approximately 4,500 lineal feet of the Napa River that exhibits many signs of a steep eroding banks and a degraded channel including the prevalence of long glides with limited expression of riffle pool features. There are number of tall, over-steepened banks on the along the right bank of the reach. A narrow, yet mature, riparian corridor exists along the reach which supports discrete stands of large valley oak, black walnut, bay laurel, and willow that support a broken canopy structure overhanging the channel.

The following summary updates the project actions based on the 65% design for the Group B Sites 15, 17, 18, 19 and 20.

3.4.1 Ecohydrology

For Group B Sites 15, 17, 18, 19, and 20 ESA paired a HEC-EFM statistical analysis with a 1D hydraulic model of the proposed grading to guide the placement of habitat structures, riffle enhancements, and design of off channel habitat features (flood benches and alcoves). See Section 3.5.1 for methods and results of HEC-EFM statistical analysis.

3.4.2 Site 15

The Sites 15, 18, 19, and 20 will function on the eastern side of the Napa River as an integrated system and will establish an expanded and well-connected network of floodplain elements (Appendix D). Site 15 primarily is the managed retreat zone that encompasses Sites 18, 19 and 20. As such Site 15 includes a high-flow / seasonal wetland connection between sites 19 and 20, and expands the riparian corridor through vineyard setbacks and revegetation in Sites 18-20.

Managed Retreat

A significant portion of Site 15 is the managed retreat zone surrounding Sites 18, 19, and 20 (Station 354+00 to 394+00). Vineyards will be set back to the new managed streambank retreat line. A new access road and berm commensurate with the current level of flood projection will be constructed. Areas within the managed streambank retreat zone (but not within existing riparian habitat) that are graded may receive vegetation management and/or revegetation.

Seasonal Wetland Creation

A seasonal wetland swale feature will be constructed at Site 15 connecting Site 19 and Site 20. The seasonal wetland is located in former vineyard between Station 376+00 and 382+00. This feature would capture local rainfall and overflows from the Napa River. The wetland feature is set in the upland zones of the site and is anticipated to receive direct flows from the Napa River during the peak of typical winter high flow events (Q1 and above).

Planting Mounds

Planting mounds are proposed in former vineyards between Stations 376+00 and 382+00 to facilitate revegetation and expansion of riparian corridor while minimizing ground disturbance in a culturally sensitive area.

Native Revegetation

Seasonal Wetland Creation and Planting Mounds set the physical template of Site 15. The project will use Native Revegetation to jump-start biological processes and establish a robust riparian and upland forest around the newly graded wetland. Native Revegetation will include soil preparation and the planting of native shrubs, trees, and plugs in discrete hydrologic niches along channel banks, wetlands, and upland areas.

Vegetation Management

In areas adjacent to the project site, Vegetation Management will be implemented to remove invasive plants and Pierce's disease (a lethal disease of grape vines) host plants. This action includes selectively applied mechanical and/or chemical treatment methods. For example, it may include hand removal, excavation of Arundo roots or the application of Herbicides according to the product label directions and as approved by the U.S. Environmental Protection Agency and the California Department of Pesticide Regulation. Following treatment, these areas will be planted with appropriate native overstory and understory plants (non-Pierce's disease host plants).

Upland Brush Piles

The restoration design incorporates Upland Brush Piles as a temporary habitat feature that will utilize slash and vegetation generated through clearing and grubbing activities that would provide distinct cover elements for birds, reptiles, and mammals before site vegetation is established.

TABLE 4
GROUP B SITE 15 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
15	354+00 - 394+00	Managed Retreat		X						X
15	360+00 - 368+00	Planting Mounds		X						
15	376+00 - 382+00	Seasonal Wetlands		X						
15	376+00	Upland Brush Pile		X						
15	377+00	Upland Brush Pile		X						
15	377+50	Upland Brush Pile		X						
15	378+00	Upland Brush Pile		X						
15	378+50	Upland Brush Pile		X						
15	380+00	Upland Brush Pile		X						
15	380+50	Upland Brush Pile		X						
15	381+50	Upland Brush Pile		X						

This page intentionally left blank

3.4.3 Site 17

Site 17 creates channel widening in the form of an alcove on the inside of a meander bend that will maintain topographic protection from moderate flows. The alcove will contain various habitat features establishing highly connected complex floodplain habitat for winter refuge and rearing for salmonids.

Channel Widening

Creation of a new alcove will maximize flow area and increase the channel width to depth ratio by establishing stable bank slopes, integrating low graded feature that regularly winter connectivity during winter base flows to create off-channel habitat to support rearing salmonids (winter and spring). Some topographically high areas will be maintained to provide protection from moderate flows. The alcove will contain various habitat features to provide cover and refuge for rearing salmonids during winter base flows.

Add Habitat Structures

Although grading elements are intended to influence geomorphic processes and create habitat conditions conducive for Steelhead rearing and refuge, these features will benefit from structural elements that provide immediate habitat complexity to the graded surface. The Site 17 design includes a total of 15 habitat structures, that includes Habitat Log Structures, Topple Tree Structures, Tree Habitat Structures, Live Pole Habitat Structures, Willow Baffles, and Boulder Clusters, positioned in the new topographic feature to provide cover, velocity refuge, sediment sorting, and riffle enhancement. Each structure is specifically designed to provide summer (instream), winter refuge, or winter rearing habitat depending on its location. A complete list of habitat structures and their targeted habitat and geomorphic function is provided in Table 5.

Biotechnical Bank Stabilization

Brush Mattresses and Live Willow Plantings will be used to help stabilize and provide cover to the lower slope of newly graded features. Brush Mattresses use live cuttings (e.g. willow, dogwood, and cottonwood) and biodegradable erosion control fabrics to create a slope that is stabilized as the plants establish and roots hold the bank soils in place. Brush Mattresses will be installed at select newly graded areas (e.g. channel widening) where more robust short-term erosion protection and stabilization is desired prior to plant establishment. Live Willow Plantings provide similar function as Brush Mattress, but will be installed where less robust short-term erosion protection is needed.

3.4.4 Site 18

Site 18 will create a seasonal wetland that connects to the Napa River during high flows.

Seasonal Wetland Creation

A seasonal wetland depression feature will be constructed at Site 18. The seasonal wetland is located in former vineyard between Station 355+50 and 359+50. The connection lays back the upper portion of a overly steepened bank. This feature would capture local rainfall and overflows from the Napa River. The

wetland feature is set in the upland zones of the site and is anticipated to receive direct flows from the Napa River during the peak of typical winter high flow events (Q1 and above).

Upland Brush Piles

The restoration design incorporates Upland Brush Piles as a temporary habitat feature that will utilize slash and vegetation generated through clearing and grubbing activities that would provide distinct cover elements for birds, reptiles, and mammals before site vegetation is established.

TABLE 5
GROUP B SITE 17 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
17	349+00 - 353+50	Channel Widening		X	X	X		X	X	X
17	349+32 - 351+18	Willow Plantings								X
17	349+86 - 350+30	Willow Plantings								X
17	349+10 - 349+40	Brush Mattress								X
17	349+85 - 350+00	Brush Mattress								X
17	350+35 - 351+20	Brush Mattress								X
17	352+82 - 353+40	Brush Mattress								X
17	348+96	Boulder Cluster	X		X	X			X	
17	349+09	Boulder Cluster	X		X	X			X	
17	349+19	Boulder Cluster	X		X	X			X	
17	349+25	Boulder Cluster	X		X	X			X	
17	349+40	Habitat Log Structure		X	X					
17	349+62	Tree Habitat Structure	X	X	X					
17	349+72	Willow Baffle			X				X	
17	349+34	Live Pole Habitat Structure			X				X	
17	349+54	Live Pole Habitat Structure			X				X	
17	349+82	Live Pole Habitat Structure			X				X	
17	350+07	Live Pole Habitat Structure			X				X	
17	350+35	Live Pole Habitat Structure			X				X	
17	350+07	Live Pole Habitat Structure			X				X	
17	350+35	Live Pole Habitat Structure			X				X	
17	350+60	Live Pole Habitat Structure			X				X	
17	350+82	Live Pole Habitat Structure			X				X	
17	352+50	Topple Wood Structure		X	X					

TABLE 6
GROUP B SITE 18 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
18	355+50 - 359+50	Seasonal Wetland		X						X
18	356+00	Upland Brush Pile		X						
18	356+50	Upland Brush Pile		X						
18	357+50	Upland Brush Pile		X						
18	357+50	Upland Brush Pile		X						
18	359+00	Upland Brush Pile		X						

3.4.5 Site 19

Site 19 expands the riparian corridor from Station 368+00 to 376+00 by creating seasonal wetlands in former vineyard, with connections including a channel widening. The newly graded features will contain various habitat features establishing highly connected complex floodplain habitat for winter refuge and rearing for salmonids.

Channel Widening

The incised corridor will be widened at the downstream connection to the Seasonal Wetland to maximize flow area and increase the channel width to depth ratio by establishing stable bank slopes, integrating low graded feature that regularly winter connectivity during winter base flows to create off-channel habitat to support rearing salmonids (winter and spring). The widening will lay back an overly steepened bank of the incised channel. The widening will have bench that will contain various habitat features to provide cover and refuge for rearing salmonids during winter base flows.

Add Habitat Structures

Although grading elements are intended to influence geomorphic processes and create habitat conditions conducive for Steelhead rearing and refuge, these features will benefit from structural elements that provide immediate habitat complexity to the graded surface. The Site 19 design includes a total of 7 habitat structures, that includes Habitat Log Structures, Topple Tree Structures, Tree Habitat Structures, Live Pole Habitat Structures, Willow Baffles, and Boulder Clusters, positioned in the new topographic feature to provide cover, velocity refuge, sediment sorting, and riffle enhancement. Each structure is specifically designed to provide summer (instream), winter refuge, or winter rearing habitat depending on its location. A complete list of habitat structures and their targeted habitat and geomorphic function is provided in Table 7.

Biotechnical Bank Stabilization

Brush Mattresses and Live Willow Plantings will be used to help stabilize and provide cover to the lower slope of newly graded features. Brush Mattresses use live cuttings (e.g. willow, dogwood, and cottonwood) and biodegradable erosion control fabrics to create a slope that is stabilized as the plants establish and roots hold the bank soils in place. Brush Mattresses will be installed at select newly graded areas (e.g. channel widening) where more robust short-term erosion protection and stabilization is desired prior to plant establishment. Live Willow Plantings provide similar function as Brush Mattress, but will be installed where less robust short-term erosion protection is needed.

Seasonal Wetland Creation

A seasonal wetland depression feature will be constructed at Site 19 that connects to Site 20 via Site 15. The seasonal wetland is located in former vineyard. This feature would capture local rainfall and overflows from the Napa River. The wetland feature is set in the upland zones of the site and is anticipated to receive direct flows from the Napa River during the peak of typical winter high flow events (Q1 and above).

Upland Brush Piles

The restoration design incorporates Upland Brush Piles as a temporary habitat feature that will utilize slash and vegetation generated through clearing and grubbing activities that would provide distinct cover elements for birds, reptiles, and mammals before site vegetation is established.

3.4.6 Site 20

Site 20 expands the riparian corridor from Station 382+00 and 385+00 by creating seasonal wetlands in former vineyard and enhances a riffle-pool reach with channel widening from 384+50 to 391+50. The newly graded features will contain various habitat features establishing highly connected complex floodplain habitat for winter refuge and rearing for salmonids.

Channel Widening

The incised corridor will be widened from Station 384+50 to 391+50 to maximize flow area and increase the channel width to depth ratio by establishing stable bank slopes, integrating low graded feature that regularly winter connectivity during winter base flows to create off-channel habitat to support rearing salmonids (winter and spring). The widening will include two benches that will contain various habitat features to provide cover and refuge for rearing salmonids during winter base flows.

Add Habitat Structures

Although grading elements are intended to influence geomorphic processes and create habitat conditions conducive for Steelhead rearing and refuge, these features will benefit from structural elements that provide immediate habitat complexity to the graded surface. The Site 17 design includes a total of 16 habitat structures, that includes Habitat Log Structures, Topple Tree Structures, Tree Habitat Structures, Live Pole Habitat Structures, Willow Baffles, and Boulder Clusters, positioned in the new topographic feature to provide cover, velocity refuge, sediment sorting, and riffle enhancement. Each structure is specifically designed to provide summer (instream), winter refuge, or winter rearing habitat depending on its location. A complete list of habitat structures and their targeted habitat and geomorphic function is provided in Table 8.

Biotechnical Bank Stabilization

Brush Mattresses and Live Willow Plantings will be used to help stabilize and provide cover to the lower slope of newly graded features. Brush Mattresses use live cuttings (e.g. willow, dogwood, and cottonwood) and biodegradable erosion control fabrics to create a slope that is stabilized as the plants establish and roots hold the bank soils in place. Brush Mattresses will be installed at select newly graded areas (e.g. channel widening) where more robust short-term erosion protection and stabilization is desired prior to plant establishment. Live Willow Plantings provide similar function as Brush Mattress, but will be installed where less robust short-term erosion protection is needed.

TABLE 7
GROUP B SITE 19 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
19	368+00 - 370+00	Channel Widening		X	X	X		X	X	X
19	368+00 - 376+00	Seasonal Wetland		X						
19	368+27 - 368+86	Brush Mattress								X
19	369+77 - 370+00	Brush Mattress								X
19	368+86 - 369+77	Willow Pole Plantings								X
19	368+75	Willow Baffle			X				X	
19	368+50	Tree Habitat Structure	X		X					
19	369+60	Tree Habitat Structure	X		X					
19	369+03	Live Pole Habitat Structure			X				X	
19	369+32	Live Pole Habitat Structure			X				X	
19	369+56	Live Pole Habitat Structure			X				X	
19	369+82	Live Pole Habitat Structure			X				X	
19	369+00	Upland Brush Pile		X						
19	370+22	Upland Brush Pile		X						
19	370+80	Upland Brush Pile		X						
19	371+77	Upland Brush Pile		X						
19	373+00	Upland Brush Pile		X						
19	375+00	Upland Brush Pile		X						

TABLE 8
GROUP B SITE 20 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
20	382+00 - 385+00	Seasonal Wetland		X						X
20	382+50	Tree Habitat Structure	X		X					
20	382+75	Upland Brush Pile		X						
20	383+73	Upland Brush Pile		X						
20	384+60	Upland Brush Pile		X						
20	384+50 - 391+50	Channel Widening		X	X	X		X	X	X
20	384+54 - 385+23	Brush Mattress								X
20	387+14 - 387+36	Brush Mattress								X
20	388+74 - 389+42	Brush Mattress								X
20	391+20 - 391+50	Brush Mattress								X
20	385+23 - 387+14	Willow Pole Planting								X
20	389+42 - 391+20	Willow Pole Planting								X
20	384+50	Tree Habitat Structure	X		X					
20	387+25	Tree Habitat Structure	X		X					
20	384+75	Willow Baffle			X				X	
20	385+20	Willow Baffle			X				X	
20	389+40	Willow Baffle			X				X	
20	390+57	Log Habitat Structure			X					
20	391+00	Log Habitat Structure			X					
20	391+41	Log Habitat Structure			X					
20	385+40	Willow Pole Habitat Structure			X				X	
20	385+75	Willow Pole Habitat Structure			X				X	
20	386+16	Willow Pole Habitat Structure			X				X	
20	386+56	Willow Pole Habitat Structure			X				X	
20	389+56	Willow Pole Habitat Structure			X				X	
20	389+98	Willow Pole Habitat Structure			X				X	
20	390+53	Willow Pole Habitat Structure			X				X	
20W	384+50 - 390+00	Managed Retreat		X						X
20W	387+60 - 389+42	Planting Mounds		X						

Seasonal Wetland Creation

A seasonal wetland depression feature will be constructed at Site 20 that connects downstream to Site 19 wetland through the Site 15 wetland swale. The seasonal wetland is located in former vineyard between Station 382+00 and 385+00. This feature would capture local rainfall and overflows from the Napa River. The wetland feature is set in the upland zones of the site and is anticipated to receive direct flows from a connection to the Napa River during the peak of typical winter high flow events (Q1 and above). The connection will lay back an overly steepened bank of the incised channel.

Upland Brush Piles

The restoration design incorporates Upland Brush Piles as a temporary habitat feature that will utilize slash and vegetation generated through clearing and grubbing activities that would provide distinct cover elements for birds, reptiles, and mammals before site vegetation is established.

Managed Retreat

The west side of Site 20 will be Managed Retreat from Station 384+50 to 390+00. Vineyards will be set back to the new managed streambank retreat line. A new access road and berm commensurate with the current level of flood projection will be constructed. Areas within the managed streambank retreat zone (but not within existing riparian habitat) that are graded may receive vegetation management and/or revegetation actions.

Planting Mounds

Planting mounds are proposed in former vineyards between Stations 387+60 and 389+42 to facilitate revegetation and expansion of riparian corridor while minimizing ground disturbance in a culturally sensitive area.

Native Revegetation

Channel Widening, Seasonal Wetland Creation, and Planting Mounds set the physical template of Site 20. The project will use Native Revegetation to jump-start biological processes and establish a robust riparian and upland forest around the newly graded wetland. Native Revegetation will include soil preparation and the planting of native shrubs, trees, and plugs in discrete hydrologic niches along channel banks, wetlands, and upland areas.

Vegetation Management

In areas adjacent to the project site, Vegetation Management will be implemented to remove invasive plants and Pierce's disease (a lethal disease of grape vines) host plants. This action includes selectively applied mechanical and/or chemical treatment methods. For example, it may include hand removal, excavation of Arundo roots or the application of Herbicides according to the product label directions and as approved by the U.S. Environmental Protection Agency and the California Department of Pesticide Regulation. Following treatment, these areas will be planted with appropriate native overstory and understory plants (non-Pierce's disease host plants).

3.5 Group C

OVOK Group C is located immediately downstream of the California Department of Fish and Wildlife Napa River Ecological Reserve along the Napa River. Group C is composed of Restoration Sites 14, 13, 12, and 11 and are part of an integrated design intended to function and holistically enhance conditions within the reach. Based on the project size, grading volume, and construction period limitations, Group C has been split into three (3) construction actions; Site 14 is located along the west bank of the Napa River and is scheduled for construction in 2016 while Sites 13, 12, and 11 are located along the east bank of the Napa River and are scheduled for construction in 2017 and 2018 based on available funding.

Restoration Sites 14, 13, 12, and 11 include approximately 3,000 lineal feet of the Napa River that exhibits many signs of a degraded channel including a prevalence of long glides with limited expression of riffle pool features. Existing riffles are primarily associated with resistant sandy/clay formations underlying the channel suggesting they are controlled by geologic factors instead of fluvial forces. Floodplain benches exist along the east bank (Sites 13, 12, and 11) but are not activated under flows less than the 2-year flood event. Along the right bank, floodplain features are absent with slopes that exceed 1:1 and transition abruptly to an existing berm located at top of bank. A narrow riparian corridor exists at Site 14 between the active channel and the existing agricultural berm which supports discrete stands of large valley oak, black walnut, bay laurel, and willow that support a broken canopy structure overhanging the channel.

The following summary updates the project actions based on the 100% design for the Group C Site 14 project (constructed in 2016) and the 65% design for the Group C Sites 13, 12 and 11.

3.5.1 Ecohydrology

For Group C Sites 14, 13, 12, and 11 ESA paired a HEC-EFM statistical analysis with a 1D hydraulic model of the proposed grading to guide the placement of habitat structures, riffle enhancements, and design of off channel habitat features (flood benches and alcoves).

Two flow gages exist on the Napa River near the Group C project site – the Oakville gage (USGS #11458000) and the St. Helena gage (USGS #11456000). Each gage provides reporting of average daily flows and was used in the HEC-EFM analysis. Given that Group C is located in between the two existing flow gages, a weighted flow based on stream distance was developed to inform design. While an area weighted approach utilizing the watershed area of each gage would typically be used for this type of application, the existence of Conn Creek Dam and its flow regulation complicates matters. For this reason, a simpler stream distance weighted approach was used. The following table summarizes stream distances from the Group C project site to each gage.

TABLE 9
COMPARISON OF STREAM DISTANCES FOR CROUP C SITES

Gage	Stream Distance from Group C to Gage (ft)
Oakville (USGS #11458000)	24830.5
St. Helena (USGS #11456000)	69300.7

The Group C sites are closer to the Oakville gage, and are approximately 74% of the distance between the two gages. This stream distance was used to weight the HEC-EFM output flows for Group C. HEC-EFM was used to assess flow statistics associated with the 7-day, 14-day, and 21-day durations. These three durations were selected to better understand the sensitivity of inundation duration on flow statistics and how selection of a lower duration impacts inundation frequency (restoration element activation) under varying design criteria. Other HEC-EFM input data included:

1) Season definition of January 1 to April 30
2) Water year range of 1960 to 2012
3) Time series specification of 66.7% exceedance (1.50-year)

For each duration (7-, 14-, and 21-days), HEC-EFM develops a population of minimum flows occurring over a window of defined duration. From these minimum flows we utilized the user defined percentile option to understand the distribution of flows meeting the 7-, 14-, and 21- day durations. Table 5 summarizes HEC-EFM output for the three durations analyzed and Figure 6 provides a graphical representation of statistical output.

TABLE 10
ECOHYDROLOGY FLOWS FOR VARYING DURATIONS

User Defined Flow Percentile (%)	% Exceedance	AVERAGE Q (cfs)		
		7-day Durations	14-day Duration	21-day Duration
1	99	8.7	13.0	68.9
5	95	11.3	13.8	14.7
10	90	15.6	17.3	17.2
20	80	28.7	25.1	23.3
25	75	31.3	27.7	25.9
30	70	34.8	30.3	25.9
40	60	51.3	44.1	36.2
50	50	64.3	59.7	46.5
60	40	84.3	67.4	56.9
70	30	105.2	83.0	72.4
75	25	117.4	89.9	75.0
80	20	130.4	102.0	81.9
90	10	195.6	133.1	99.1
95	5	273.9	157.3	112.9
99	1	340.8	200.6	134.4

Figure 6 highlights the 117.4 cfs design flow based on a 25% exceedance probability of the 7-day duration flow statistics. This represents a flow that would be sustained for a minimum of 7 days for at least 25% of the 7-day running windows during the rearing season (January 1st – April 30th) on average 2 out of every 3 years (1.5-year recurrence interval). The graph also shows how this flow relates to other (14- and 21-day) durations. This same design flow would be sustained for a minimum of 7 days for ~15%

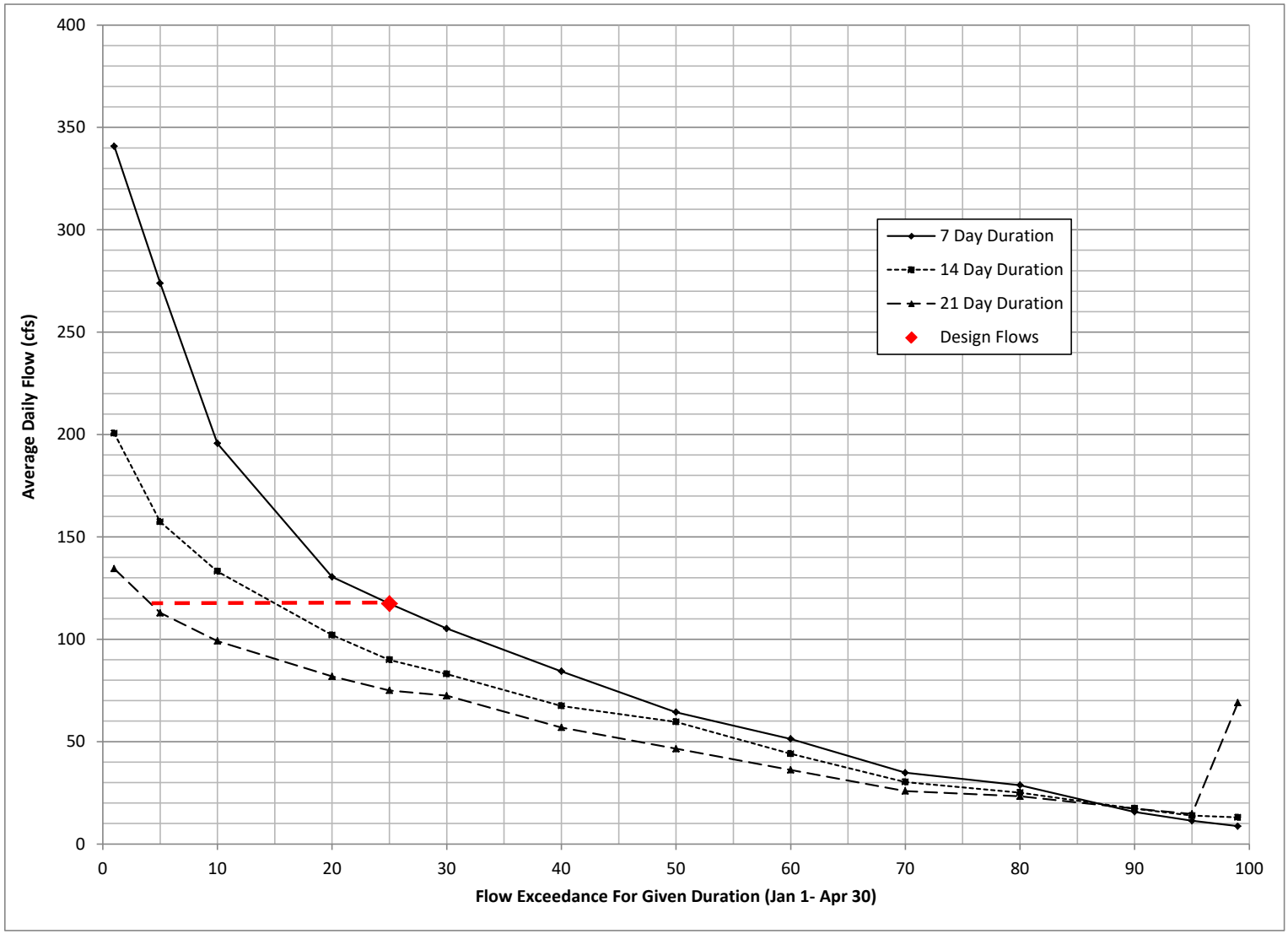


Figure 6
Group C Sites 14, 13, 12, and 11 HEC-EFM Results

of the 14-day windows within the same season, and for ~5% of the 21-day windows within the same season every 2 out of 3 years.

Selection of flow durations for restoration of rearing habitat are often based on trophic cascade relationships and specifically the amount of time needed for primary productivity to drive macro-invertebrate populations to feed juvenile fish. Previous studies have shown that values of 14-21 days represent the minimum amount of time for macro-invertebrate populations become established on floodplain features. However, in the Napa River system, hydraulic residence times are sufficiently low that it may not be possible to maintain primary and secondary producers on a single habitat feature (floodplain bench or alcove) for the duration needed. An alternative approach would select flow durations based on behavioral considerations or observations of habitat utilization. Although this project does not entail behavioral observations, we acknowledge that restoration design should consider both primary productivity and behavioral components.

3.5.2 Site 14

The Group C design (including Sites 14, 13, 12 and 11) will function as an integrated system and will establish a realigned channel within an expanded and well-connected network of floodplain elements (Appendix D). The existing berm at Site 14 will be setback from the Napa River to accommodate restoration and channel widening actions on Sites 13 and 12. As such, the Site 14 design focuses on setting back the existing berm, stabilizing actively eroding banks, creating a wider floodplain and conveyance area, and establishing highly connected floodplain features for winter refuge and rearing for salmonids.

Berm Setback

As described above, the Site 14 design includes setting back approximately 3,000 lineal feet of an existing berm situated along the top of bank. The extents of berm setback will vary between 70 and 185 feet and will permanently convert actively farmed vineyards to riparian and floodplain habitat. The new berm top width will be 25 feet to facilitate vineyard equipment turning radiuses and will include a plantable (vineyard side) slope. Setback of the berm will support and augment the function and benefits of future channel and floodplain restoration actions at Sites 13 and 12.

Channel Widening & Floodplain Restoration

On the channel side of the set-back berm restoration actions will maximize flow area and increase the channel width to depth ratio by establishing stable bank slopes, integrating flood bench and floodplain features, and creating off-channel habitat areas to support rearing salmonids (winter and spring). Channel widening actions at Site 14 can be categorized and grouped based on the degree of widening and location along the reach.

In the upper 1,500 lineal feet (stations 256+00 and 271+00), channel widening actions will focus on establishing stable side slopes (3:1 to 4:1) between the new berm and existing channel. Banks will be selectively laid back along the entire segment to increase the width to depth ratio and establish floodplain features where space allows. Widening locations between stations 256+00 and 271+00 and a floodplain

bench at station 260+00 have been selected to preserve established trees that provide canopy structure as well as their proximity relative to existing and proposed riffle locations. Channel widening actions in this segment of the project site are anticipated to remove excess sediment, stabilize actively eroding slopes and establish flow expansions and contractions that will pair with and sustain future channel restoration (constructed riffles) actions at Site 13.

In the lower 1,400 lineal feet (stations 240+00 and 256+00), channel widening actions will include slope stabilization and incorporation of large floodplain (high flow connection) and off-channel habitat areas (floodplain benches). Similar to the upstream segment, the location of slope stabilization and floodplain features were selected based on proximity to existing riffle locations at Site 13 and to preserve large trees that provide significant canopy structure over the channel. Three (3) floodplain benches with variable inundation regimes will be established immediately adjacent to the channel. Elevations, and therefore the inundation regime, of the floodplain benches were set based on the Site 14 HEC-EFM analysis described above. As such, these areas are expected to be inundated for 25% of all 14-day windows between January 1st and April 30th every 2 out of 3 years which corresponds to a discharge of approximately 90 cfs.

The design also includes installation of floodplain roughness features (willow baffles, native live pole planting) and biotechnical streambank stabilization measures (brush mattress) throughout the grading footprint. Up to 700 lineal feet of brush mattress, 1,500 lineal feet of pole plantings, and 11 willow baffles would be installed. Table 6 provides a summary of target habitat and geomorphic objectives for each biotechnical feature.

Add Large Wood and Boulders

Although grading elements are intended to influence geomorphic processes and create habitat conditions conducive for Steelhead rearing and refuge, these features will benefit from structural elements that provide immediate habitat complexity. The Site 14 design includes a total of 30 habitat log structures positioned in the landscape to supplement channel widening activities (bank stabilization, floodplain benches, and backwater areas). Each element is specifically designed to provide summer (instream), winter refuge, or winter rearing habitat depending on its location. The Site 14 design also includes 13 boulder clusters to provide velocity breaks (summer and winter rearing habitat), promote sediment sorting, and recruit gravels in the mainstem Napa River. A complete list of habitat structures and their targeted habitat and geomorphic function is provided in Table 11.

TABLE 11
GROUP C SITE 14 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
14	240+20	Boulder Cluster	X		X	X			X	
14	240+20 - 240+77	Brush Mattress								X
14	240+28 - 240+88	Alcove		X				X		
14	240+35	Habitat Log Structure		X						
14	240+44	Habitat Log Structure		X						
14	240+66	Habitat Log Structure		X						
14	240+80	Habitat Log Structure		X						
14	240+87	Habitat Log Structure		X						
14	240+97	Habitat Log Structure		X						
14	240+98	Boulder Cluster	X		X	X			X	
14	242+21 - 242+43	Brush Mattress								X
14	243+00 – 244+00	Alcove		X						
14	243+06 - 243+43	Brush Mattress								X
14	243+13 - 245+63	Brush Mattress								X
14	243+15	Boulder Cluster	X		X	X			X	
14	243+37	Boulder Cluster	X		X	X			X	
14	244+74 - 246+07	Willow Pole Plantings	X							X
14	245+54 - 246+25	Floodplain Bench		X	X					
14	245+74	Habitat Log Structure	X	X	X					
14	245+81	Habitat Log Structure		X	X					
14	245+91	Willow Baffle		X	X					
14	246+02	Willow Baffle		X	X					
14	246+04	Boulder Cluster	X		X	X			X	
14	246+16	Habitat Log Structure		X	X					
14	246+18 - 248+08	Brush Mattress								X
14	246+49	Habitat Log Structure	X		X					
14	246+61	Habitat Log Structure	X		X					
14	247+80 - 249+25	Floodplain Bench		X	X			X		
14	247+94	Habitat Log Structure		X	X					
14	248+08 - 249+13	Willow Pole Plantings	X							X
14	248+22	Habitat Log Structure		X	X					
14	248+37	Habitat Log Structure		X	X					
14	248+41	Habitat Log Structure		X	X					
14	248+67	Willow Baffle		X	X					
14	248+70	Habitat Log Structure		X	X					
14	248+88	Boulder Cluster	X		X	X		X	X	
14	248+92	Habitat Log Structure		X	X					
14	249+12	Boulder Cluster	X		X	X		X	X	
14	249+13 - 249+66	Brush Mattress								X
14	249+24	Willow Baffle		X						

TABLE 11
GROUP C SITE 14 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
14	249+66 - 250+05	Willow Pole Plantings	X							X
14	250+00	Habitat Log Structure		X	X					
14	250+05 - 250+78	Brush Mattress								X
14	250+40	Habitat Log Structure	X		X					
14	250+40 - 253+20	Floodplain Bench		X	X			X		
14	250+52	Habitat Log Structure		X	X					
14	250+63	Boulder Cluster	X		X	X			X	
14	250+73	Willow Baffle		X	X				X	
14	250+77	Habitat Log Structure		X	X					
14	250+78 - 252+38	Willow Pole Plantings	X							X
14	250+90 - 251+15	Brush Mattress								X
14	250+94	Habitat Log Structure		X	X					
14	250+94	Habitat Log Structure		X	X					
14	251+03	Habitat Log Structure		X	X					
14	251+15 - 252+22	Willow Pole Plantings	X							X
14	251+22	Willow Baffle		X					X	
14	251+59	Willow Baffle		X					X	
14	251+64 - 252+41	Brush Mattress								X
14	251+90	Boulder Cluster	X		X	X		X	X	
14	252+22	Boulder Cluster	X		X	X		X	X	
14	252+38 - 253+27	Brush Mattress								X
14	252+41	Willow Baffle		X						
14	252+41	Apex Log Structure		X	X			X	X	
14	252+53	Willow Baffle		X						
14	252+93	Habitat Log Structure		X	X					
14	253+15	Habitat Log Structure		X	X					
14	254+81 - 255+66	Brush Mattress								X
14	255+29	Habitat Log Structure	X		X					
14	255+52	Habitat Log Structure		X						
14	255+59	Habitat Log Structure		X						
14	255+71	Willow Baffle		X				X		
14	255+98 - 256+18	Brush Mattress								X
14	258+50 - 260+97	Flood Bench		X	X					
14	258+53 - 260+93	Brush Mattress								X
14	260+52	Habitat Log Structure	X		X					
14	260+68	Habitat Log Structure	X		X					
14	260+93 - 261+60	Willow Pole Plantings	X							X
14	261+60 - 264+64	Brush Mattress								X
14	261+70	Boulder Cluster	X		X	X			X	
14	263+38 - 264+49	Flood Bench		X	X			X		

TABLE 11
GROUP C SITE 14 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting	
14	263+68	Boulder Cluster	X		X			X	X	
14	263+85	Boulder Cluster	X		X			X	X	
14	264+52 - 268+53	Flood Bench		X				X		
14	264+64 - 265+93	Willow Pole Plantings	X							X
14	265+92 - 267+15	Flood Bench		X	X	X		X		
14	265+93 - 267+37	Brush Mattress								X
14	266+74	Boulder Cluster	X		X	X		X	X	
14	267+02	Habitat Log Structure		X	X					
14	267+15	Habitat Log Structure		X	X					
14	267+37 - 270+54	Willow Pole Plantings	X							X

This page intentionally left blank

3.5.3 Site 13

Sites 13 and 14 comprise one of the most incised reaches on the Napa River. Incision has been partially arrested by rip rap placed under the Yountville Cross Road Bridge which creates a 2 foot high elevation drop across approximately 50 feet of channel that is a partial barrier to migrating salmonids. Channel incision has exposed existing clay hard-pan layers and resulted in homogeneous habitat conditions; long and deep glides that extend for approximately 1,500 feet downstream of the Yountville Crossroad Bridge. Work proposed at Site 13 will function in concert with already constructed channel widening elements at Site 14 to initiate changes in channel hydraulics and sediment transport processes to produce self-maintaining riffle pool features.

Channel Widening and Riffle Creation

The channel bank and existing vineyard on the east bank of Napa River will be set back in four discrete areas to increase flow area and enhance existing riffles at each location. The channel widening will occur (from downstream to upstream) between Stations 255+00 and 257+00, 257+50 and 260+50, 262+00 and 265+00, 266+00 and 269+50 to provide a stable cross-section that promotes deposition of spawning sized gravels during effective discharge events ($Q_{1.5}$).

Considerable geomorphic research on how riffle pool morphology is maintained suggests a correlation between riffle persistence and the presence of velocity reversals (Keller, 1971; Thompson, 1986; MacWilliams et al., 2006; Caamaño et al., 2010, White et al, 2010). These researchers argue that the velocity reversal theory provides the mechanism by which relative differences in channel elevations (riffles and pools) are maintained. The velocity reversal process also helps describe why riffles aren't obliterated as discharge and average velocity increases with increasing discharge. During low flow conditions the highest velocities are located at or near relative highs and the widest locations of a channel (riffles) but as discharge increases, the location of maximum velocity shifts to narrower locations (pools). This spatial distribution of velocity also influences shear stress patterns which determine whether coarse sediments will either deposit or move through a channel segment. As flows recede, coarse substrate deposited at relatively wide locations remains and interacts with discharge to create what is observed as a riffle (shallow and fast moving water).

Channel widening and riffle creation elements at Site 13 utilize the velocity reversal theory as a physical process-based approach to constructing self-sustaining riffle pools along the main stem Napa River. The proposed grading actions will substantially increase channel width to a maximum of 110 feet at station 263+50 and also include constructed riffles (gravel fill ranging from 1 to 4 feet in thickness) at each channel widening location. Up to 1,100 cubic yards of imported washed spawning gravels (D_{50} ~42 mm) would be placed to jump-start riffle forming processes and backwater the existing partial migration barrier (Figure 7) below the Yountville Cross Road bridge.

For channel widening to enhance and maintain constructed riffles, widening actions would need to reduce sediment competence at riffles during flows responsible for the majority of sediment moving through the system; the effective discharge. In gravel-bed systems like the Napa River at Site 13, effective discharge typically falls near the statistical 1.5-year ($Q_{1.5}$) peak flow event. Based on the weighted gage analysis

presented above, the $Q_{1.5}$ for Sites 13, 12, and 11 is approximately 7,300 cfs. During the initial design process, channel width was increased until computed shear stress at riffle crests was below the critical values for 42 mm gravels (0.72 lb-f/ft^2) during the effective discharge. Therefore, channel width was varied to establish riffle crests that are stable at the effective discharge.

To determine if grading actions would result in a velocity reversal and riffle persistence at the site, design topography was evaluated using the U.S. Army Corps of Engineers HEC-RAS modeling software. Results of this analysis for the effective discharge ($Q_{1.5}$) are provided in Figure 8 and indicate the highest velocities are located at riffles during base flow conditions but then shift to pools during the $Q_{1.5}$ (7,300 cfs) event. This dynamic behavior in the location of maximum velocity would tend to deposit coarse substrate on riffles during significant substrate mobilizing events and scour pools; maintaining overall relief and riffle pool morphology across the site. Model predicted shear stress values for the placed spawning gravels during the effective discharge (7,300 cfs) are provided in Figure 9. Similar to the observed maximum velocity, shear stress is the lowest at riffles and highest in pools during effective discharge suggesting deposition of spawning gravels will occur preferentially at riffle crests. In addition, shear stress values near the riffle crests are within the partial or no transport zone for spawning sized gravels while shear stress in the pools is in the upper region of partial and full transport. Overall, results suggest the proposed grading actions will establish the physical processes responsible for riffle creation and maintenance at the site. Future additions of gravel are not anticipated as gravel moving through the system will deposit on the created/widened riffles.

Floodplain Restoration

The existing vineyard will be removed and selectively lowered to provide a network of high flow secondary channels and seasonal wetlands intended to increase the frequency and duration of flood inundation across the site. The channel network will connect the main stem Napa River to the secondary channel and seasonal wetlands.

Seasonal Wetland Creation

A total of eight seasonal wetland features would be constructed at Site 13. Five of the eight structures (Station 258+00 to 270+00) would be located within the existing vineyard and would capture local rainfall and Napa River overflows. Three of the seasonal wetlands would be located in the poison-hemlock dominated upland between Station 253+00 and 257+00. These features would capture local rainfall and overflows from the Napa River secondary channel bordering the eastern edge of the site. The wetland features are set in the upland zones of the site and are not anticipated to receive direct flows from the Napa River during typical winter low-flow conditions.

Add Large Wood

Up to 24 Log Habitat Structures would be installed at Site 13 to increase aquatic habitat complexity at specific locations. Impact areas associated with log habitat structures overlap the grading areas for riffle creation, channel widening, and floodplain restoration.

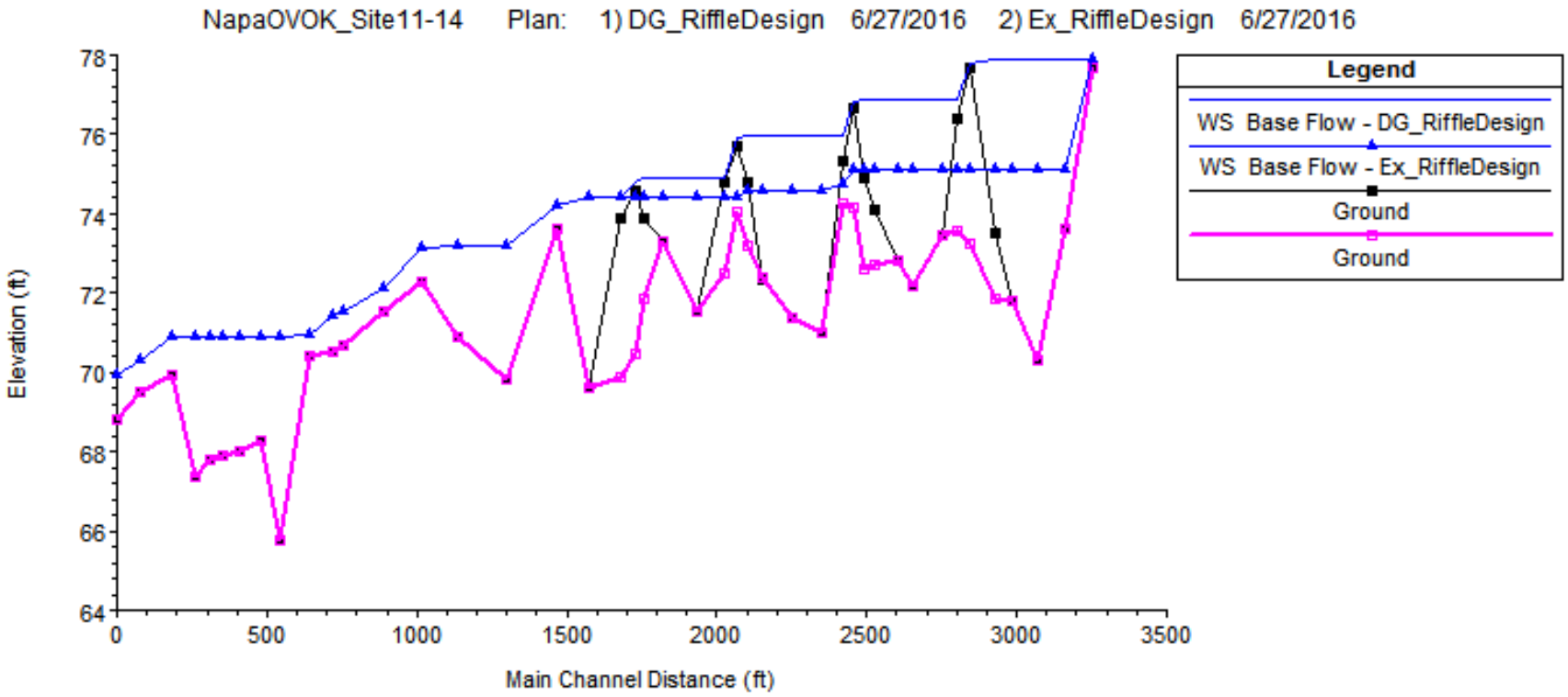


Figure 7
Group C Site Low Flow Water Surface Profile

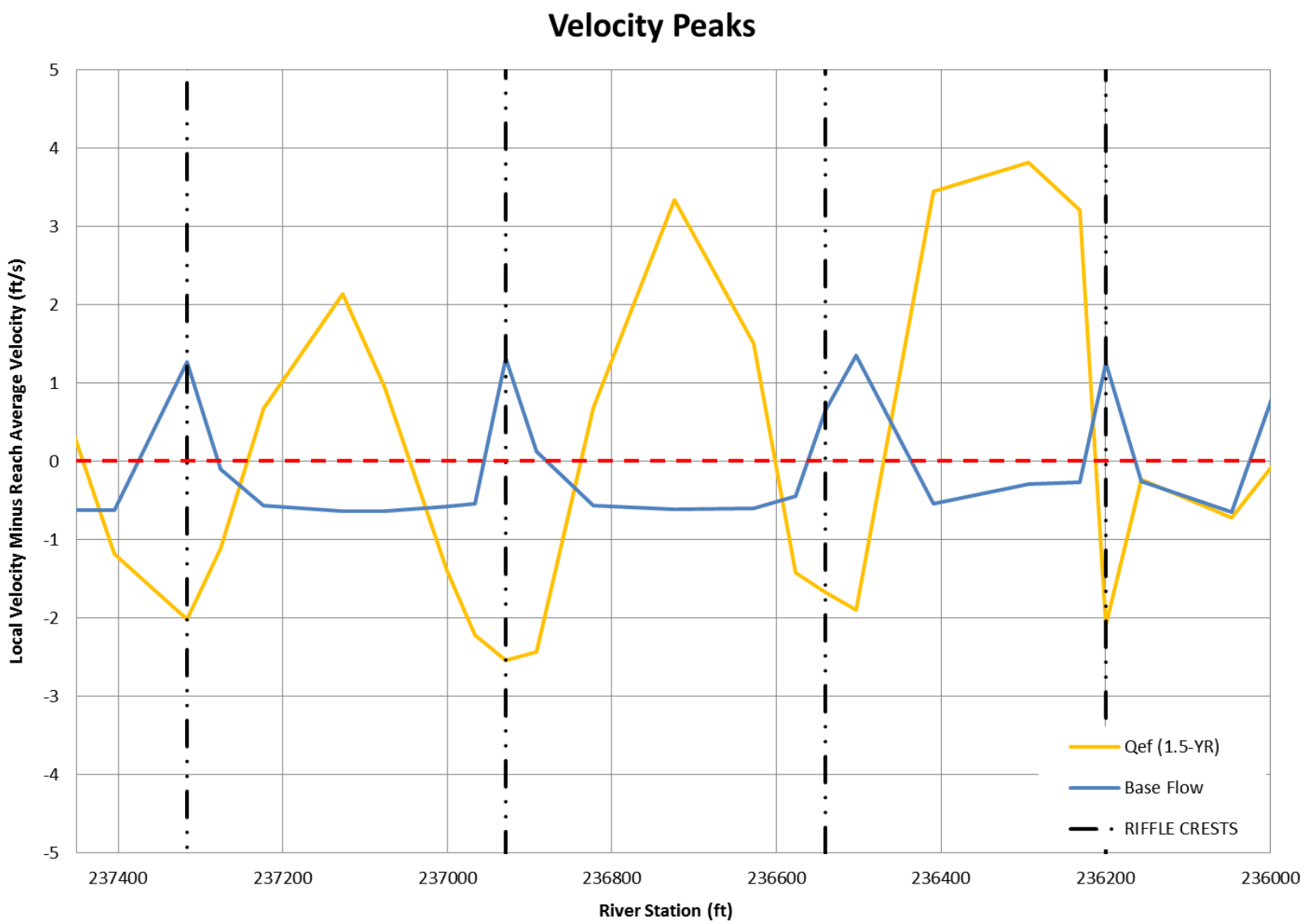


Figure 8
Group C Site 13 HEC-RAS Effective Discharge Velocity

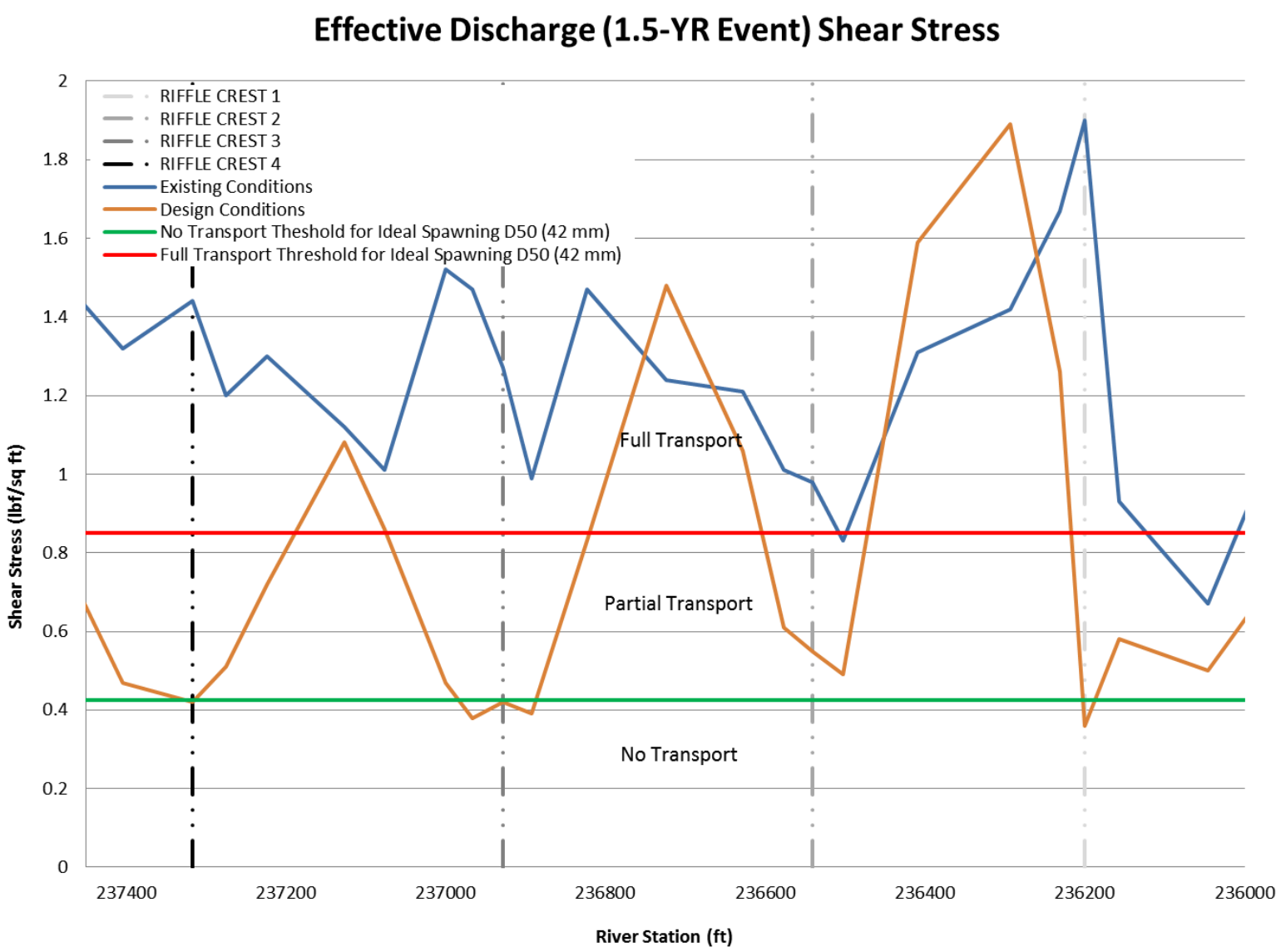


Figure 9
Group C Site 13 HEC-RAS Effective Discharge Shear Stress

3.5.4 Site 12

Site 12 encompasses approximately 500 feet of the left bank of the Napa River and adjoining vineyard. The river channel at this location is entrenched and confined with limited floodplain connection but contains discrete stands of large native trees along its uppermost boundary that provide significant canopy structure over the Napa River. The design approach at Site 12 will blend channel widening and floodplain restoration actions by connecting to seasonal wetlands at Site 13 and establishment of a flood bench.

Channel Widening and Floodplain Restoration

Channel banks will be widened and lowered to create a floodplain bench between Station 249+00 and 250+50. The bench elevation and inundation regime was set based on the Site 14 HEC-EFM analysis described above. As currently designed, the bench at Site 12 is expected to be inundated for 50% of all 21-day windows between January 1st and April 30th every 2 out of 3 years which corresponds to a discharge of approximately 50 cubic feet per second. Upslope from the flood bench, the existing vineyard will be selectively lowered to provide a connection to seasonal wetlands established on Site 13.

Add Large Wood

Log Habitat Structures would be installed at Site 12 to increase instream aquatic habitat complexity. Wood structures will be located along the low flow channel margin or on the floodplain bench to maximize the degree of inundation and habitat activation.

3.5.5 Site 11

Restoration Site 11 is a non-jurisdictional perennial stormwater detention pond that is also used to temporarily store water for vineyard frost protection and irrigation. The pond includes established riparian cover along its western edge but is disconnected from the Napa River by a 5- to 6-foot tall berm. An unnamed tributary that drains a small watershed of mostly vineyard and rural residential land uses flanks the pond to the north. Proposed restoration elements are described below.

Seasonal Wetland Creation

The existing perennial pond will be filled and elevated to establish a seasonal wetland feature similar to the size of the existing perennial pond (~1 acre). The seasonal wetland would be designed to dry out during average rainfall years to promote utilization by native amphibians while making conditions inhospitable for Bull Frogs (*Lithobates catesbeianus*) which currently inhabit the site. It is anticipated the seasonal wetland will provide habitat for waterfowl throughout the winter, spring, and early summer but that it would dry before the onset of precipitation. The seasonal wetland will include a highly variable and complex topographic network to maximize edge habitat.

Floodplain Restoration

The newly established seasonal wetland would be connected to the unnamed tributary and the Napa River. A small connection (approximately 17 feet wide) will be graded along the northeastern pond edge to capture storm-flows from the adjacent tributary. The existing pond berm will be lowered to increase floodplain connectivity, provide a nutrient source for the seasonal wetland, and facilitate annual flushing

of the feature. Connection to the tributary is intended to mimic historic seasonal wetlands located at the fringe of alluvial fans and will increase overall riparian corridor continuity at the site. Given the high connection elevation of the proposed seasonal wetland relative to the Napa River, we do not anticipate the pond will provide refuge for aquatic species or lead to widespread stranding during typical winter storm events. Based on the current grading plan the Napa River wouldn't begin to backwater the seasonal wetland until flows exceeded a 2-year event.

Add Large Wood

The project would include the addition of upland brush piles and log habitat structures to increase habitat complexity and create a range of cover elements during both inundated and dry conditions in the seasonal wetland.

This page intentionally left blank

TABLE 12
GROUP C SITES 11, 12, & 13 PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization	Seasonal Wetland Creation
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting		
13	259+30 – 269+60	Seasonal Wetland									X
13	267+30 – 269+52	High Flow Connection									
13	266+30 – 268+30	Riffle Creation (Augment Channel)	X		X	X		X	X		
13	266+00 – 269+50	Channel Widening		X	X	X		X	X	X	
13	262+30 – 265+50	High Flow Connection									
13	258+65 – 262+50	Seasonal Wetland									X
13	262+00 – 265+00	Channel Widening		X	X	X		X	X	X	
13	262+48 – 264+20	Riffle Creation (Augment Channel)	X		X	X		X	X		
13	257+50 – 260+50	Channel Widening		X	X	X		X	X	X	
13	258+50 – 260+20	Riffle Creation (Augment Channel)	X		X	X		X	X		
13	255+00 – 257+00	Channel Widening		X	X	X		X	X	X	
13	254+85 – 256+55	Riffle Creation (Augment Channel)	X		X	X		X	X		
13	253+65 – 255+15	Seasonal Wetland									X
12	249+00 – 250+50	Channel Widening		X	X	X		X	X	X	
11	239+60 – 243+45	Seasonal Wetland									X

This page intentionally left blank

3.6 Group D

The following restoration design descriptions represent the Napa OVOK Group D 65% design plans. As planning and design progress through the construction groupings and as funding for implementation becomes available, additional detail will be provided to this basis of design.

3.6.1 Ecohydrology

For Group D Sites 10 and 9, ESA paired a HEC-EFM statistical analysis with a 1D hydraulic model of the proposed grading to guide the placement of habitat structures, riffle enhancements, and design of off channel habitat features (flood benches and alcoves). The results of the HEC-EFM analysis give a target discharge of 50 cfs, this discharge rate is approximately the 50% exceedance for a 14- to 21-day target duration (Table 10, Section 3.5.1). The design discharge of 50 cfs was selected based on the physical parameters needed to achieve high quality salmonid habitat as well as from experience gained from sites upstream of Group D.

3.6.2 Site 10

Restoration Site 10 includes a setback berm that was created in the 1960's to provide a buffer between the managed vineyard and Napa River. The western edge of the berm is lined with native oaks and walnuts to be preserved. The area between the existing berm and the river is dominated by young seedlings, ruderal grasses, and limited stands of large walnut and oaks. This site is characterized by active channel bank erosion and incising with an adjacent floodplain bench approximately 150 feet wide. Restoration opportunities at Site 10 were primarily constrained by the availability of adjacent vineyard land and further developed to preserve high value riparian vegetation. The Site 10 restoration elements include two areas of channel widening with integrated habitat enhancement structures, floodplain restoration in the form of high flow swales, and vegetation management within the larger project footprint. Sites 10 and 9 are designed to be an integrated feature continuous along 1350 linear feet of the Napa River.

Channel Widening

At Sites 10 and 9, the west bank of the Napa River will be widened at three discrete locations to increase flow area, encourage deposition, and promote subsequent riffle formation. Channel widening will be constructed at stations 163+50 to 167+00, stations 169+00 to 172+00 and stations 172+50 to 175+00 with apex bench widths of 90, 80 and 60 feet, respectively. The bench elevations range from 61.0 feet NAVD downstream at Site 9 to 61.3 and 62.3 feet NAVD at Site 10. The design intent of the channel widening feature is to create more stable channel cross sections that promote deposition of spawning sized gravels during effective discharge events ($Q_{1.5}$).

For channel widening to enhance physical processes, widening actions would need to reduce sediment competence at expansion features during flows responsible for the majority of sediment moving through the system; the effective discharge. In gravel-bed systems like the Napa River at Sites 10 and 9, effective discharge typically falls near the statistical 1.5-year ($Q_{1.5}$) peak flow event. Based on the weighted gage analysis presented above, the $Q_{1.5}$ for Sites 13, 12, and 11 is approximately 7,300 cfs. Located just

downstream, for simplicity the effective discharge for Sites 10 and 9 is assumed to be equivalent to values calculated from the weighted gage analysis for Sites 13, 12, and 11.

The design process for Sites 10 and 9 involved iterating channel planform (shape, elevation, and width) until computed shear stress at expansion features was below the critical values for 42 mm gravels (0.72 lb-f/ft^2 and 0.43 lb-f/ft^2), the target ideal spawning gravel size, during the effective discharge. Creating depositional conditions through channel widening ultimately is intended to promote riffle formation and subsequent riffle pool structure at Sites 10 and 9.

To determine if grading actions would result in beneficial hydraulics and deposition of target gravel sizes at the site, design topography was evaluated using the U.S. Army Corps of Engineers HEC-RAS modeling software. Results of this analysis are provided in Figure 10 and show shear stress for the design and existing conditions at both the eco-hydraulic target discharge (50 cfs) and the effective discharge, $Q_{1.5}$ (7,300 cfs). For the effective discharge, the results of Figure 10 show reductions in shear stress from full transport levels for existing conditions to partial or no-transport levels corresponding to locations with designed channel widening. Overall, results suggest that deposition in the target range of gravel diameters is expected as part of the function of the proposed site hydraulics, and will establish the physical processes responsible for riffle creation and maintenance.

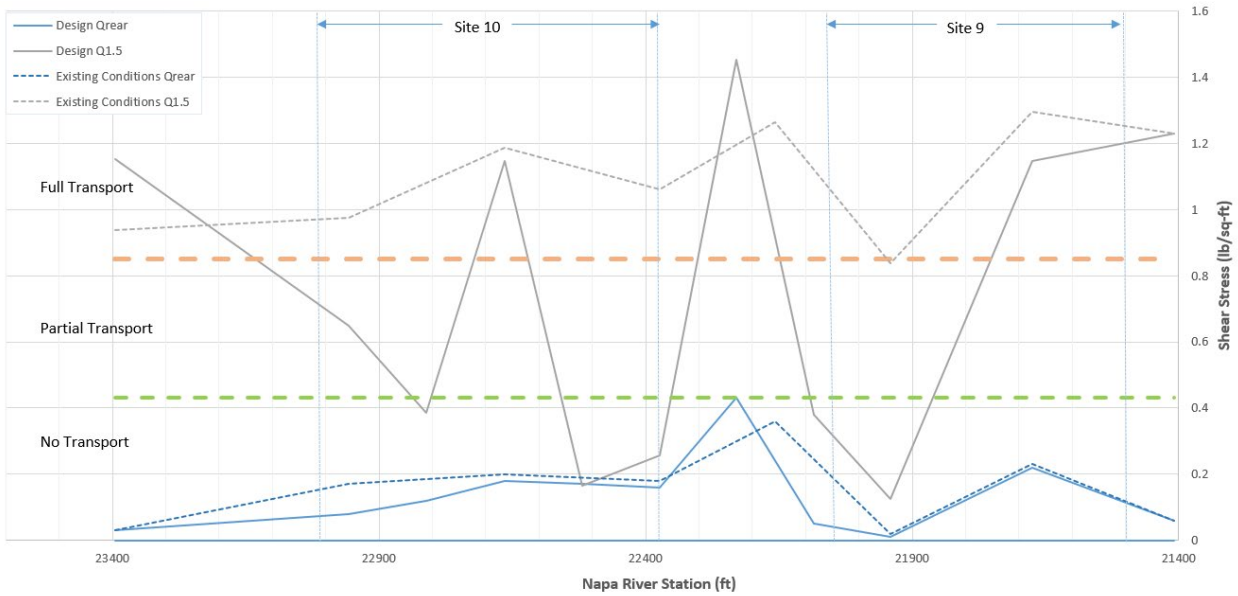


Figure 10
Group D Site 10 & 9 HEC-RAS Effective Discharge and Shear Stress

Floodplain Restoration

The channel expansion features at Sites 10 and 9 are connected by channel-parallel high flow swales designed to convey the effective discharge ($Q_{1.5}$). These features are intended to increase the frequency and duration of flood inundation across the site as well as provide off-channel refugia during high flows. In addition, areas of the existing floodplain bench between the constructed channel expansions will remain undisturbed to preserve stands of well-developed oak and walnut. Floodplain restoration activities at Site 10 will extend downstream and connect to proposed improvements at Site 9.

Add Habitat Enhancement Structures

Habitat Enhancement Structures would be installed at Site 10 to increase instream aquatic habitat complexity. Habitat enhancement structures at site 10 include 3 topple trees, 6 large rootwad habitat structures, 535 linear feet of brush mat and 174 linear feet of live pole planting, 5 willow baffles, 3 live pole habitat structures, 17 upland brush piles, 5 small tree habitat structures, and 9 boulder clusters.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly exposed surfaces in graded areas and adjacent non-graded areas with an assemblage of native plants consistent with the target habitat types.

3.6.3 Site 9

Restoration Site 9 is located upstream of a significant channel bend next to an existing fruit orchard and is immediately downstream of Site 10. Channel banks at Site 9 are nearly vertical and range between 20 and 25 feet high. In-channel habitat is dominated by a continuous glide feature and a single point bar located at the lower extent of the project site. A single line of mature oaks and native walnuts line the top of bank while the understory is dominated by poison oak, non-native grasses, and Himalayan blackberry. Site 9 is directly downstream of Site 10, and is similarly characterized by active channel bank erosion and incising with an adjacent floodplain bench approximately 150 feet wide. Restoration opportunities at Site 9 were primarily constrained by the availability of adjacent vineyard land and further developed to preserve existing high value riparian vegetation. The Site 9 restoration elements include one area of channel widening with integrated habitat enhancement structures, adjacent floodplain restoration, and vegetation management within the larger project footprint. Work proposed at Site 9 is designed to function in concert with the proposed channel widening elements at Site 10 to initiate changes in channel hydraulics and sediment transport processes to produce self-maintaining riffle pool features.

Channel Widening

Reference Site 10, Channel Widening.

Floodplain Restoration

The channel expansion features at Sites 10 and 9 are connected by channel-parallel high flow swales designed to convey the effective discharge ($Q_{1.5}$). These features are intended to increase the frequency and duration of flood inundation across the site as well as provide off-channel refugia during high flows.

In addition, 200 linear feet of existing floodplain bench between Sites 10 and 9 will remain undisturbed to preserve stands of well-developed oak and walnut.

Add Habitat Enhancement Structures

Habitat Enhancement Structures would be installed at Site 9 to increase instream aquatic habitat complexity. Habitat enhancement structures at site 9 include 3 large rootwad habitat structures, 360 linear feet of brush mat and 39 linear feet of live pole planting, 4 willow baffles, 8 upland brush piles, 3 small tree habitat structures, and 5 boulder clusters.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly exposed surfaces in graded areas and adjacent non-graded areas with an assemblage of native plants consistent with the target habitat types.

3.6.4 Site 7

Restoration Site 7 is on the outside of a bend in the river where existing bank slopes are approximately 1:1 and protected by rip rap. The top of bank is lined with a series of old growth oaks, bays, and walnuts that would be protected. A water supply reservoir and associated infrastructure abuts the channel and is oriented perpendicular to the riparian corridor. During previous high flow events erosion has been documented at the base of the water supply reservoir. Restoration opportunities at Site 7 were constrained by the availability of adjacent vineyard land and the presence of existing utilities infrastructure. The Site 7 restoration elements include seasonal wetland creation, vegetation management, and vineyard access road relocation with the overall goal of widening the riparian corridor and creating a managed retreat envelope that facilitates beneficial channel evolution.

The existing vineyard access road will be set back approximately 60 feet to coincide with an abrupt bend in the Napa River at station 154+00. The design intent is to create a wider corridor for normal channel processes to occur and facilitate long term geomorphic stability along the left channel bank.

Seasonal Wetland Creation

A wetland depression will be graded in the left overbank area behind the existing old growth trees at the site. This seasonal wetland feature will create gentle and varying slopes down to 3 feet below existing topography. The seasonal wetland will be wetted by precipitation and the basin upslope from the proposed grading and will provide habitat for terrestrial species.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and planting of native species consistent with target habitat types in three areas at site 7: the managed retreat area, along the north portion of the existing water supply resevoir, and along the new wetland depression feature.

3.6.5 Site 4

Restoration Site 4 is located on the left bank upstream of where the Napa River splits to a historic slough or bypass channel. Sites 4, 4A are intended to function as an integrated system focused on hydraulic connectivity to the secondary channel and alleviation of pressure on the channel banks at the bifurcation node. Restoration opportunities at site 4 were constrained by the availability of adjacent vineyard land and further design development focused on preservation of existing high-value riparian vegetation. The site 4 restoration elements include bank stabilization and tributary enhancement, floodplain restoration, addition of habitat enhancement structures, and vegetation management.

Bank Stabilization and Tributary Enhancement

Bank stabilization measures are proposed from stations 121+00 to 119+00 and will be integrated with grading features focused on hydraulic connectivity between the Napa river main stem and the secondary channel. The eroding bank will be stabilized through grading activities to establish suitable conditions for biotechnical bank stabilization measures and native revegetation.

Seasonal Wetland Creation

An existing wetland feature will be enhanced and expanded through grading activities to better connect the wetland with the river and increase its inundation frequency and extent. The existing wetland will be graded in the left overbank area adjacent to the Napa River split so that portion of the wetland feature will flood during a 1.5-year flood event. An existing drainage channel will be realigned at the site to integrate local drainage patterns with the proposed expanded wetland. The expansion of this wetland will also require a realignment of vineyard access roads.

Add Habitat Enhancement Structures

Habitat enhancement structures would be installed at Site 4 to increase instream aquatic habitat complexity and provide initial cover in newly graded upland areas. Habitat enhancement structures at site 4 include adding 119 linear feet of brush mat, 298 linear feet of live pole planting, and 5 upland brush piles.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly exposed surfaces in graded areas and adjacent non-graded areas with an assemblage of native plants consistent with the target habitat types.

3.6.6 Site 4a

Restoration Site 4a is located at the split of the Napa River to a historic slough or bypass channel. The banks between the mainstem channel and bypass channel are experiencing significant erosion and retreat. Restoration opportunities at site 4a were constrained by the availability of adjacent vineyard land with further design development focusing on preservation of existing high-value riparian vegetation. The site 4a restoration elements include bank stabilization and tributary enhancement, and vegetation management.

Bank Stabilization and Tributary Enhancement.

Site 4a grading will focus on smoothing the bifurcation node from Napa river stations 116+00 to 118+00 and secondary channel stations 50+50 to 52+50. The eroding bank will be stabilized through grading activities to establish suitable conditions for biotechnical bank stabilization measures and native revegetation. The vineyard access road at site 4a will be set back approximately 80 feet to provide space for bank stabilization measures and to facilitate beneficial channel evolution. Bank stabilization measures at the entrance to the tributary channel are intended to enhance hydraulic connectivity and alleviate pressure on the channel banks.

A proposed boulder field will be positioned in the Napa river main channel from stations 116+80 to 117+20 to help back-water the secondary channel and slow velocities along the adjacent left bank.

Add Habitat Enhancement Structures

Habitat enhancement structures would be installed at Site 4a to increase instream aquatic habitat complexity and provide initial cover in newly graded upland areas. Habitat enhancement structures at site 4 include adding 91 linear feet of brush mat, and 89 linear feet of live pole planting.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly exposed surfaces in graded areas with an assemblage of native plants consistent with the target habitat types.

3.6.7 Site 4b

Restoration Site 4b is located east of Site 2b in the split channel reach where the river channel is entrenched and actively widening. The reach is confined but contains the most diverse habitat conditions in the project reach, with a tightly spaced riffle-pool form. There is abundant utilization by spawning salmon, however a preliminary sediment transport assessment showed that spawning gravel is very vulnerable to erosion.

Managed Retreat

The vineyard and vineyard access road will be set back approximately 50 feet from the top of bank from Napa River stations 98+00 to 116+00.The design intent is to create a wider corridor to support expansion of the riparian corridor and facilitate long term geomorphic stability along the left channel bank.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly created managed retreat area with an assemblage of native plants consistent with the target habitat types.

3.6.8 Site 3

Restoration Site 3 is adjacent to the bypass channel of the Napa River and was suggested by the landowner as a location for active widening and restoration planting. Site 3 is located at stations 35+00 to 38+50 along the secondary channel. Restoration opportunities at site 3 were constrained by the availability of adjacent vineyard land and nearby cultural resources with further design development focusing on preservation of existing high-value riparian and upland vegetation. The site 3 restoration elements include channel widening, floodplain restoration, addition of habitat enhancement structures, and vegetation management.

Channel Widening

The east bank of the Napa River tributary channel will be widened from stations 36+00 to 38+00 with an apex bench width of 40 feet to create an alcove that provides off-channel refugia and sediment deposition. The alcove is set to elevation 51.0 feet NAVD. ESA developed the design of the channel widening feature based on modelled conditions at the site. The alcove is designed to inundate at the ecohydraulic target flow of 50 cfs extracted from the HEC-EFM statistical analysis for the Napa River (See Section 3.5.1 for HEC-EFM methods). As a result of channel widening actions, deposition leading to enhanced stream-channel processes is intended and anticipated at the site 3 alcove feature.

Seasonal Wetland Creation

The adjacent fallow field will be lowered to create a series of two depressional features that function as wetland habitat during the wet months. The wetland features will capture local precipitation and surface flow, and provide seasonally ponded wetland habitat areas.

Add Habitat Enhancement Structures

Habitat enhancement structures would be installed at Site 3 to increase instream aquatic habitat complexity and provide initial cover in newly graded upland areas. Habitat enhancement structures at site 3 include adding 2 large rootwad habitat structures, 147 linear feet of brush mat and 176 linear feet of live pole planting, 1 willow baffle, 7 upland brush piles, 2 small tree habitat structures, and 5 boulder clusters.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and planting of native species consistent with target habitat types along the existing fallow field west of the site, and along newly graded surfaces (seasonal wetlands and alcove).

3.6.9 Site 2a

Sites 2a, 1, and Neverbend are intended to function as an integrated system focused on hydraulic connectivity to the secondary channel and reductions in degradation along the channel banks adjacent to the confluence node. Restoration Site 2a is located on the right bank of the Napa River at the confluence with the bypass channel. The reach is confined but contains the most diverse habitat conditions in the project reach, with a tightly spaced riffle-pool form. There is abundant utilization by spawning salmon, however a preliminary sediment transport assessment showed that spawning gravel is very vulnerable to

erosion. Restoration opportunities at site 2a were primarily constrained by the availability of adjacent vineyard land with further design development focusing on preservation of existing high-value riparian vegetation. The site 2a restoration elements include channel widening, Bank stabilization and tributary Enhancement, habitat enhancement structures, and vegetation management.

Channel Widening

The west bank of the Napa River will be widened from stations 72+00 to 75+50 with an apex bench width of 40 feet and a bench elevation set to 47.3 feet NAVD. The channel widening geometry will create a larger cross sectional area that supports floodplain and bank stability and promotes gravel deposition and recruitment. The vineyard access road adjacent to site 2a will be set back approximately 80 feet to provide space for channel widening measures. This restoration action is focused on an actively eroding bank and will therefore treat bank erosion and will also establish an in-channel bench to recruit gravel and promote riffle formation.

ESA developed the design of the channel widening feature based on modelled conditions at the site. The alcove is designed to inundate at the ecohydraulic target flow of 50 cfs extracted from the HEC-EFM statistical analysis for nearby reaches of the Napa River (See Section 3.5.1 for HEC-EFM methods). As a result of channel widening actions, gravel recruitment and subsequent riffle enhancement are intended and anticipated at the site 2a widening feature.

Bank Stabilization and Tributary Enhancement

Site 2a grading will set back the top of bank from Napa river stations 70+00 to 72+00 to stabilize the eroding bank and contribute to the intended hydraulics at the confluence node at Neverbend. The bank set backs at Site 2a will help to establish suitable conditions for biotechnical bank stabilization measures and native revegetation. Bank stabilization measures at the exit of the tributary channel are intended to enhance hydraulic connectivity and alleviate pressure on the channel banks.

Add Habitat Enhancement Structures

Habitat enhancement structures will be installed to enhance maintenance of pools, promote spatially complex hydraulic flow fields, provide immediate habitat improvements for salmonids, and provide initial cover in newly graded upland areas. Habitat enhancement structures at site 2a include adding 2 topple trees, 3 large rootwad habitat structures, 58 linear feet of brush mat and 217 linear feet of live pole planting, 1 live pole habitat structure, 2 small tree habitat structures, and 2 boulder clusters.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly exposed surfaces in graded areas and adjacent ungraded areas with an assemblage of native plants consistent with the target habitat types.

3.6.10 Site 2b

Restoration Site 2b is located in the split channel reach where the river channel is entrenched and actively widening. The reach is confined but contains the most diverse habitat conditions in the project reach, with

a tightly spaced riffle-pool form. There is abundant utilization by spawning salmon, however a preliminary sediment transport assessment showed that spawning gravel is very vulnerable to erosion. Site 2b is located at stations 35+00 to 38+50 along the Napa River. Restoration opportunities at Site 2b were primarily constrained by the availability of adjacent vineyard land with further design development focusing on preservation of existing high-value riparian vegetation. The Site 2b restoration elements include bank stabilization, habitat enhancement structures, and vegetation management.

Bank Stabilization

The top of the west bank of the Napa River will be set back from stations 87+00 to 88+50 and 90+50 to 92+00 to a width of 20 feet and 40 feet, respectively. Grading actions are intended to stabilize the eroding bank, limit erosion at the site, and support existing in-channel processes. The bank set backs at Site 2b will help to establish suitable conditions for biotechnical bank stabilization measures and native revegetation.

Habitat Enhancement Structures

Habitat enhancement structures will be installed to enhance maintenance of pools, promote spatially complex hydraulic flow fields, and provide immediate habitat improvements for salmonids. Habitat enhancement structures at Site 2b include adding 5 large rootwad habitat structures, 98 linear feet of brush mat, and 194 linear feet of live pole planting.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly exposed surfaces in graded areas and adjacent non-graded areas with an assemblage of native plants consistent with the target habitat types.

3.6.11 Neverbend

The Neverbend Restoration Site is located at the downstream connection between the Napa River and tributary channel. Neverbend is intended to provide integrated function with sites 2a, and 1. As a functional unit these sites promote hydraulics conducive to gravel recruitment and riffle formation. Grading actions at Neverbend aim to create more frequent floodplain activation, and increase overall channel bank stability at the tributary channel confluence node.

Restoration opportunities at Neverbend were constrained by the availability of adjacent vineyard land with further design development focusing on preservation of existing high-value riparian and upland vegetation. The Neverbend restoration elements include channel widening and tributary enhancement, floodplain restoration, habitat enhancement structures, and vegetation management.

Channel Widening and Tributary Enhancement.

The right bank of the Napa River tributary channel will be widened from stations 1+00 to 2+50 with an apex bench width of 60 feet. The left bank of the Napa River main stem will be widened from station 72+00 to 73+50 with an apex bench width of 25 feet and a bench invert set to elevation 49.0 feet NAVD. The channel widening features will provide a larger cross sectional area that supports floodplain and bank

stability and promotes gravel deposition and recruitment. This restoration action is focused on significantly expanding channel areas at the confluence of the two channels to support bank stability and transitional habitat zones. The floodplain grading and channel widening will be integral with a similar widening feature across the channel at Site 2a The integrated site designs will optimize the function of the widened cross section to lower channel bed shear and recruit gravel at the site.

Floodplain Restoration

The channel expansion feature at Neverbend is connected by a channel-parallel high flow swale designed to convey the effective discharge ($Q_{1.5}$). High flow swale features are intended to increase the frequency and duration of flood inundation across the site as well as provide off-channel refugia during high flows. An areas of the existing floodplain bench upstream of the constructed channel expansions will remain undisturbed to preserve stands of well-developed oak.

Habitat Enhancement Structures

Habitat enhancement structures will be installed to enhance maintenance of pools, promote spatially complex hydraulic flow fields, and provide immediate habitat improvements for salmonids. Habitat enhancement structures at Neverbend include adding 3 topple trees, 5 large rootwad habitat structures, 201 linear feet of brush mat and 97 linear feet of live pole planting, 2 live pole habitat structures, 1 small tree habitat structure, and 2 boulder clusters.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly exposed surfaces in graded areas and adjacent ungraded areas with an assemblage of native plants consistent with the target habitat types.

3.6.12 Site 1

Restoration Site 1 is just downstream of the confluence of the split flow region of the Napa River and connects directly to Site 2a. The site is highly entrenched and actively widening. Restoration opportunities at Site 1 were primarily constrained by the availability of adjacent vineyard land with further design development focusing on preservation of existing high-value riparian vegetation. The site 2a restoration elements include channel widening, Bank stabilization and tributary Enhancement, habitat enhancement structures, and vegetation management.

Channel Widening

The west bank of the Napa River will be widened from stations 64+50 to 67+00 with an apex bench width of 40 feet and a bench elevation set to 47.3 feet NAVD. The channel widening geometry will create a larger cross sectional area that supports floodplain and bank stability and promotes gravel deposition and recruitment. The vineyard access road adjacent to site 1 will be set back approximately 80 feet to provide space for channel widening measures. This restoration action is focused on an actively eroding bank and will therefore treat bank erosion and will also establish an in-channel bench to recruit gravel and promote riffle formation.

ESA developed the design of the channel widening feature based on modelled conditions at the site. The alcove is designed to inundate at the ecohydraulic target flow of 50 cfs extracted from the HEC-EFM statistical analysis for nearby reaches of the Napa River (See Section 3.5.1 for HEC-EFM methods). As a result of channel widening actions, gravel recruitment and subsequent riffle formation and stability are intended and anticipated at the site 1 widening feature.

Add Habitat Enhancement Structures

Habitat enhancement structures would be installed at Site 3 to increase instream aquatic habitat complexity and provide initial cover in newly graded upland areas. Habitat enhancement structures at site 1 include adding 2 topple trees, 2 large rootwad habitat structures, 279 linear feet of brush mat and 159 linear feet of live pole planting, 2 willow baffles, 1 live pole habitat structure, 1 small tree habitat structure, and 3 boulder clusters.

Vegetation Management

Vegetation management actions will focus on removal of non-native vegetation and revegetation along newly exposed surfaces in graded areas and adjacent ungraded areas with an assemblage of native plants consistent with the target habitat types.

This page intentionally left blank

TABLE 13
GROUP D SITES 10, 9, 7, 4, 4A, 4B, 3, 2A, 2B, 1, NEVERBEND PROPOSED RESTORATION ELEMENTS, TARGET HABITAT, & GEOMORPHIC FUNCTION

Site	Plan Station	Restoration Element	Target Habitat			Geomorphic Function				Bank Stabilization	Seasonal Wetland Creation
			Summer	Winter Refuge	Winter/Spring Rearing	Gravel Recruitment	Pool Scour	Riffle Maintenance	Sediment Sorting		
10	176+00 – 169+00	Channel Widening		X	X	X		X	X	X	
10	173+50 – 171+00	High Flow Connection									
10	173+50 – 171+00	Tree Island									
10	169+50 – 166+00	High Flow Connection									
10	169+50 – 167+50	Tree Island									
9	167+00 – 162+50	Channel Widening		X	X	X		X	X	X	
9	163+75 – 163+00	High Flow Alcove									
7	152+50 – 150+00	Seasonal Wetland									X
4	121+00 -118+00	Bank Setback								X	
4	119+50 – 116+00	Seasonal Wetland									X
4a	118+50 – 116+00	Bank Setback								X	
4b	116+00 – 98+00	Managed Retreat									
3	38+50 – 35+00 *	Channel Widening		X	X	X		X	X	X	
3	38+00 – 35+00 *	Seasonal Wetland									X
2b	92+20 – 91+40	Bank Setback								X	
2b	88+50 – 87+00	Bank Setback								X	
2a	75+60 – 72+00	Channel Widening		X	X	X		X	X	X	
2a	72+00 – 69+60	Bank Setback									
1	67+00 – 64+20	Channel Widening		X	X	X		X	X	X	
NVB	5+20 – 2+20*	High Flow Connection									
NVB	3+50 – 2+50*	Tree Island									
NVB	2+20 – 1+20*	Channel Widening		X	X	X		X	X	X	
NVB	73+50 – 72+00	Channel Widening		X	X	X		X	X	X	

*Stationing along Napa River Secondary Channel (Referred to as Neverbend Alignment in Design Drawings)

TABLE 14
NAPA OVOK RESTORATION SUMMARY

Site	Property	Channel Length (linear feet)	Area (acres): total/ floodplain	Enhancements	Vineyard Removed (acres)	Notes
Group A: 3 sites, 2,550 linear feet						
23	Constellation	330	1.4 AC/ 1.3 AC	2 Flow Forcing LWS, 2 Habitat LWS, 2 Willow Baffles, 81 feet of brush mat, 184 feet of VSL	0.75	Channel widening, biotechnical stabilization, and vegetation management
22	Constellation	800	2.9 AC/ 2.7 AC	1 Apex log structure, 4 Flow Forcing LWS, 8 Habitat LWS, 1 Live LWS, 200 feet of brush mat, 135 feet of VSL, 3 boulder clusters	0.77	Floodplain restoration, biotechnical stabilization, revegetation and vegetation management
21	Constellation	690	1.6 AC/ 1.2 AC	4 Log Revetment structures, 5 Habitat LWS, 1 Live LWS, 173 feet of brush mat, 126 feet of VSL, 7 boulder clusters	0.40	Floodplain restoration, biotechnical stabilization, and revegetation /vegetation management
Group B: 6 Sites, 4520 linear feet						
20 (west)	Gamble	500	1.57 AC/ 1.57 AC	450 feet of planting mounds	1.57	Managed Retreat
20 (east)	State Farm	1560	5.21 AC/ 1.89 AC	3 large rootwad habitat structures, 220 linear feet of brush mat 400 linear feet of live pole planting, 3 willow baffles, 7 live pole habitat structures, 3 upland brush piles, 3 tree habitat structures, 2 boulder clusters	4.35	Channel widening, Floodplain restoration, biotechnical stabilization, revegetation, and vegetation management
19	State Farm	820	2.28 AC/ 1.96 AC	3 large rootwad habitat structures, 80 linear feet of brush mat 110 linear feet of live pole planting, 1 willow baffles, 4 live pole habitat structures, 6 upland brush piles, 2 tree habitat structures, 2 boulder clusters	1.68	Floodplain restoration, biotechnical stabilization, revegetation, and vegetation management
18	State Farm	580	1.27 AC/ 1.06 AC	7 upland brush piles	2.22	Channel widening, biotechnical stabilization, revegetation, and vegetation management
17	State Farm	750	1.41 AC/ 0.51 AC	1 topple trees 1 large rootwad habitat structure, 160 linear feet of brush mat 190 linear feet of live pole planting, 7 live pole habitat structures, 1 tree habitat structures, 4 boulder clusters	0.62	Channel widening, Floodplain restoration, biotechnical stabilization, revegetation, and vegetation management
15	Gamble	810	7.99 AC/ 1.15 AC	7 upland brush piles 200 feet of planting mounds	2.76	Managed Retreat
Group C: 3 Sites, 5630 linear feet						
14	Treasury Wine Estates	3400	16.9 AC/ 11.8 AC	2 Apex Log Structures, 33 habitat log structures, 1470 linear feet of brush mat 1060 linear feet of live pole planting, 10 willow baffles, 14 boulder clusters	12.19	Channel widening, Floodplain restoration, biotechnical stabilization, revegetation, and vegetation management
13	Missimer	1450	16.18 AC/ 13.9 AC	9 habitat log structures, 9 live wood structures, 510 linear feet of brush mat 1040 linear feet of live pole planting, 16 willow baffles	6.09	Channel widening, Floodplain restoration, biotechnical stabilization, revegetation, and vegetation management and gravel augmentation

Site	Property	Channel Length (linear feet)	Area (acres): total/ floodplain	Enhancements	Vineyard Removed (acres)	Notes
12	Traina	680	1.35 AC/ 1.35 AC	2 habitat log structures, 100 linear feet of brush mat 60 linear feet of live pole planting 1 willow baffles	3.60	Channel widening, , biotechnical stabilization, and vegetation management
Group D: 11 Sites, 6520 linear feet						
10	Miller	879	2.57 AC/2.57 AC	3 topple trees, 6 large rootwad habitat structures, 535 linear feet of brush mat 174 linear feet of live pole planting, 5 willow baffles, 3 live pole habitat structures, 17 upland brush piles, 5 small tree habitat structures, 9 boulder clusters	0	Channel widening, high-flow swale creation, and vegetation management
9	Clark	444	1.69 AC/1.69 AC	3 large rootwad habitat structures, 360 linear feet of brush mat 39 linear feet of live pole planting, 4 willow baffles, 8 upland brush piles, 3 small tree habitat structures, 5 boulder clusters.	0	High-flow swale creation, channel widening, and vegetation management
7	Constellation	254	0.49 AC/0 AC	5 upland brush piles.	0.97	Seasonal wetland creation, managed retreat, vegetation management, and vineyard access road relocation
4	Constellation	587	1.31 AC/0.67AC	119 linear feet of brush mat 298 linear feet of live pole planting, 5 upland brush piles	1.28	Seasonal wetland creation, tributary enhancement, vegetation management, and vineyard access road relocation
4a	Miller	380	0.32 AC/0.32 AC	91 linear feet of brush mat, 89 linear feet of live pole planting, 1 boulder field	0.36	Tributary enhancement, vegetation management, and vineyard access road relocation
4b	Miller	1814	2.21 AC/0 AC	None	1.98	Managed Retreat, Vegetation management.
3	Constellation	323	1.43 AC/0.77 AC	2 large rootwad habitat structures, 147 linear feet of brush mat 176 linear feet of live pole planting, 1 willow baffle, 7 upland brush piles, 2 small tree habitat structures, 5 boulder clusters.	3.87	Channel widening, seasonal wetland creation, vegetation management, and vineyard access road relocation
2a	Cheung	371	0.7 AC/0.7 AC	2 topple trees, 3 large rootwad habitat structures, 58 linear feet of brush mat 217 linear feet of live pole planting, 1 live pole habitat structure, 2 small tree habitat structures 2 boulder clusters.	0.80	Channel widening, vegetation management, and vineyard access road relocation
2b	Cheung	304	0.27 AC/0.27 AC	5 large rootwad habitat structures, 98 linear feet of brush mat, 194 linear feet of live pole planting.	0.27	Bank laybacks, vegetation management, and vineyard access road relocation
1	Silverado Premium	520	0.92 AC/0.92 AC	2 topple trees, 2 large rootwad habitat structures, 279 linear feet of brush mat 159 linear feet of live pole planting, 2 willow baffles, 1 live pole habitat structure, 1 small tree habitat structure, 3 boulder clusters.	1.14	Channel widening, vegetation management, and vineyard access road relocation
Neverbend	Neverbend	646	0.77 AC/0.77 AC	3 topple trees, 5 large rootwad habitat structures, 201 linear feet of brush mat 97 linear feet of live pole planting, 2 live pole habitat structures, 1 small tree habitat structure, 2 boulder clusters.	0.67	Tributary enhancement achieved by high-flow swale creation, channel widening, and vegetation management

This page intentionally left blank

4. REFERENCES

Caamaño D, Goodwin P, Buffington JM (2010) Flow structure through pool-riffle sequences and a conceptual model for their sustainability in gravel-bed rivers. River Research and Applications 28: 377–389.

Fischenich, C. 2001. Stability Thresholds for Stream Restoration Materials. EMRRP Technical Notes Collection (ERDC-TN- EMRRP-SR-29), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

MacWilliams Jr., M.L., Wheaton, J.M., Pasternack, G.B., Street, R.L., Kitanidis, P.K., 2006. Flow convergence routing hypothesis for pool–riffle maintenance in alluvial rivers. Water Resources Research 42, W10427. doi:10.1029/2005WR004391.

Moyle, P. B. 2002. Salmon and Trout, Salmonidae - Chinook Salmon, (Oncorhynchus tshawytscha) in Inland Fishes of California. Los Angeles, California: University of California Press, 251-263.

NRCD, 2014. Napa River OVOK Project – Group A 65% Preliminary Design Review Memorandum, Napa County Resource Conservation District, Jonathan Koehler, Senior Biologist

Raleigh, R. F., W. J. Miller, and P. C. Nelson. 1986. Habitat Suitability Index Models and Instream Flow Suitability Curves: Chinook Salmon. Report # Rep. 82(10.122). U.S Fish Wildl. Serv. Biol.

SFEI, 2012. Napa River Watershed Profile: Past and Present Characteristics with Implications for Future Management of the Changing Napa River Valley. Richmond, CA: San Francisco Estuary Institute; 2012 p. 172.

Sommer, T., D. McEwan, and G. H. Burgess. 2001. Factors Affecting Chinook Salmon Spawning in the Lower Feather River in Contributions to the biology of Central Valley salmonids. R.L.Brown. (ed.), CDFG, 269-297.

Stillwater Sciences, 2002. Napa River Basin Limiting Factor Analysis. Final Technical Report, 2002

Thompson, A., 1986. Secondary flows and the pool–riffle unit: a case study of the processes of meander development. Earth Surface Processes and Landforms 11, 631–641.

USFWS, 1968. Analysis of fish habitat of the Napa River and tributaries, Napa County, California, with emphasis given to Steelhead trout production. October 21, 1968. Memorandum to file

White JQ, Pasternack GB, Moir HJ (2010) Valley width variation influences riffle-pool location and persistence on a rapidly incising gravel-bed river. Geomorphology 121: 206-221.

This page intentionally left blank

5. APPENDICES

This page intentionally left blank