Dry Creek Adaptive Management Plan (AMP)

Final

Prepared for

Sonoma County Water Agency

Prepared by

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Executive Summary

The Russian River Biological Opinion (RRBIOP, NMFS 2008) identifies the operation of Warm Springs Dam as adversely modifying critical habitat in Dry Creek and jeopardizing coho salmon (endangered) and steelhead (threatened). To alleviate these impacts, the RRBIOP compels the Sonoma County Water Agency (Water Agency) and the United States Army Corps of Engineers (USACE) to implement projects along up to six miles of mainstem Dry Creek. Projects will be designed and implemented with the objective of addressing the lack of low water velocity areas with adequate cover and appropriate water depth that limit habitat suitability for juvenile salmonids in general and juvenile coho salmon in particular. Multiple habitat enhancement projects over the 14 mile length will occur in phases during the 15 year time-period covered by the RRBIOP.

A question raised by the RRBIOP is whether Dry Creek habitat enhancements will have the desired benefits. This question is important both for receiving credit toward the total amount of habitat enhancements set forth in the RRBIOP (six miles) and for assessing the relative effectiveness of various habitat enhancements options. For the latter reason, the RRBIOP states that "an adaptive management, monitoring and evaluation plan" will be developed that identifies "project goals, objectives and success criteria". ESSA Technologies Ltd. (an independent consulting firm from Vancouver Canada) facilitated the collaborative development of an adaptive management plan (AMP) for Dry Creek in an iterative process of meetings, discussions and document revision. This document captures the outcomes of that process.

The goal of the Dry Creek AMP is to serve as a guide for monitoring juvenile coho and steelhead populations and the habitats they live in over multiple years to detect change resulting from habitat enhancement. A series of multi-agency workshops were convened to address the following objectives:

1. Identify performance measures;
2. Develop success criteria for each performance measure;
3. Select approaches for evaluating performance measures relative to success criteria;
4. Agree on a set of decision rules for determining credit toward the total amount of habitat enhancement.

Evaluation of performance measures will be based on the results of implementation monitoring to determine if the habitat enhancement was done according to the approved design, effectiveness (habitat) monitoring to determine if the enhancement is having the intended effect on physical habitat quality and validation (fish) monitoring to assess whether the habitat enhancement is achieving the intended biological objective. For each type of monitoring, quantitative data for performance measures will be gathered using specific data collection protocols. These quantitative data will then be used to qualitatively rate whether the habitat enhancement was implemented correctly, whether it is having the desired effect on physical habitat conditions and whether juvenile coho and steelhead are benefiting from the work. Ratings at smaller spatial scales will be combined within or "rolled-up" to larger spatial scales as new habitat enhancement projects are implemented. Results from habitat monitoring will play a central role in determining project success, but results from fish monitoring will influence interpretation of project success, and potentially modify future project design. Information

gained in earlier phases of the project regarding habitat enhancement measures that provide the most benefit will be fed in to the design adaptively to inform the design of future project phases.

In order to arrive at an overall qualitative rating for all habitat enhancements in Dry Creek, qualitative ratings from specific types of monitoring and scales will lead to decisions ranging from no action required (good and excellent ratings) to some remedial action (fair and poor ratings). Finally, qualitative ratings from all types of monitoring will be combined to arrive at an overall decision on how much credit to assign to the entire set of habitat enhancement projects in Dry Creek (Figure 1).

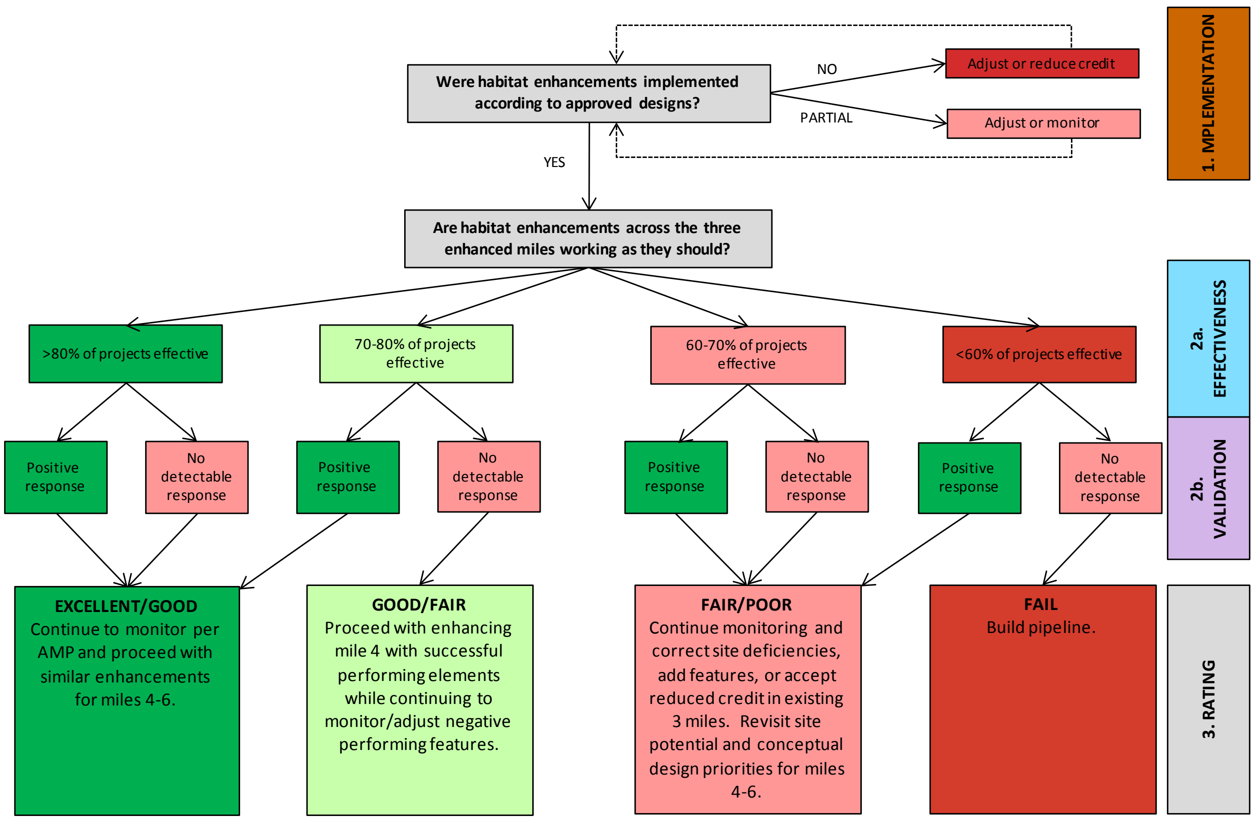

Figure 1. Process for determining course of action in 2018 after the first three miles of Dry Creek have been enhanced.

Acknowledgements

We are very grateful to the participants who have attended multiple workshops (Appendix 5) in support of the development of the Dry Creek AMP. This includes representatives from the Sonoma County Water Agency, the National Marine Fisheries Service, California Department of Fish and Wildlife, United States Army Corps of Engineers, Inter-Fluve, and ESSA Technologies Ltd. Their ideas form the core content of this document.

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Glossary of Terms

Effectiveness monitoring: Monitoring to determine if the enhancement/restoration is having the intended effect on physical habitat quality.

Estimate: A value (i.e., a point estimate) or range of values (i.e., an interval estimate) applied to a parameter of a population on the basis of sampling statistics.

Features: Individually engineered elements (e.g., large woody debris accumulation, riffle, pool, side channel, alcove, boulder cluster, etc.) that will individually or in composite make up a habitat enhancement site (see definition for Site below). Features can in some cases represent complete habitat units (see definition for Habitat Unit below), while in other cases they represent only structural components within a habitat unit (e.g., large wood placement).

Goals[1]: Desired outcomes from Dry Creek enhancement actions as articulated in applicable documents and agency missions / mandates. Goals are distinguished from objectives as follows:

- Goals are broad; objectives are narrow.
- Goals are general intentions; objectives are precise.
- Goals are intangible; objectives are tangible (i.e., measurable).
- Goals are abstract; objectives are concrete.

There are usually tradeoffs among the goals suggested by different stakeholders. *Examples:* ‘supply water to Santa Rosa’, ‘significantly improve juvenile coho production out of Dry Creek’.

Habitat Unit: A designation within a habitat classification system that allows stratification (based on natural patterns of variation) when attempting to quantify biological or physical attributes of a stream. For the purpose of habitat condition assessments (Inter-Fluve 2010) habitat units within Dry Creek have been identified as pools, scour pools, riffles, flatwaters, cascades, alcoves, or side channels. Individual habitat unit definitions are as follows:

> **Main Channel Pool**: Pools are areas with very low velocities and multiple flow vectors, spanning at least 60% of the channel width, with minimum residual depths of 2.0 feet. Water surfaces are flat.
>
> **Scour Pool**: Pools that consist of less than 60% of the channel width and are often associated with large wood, sharp meander bends, or boulders and have residual pool depths of at least 2.0 feet.
>
> **Riffle**: Riffles have obvious surface turbulence and are typically shallow water with low to moderate slopes (<4%). Water velocities are greater than 1 ft/s.
>
> **Flatwater**: Flatwaters have little surface turbulence and lack significant residual depth (less than 2 feet), with water velocities greater than pools. Flatwaters are deeper and velocity is less than in riffles; water surfaces are gently sloping.
>
> **Cascade**: Cascades are steep gradient (>4%) riffles with short falls, plunges or chutes typically dominated by boulders or bedrock.

[1] goal = fundamental objective = what you want; objective and sub-objectives = means objectives = how to get what you want

> **Alcove/Backwater Pool**: Alcove/backwater pools are pools located off the main channel in alcove or backwater areas. These units do not have a downstream flow component at the time of the survey.
>
> **Side Channel Pool/Riffle/Flatwater**: Side channels split from the main channel and reconnect downstream. Side channels can be categorized as side channel pools, riffles, or flatwaters based on the dominant habitat type in the side channel.

Implementation monitoring: Monitoring to determine if the habitat enhancement/restoration was done according to the approved design.

Large woody debris: A large piece of relatively stable woody material having a diameter greater than 30 cm (12 inches) and a length greater than 2 m (6 feet) that intrudes into the stream channel.

Objectives: The proposed means of achieving goals. Objectives are a disaggregation of goals into a logical hierarchy of desired attributes of the system. Higher level objectives in the objectives hierarchy may reflect a combination of conditions that are not directly measurable with a single metric, but sub-objectives lower in the hierarchy should correspond to performance measures that are directly measurable. (*Example*: 'create and maintain 6 miles of coho habitat').

Performance measure: A method of assessing the attainment of an objective in either quantitative or descriptive terms. More technically, the variable measured during monitoring (or calculated during analysis) and reported as an estimate of the performance of one or more management actions against one or more objectives. Performance measures can also be proxy measures or indicators for something that cannot be measured directly.

Reach: a) Any specified length of stream; b) A relatively homogeneous section of a stream having a repetitious sequence of physical characteristics and habitat types; or c) a regime of hydraulic units whose overall profile is different from another reach. It is often the principal sampling unit for collecting physical, chemical, and biological data.

> **Enhancement reach**: A specified collection of enhancement sites (see definition for site below) that are implemented in close proximity to one another.
>
> **Project reach**: A specified collection of enhancement reaches (see definition for Enhancement Reach above)

Site: One or more engineered habitat features (see definition for Features above) that have been designed to work in combination to enhance a stream reach.

Suitable habitat: Environments used by a particular species or particular life stages which provide all requirements for survival (e.g., food, shelter) at a level deemed acceptable based on project goals.

Temporal scale: The length of time over which a certain kind of response from management actions can be expected to take, and the logical duration of monitoring to detect that response.

Trend monitoring: Monitoring to detect trends in a particular performance measure (or set of performance measures) over time.

Validation monitoring: Monitoring to assess whether the habitat enhancement/restoration work is achieving the intended objective (i.e., creating habitat that is inhabited by listed salmonids and appreciably improves the production and survival of rearing steelhead and coho salmon in Dry Creek).

1.0 Introduction

1.1 Background

In September 2008, the National Marine Fisheries Service (NMFS) through Section 7 consultation under the federal Endangered Species Act (ESA) issued a Russian River Biological Opinion (RRBIOP) on the water supply, flood control, and channel maintenance operations in the Russian River watershed (NMFS 2008). The California Department of Fish and Wildlife (CDFW) issued a consistency determination on November 9, 2009, finding that the RRBIOP was consistent with the California Endangered Species Act (CESA). The RRBIOP identifies the operation of Warm Springs Dam (WSD) as adversely modifying critical habitat in Dry Creek and jeopardizing coho (endangered) and steelhead (threatened). The RRBIOP includes a Reasonable and Prudent Alternative (RPA) with a 15 year timeline for implementation that minimizes these adverse impacts. More specifically, the RPA compels the Sonoma County Water Agency (Water Agency) and the United States Army Corps of Engineers (USACE) to conduct projects along six miles of Dry Creek to enhance habitat and reduce stream velocities during critical fish-rearing months. Guidance for the types of habitat enhancement projects and target habitat conditions are outlined in the RPA. Many of the site specific details (e.g., location, form, connectivity) are identified in Inter-Fluve's Conceptual Design Report (Inter-Fluve 2012) and depend on the opportunities available in the system, which in turn are affected by both geomorphic characteristics and the cooperation of landowners. The RPA also states that the Water Agency will develop and implement an adaptive management plan to assess the effectiveness of the habitat enhancement projects:

> "Prior to construction of Phase III, IV and V enhancement projects, SCWA [the Water Agency] will develop and submit to NMFS and CDFG [CDFW] for review and approval, a post-construction adaptive management, monitoring and evaluation plan that will identify project goals, objectives and success criteria." (pg. 265; NMFS 2008)

To meet this, the Water Agency asked ESSA Technologies Ltd. (an independent consulting firm from Vancouver Canada) to facilitate the collaborative development of an adaptive management plan (AMP) for Dry Creek, involving all parties to that portion of the RPA, together with other experts, in an iterative process of meetings, discussions and document revision. The current AMP incorporates our best understanding of agreements reached during multi-agency workshops and meetings convened between 2010 and 2012 to define approaches for monitoring Dry Creek habitat enhancements so as to inform RRBIOP crediting toward the total amount of habitat enhancement area outlined in the RRBIOP. The key entities involved in implementing the RPA for Dry Creek (NMFS, CDFW, Water Agency, USACE, and Inter-Fluve) were encouraged to participate in the AMP process so that the final document accurately captures the knowledge, goals and objectives of all parties. Throughout this document we will refer to the entities that participated in this process as the "Dry Creek AMP Working Group". The initial one mile targeted for habitat enhancement of Dry Creek has been selected. This "Demonstration Mile" represents a pilot project that will serve as a guide for habitat enhancement work in later phases. It is a pilot both in regards to the design of the habitat projects themselves as well as to the associated implementation, effectiveness and validation monitoring approaches that will be used to gauge overall project success. It is expected that aspects of the AMP will be adjusted based on results from pilot implementation and analyses in the Demonstration Mile. The initial monitoring and evaluation methods described herein will be evaluated relative to their cost, feasibility and overall utility and may be revised as necessary. The general schedule for developing the Dry Creek AMP is summarized in Appendix 1.

1.2 Adaptive management – the concept

Adaptive management (AM) is a formal process for continually improving management policies and practices by learning from their outcomes (Taylor et al. 1997). The fundamental principles of AM include:

- learning to reduce critical management uncertainties;
- using what is learned to change management policy and practice (i.e., "closing the loop"; ensuring what is learned informs decisions); and
- following a formal, structured, and systematic process (i.e., not ad-hoc, trail-and-error, or simply reactionary adaptation).

AM involves synthesizing existing knowledge, exploring alternative actions, making explicit predictions of their outcomes, selecting one or more actions to implement, monitoring to see if the actual outcomes match those predicted, and then using these results to learn and adjust future management plans and policy (Walters 1986, Taylor et. al 1997, Murray and Marmorek 2003, Williams et al. 2007). This sequence can be summarized by the following 6-step process (Figure 2).

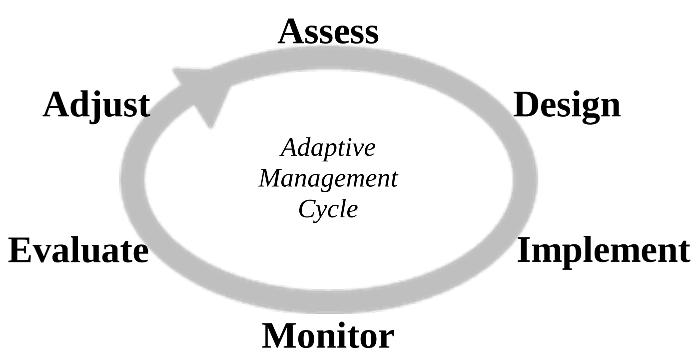

Figure 2 The adaptive management cycle (Murray and Marmorek 2003; Williams et al. 2007).

The AM process for the Dry Creek Project is intended to be iterative. After management treatments are completed and assessed, the knowledge gained will be applied to improve the next round of management, recognizing that pressures from external ecosystem drivers should be expected to change over time and these changes may influence the effectiveness of management strategies.

1.3 Purpose of the Dry Creek AMP

The goal of this Dry Creek AMP is to serve as a guide for monitoring juvenile coho and steelhead populations and the habitats they live in over multiple years (pre- and post-enhancement) to detect change resulting from the treatment conditions and distinguish between background noise or non-treatment variables (NMFS 2008). Describing rigorous methods to be employed for implementation, effectiveness and validation monitoring are the objectives of the AMP, as outlined below:

1) Defining the spatial extent and temporal horizon of the project and the alternative management actions under consideration;
2) Describing the context for Dry Creek monitoring so as to highlight the linkages between management actions and habitat attributes and fish response;
3) Describing the performance measures / indicators associated with each objective as outlined by the RRBIOP; and
4) Identifying decision rules for assessing the success of current and/or future management actions.

The key performance measures (PMs) that will be used to evaluate the implementation and effectiveness of Dry Creek enhancement projects are outlined in the RPA. Monitoring of project effectiveness will rely principally on an adaptation of procedures outlined in Harris (2004), with use of associated pre- and post-treatment checklists developed by CDFW. Standard CDFW checklists described by Harris (2004) for evaluating performance of constructed features (i.e., instream habitat, off-channel habitat and bank stabilization), have been expanded and modified by NMFS, ESSA, and the Water Agency in order to incorporate the additional quantitative metrics in the Dry Creek RPA while allowing rollup of project performance evaluations to larger spatial scales of interest (i.e., site and reach).

2.0 Project Description

2.1 RPA for coho, steelhead and Chinook in Dry Creek

Within the Russian River BiOp, the RPA can be broadly described as (NMFS 2008, pg. xvii):

1) Avoid the likelihood of jeopardizing the continued existence of endangered Central California (CCC) coho, threatened CCC steelhead and threatened California Coast (CC) Chinook;
2) Avoid the destruction or adverse modification of these species' critical habitats;
3) Implement actions that are consistent with the legal authority and jurisdictions of the Water Agency and USACE; and
4) Implement actions that are economically and technologically feasible.

2.2 Spatial extent and temporal horizon of the project

The spatial extent of management actions covered by the AMP includes the 14 mile length of Dry Creek, from WSD to the confluence with the Russian River (see Figure 1 in Inter-Fluve 2012). While the tributaries are of interest and the RPA specifies certain actions be taken by the Water Agency in tributaries (NMFS 2008, pg. xvii), they are explicitly not part of the study area and are therefore beyond the scope of the Dry Creek AMP.

The temporal horizon for undertaking and evaluating current actions is described in the RPA (Table 33, pg. 264, NMFS 2008, reproduced in Table 1 below). The timeline indicates when various habitats should be enhanced, and identifies key decision points that would occur within 15 years of project initiation (i.e., 2009 – 2023). These mandated decision points are incorporated into the AMP; however, a longer time horizon may ultimately be required to determine whether statistically and biologically significant changes occur in freshwater production. There is likely to be an inherent time lag between creation of enhanced freshwater habitat and the ramping up of coho populations, and detection of a response is made more difficult by the high variability in estuarine and marine survival rates (Bradford et al. 2005).

Table 1 Timeline of Dry Creek habitat project design, construction, implementation, monitoring, and evaluation over the next 15 years. Source: Table 33 in NMFS (2008), pg. 264.

Years	2009-10	2011-12	2013-15	2016-18	2019-20	2021-23+
Phase	I	II	III	IV	V	VI
Engineering Design	Conceptual Design	Permitting & final design: mile 1	Permitting and final design: miles 2 & 3	Permitting and final design: miles 4-6		
Engineering Construction			Construct mile 1	Construct miles 2 & 3	Construct miles 4, 5 and 6	
Design evaluation & AM			Evaluate mile 1 & boulder clusters	Evaluate miles 2, 3 & boulder clusters	Evaluate miles 4, 5 and 6	
Monitoring	Pre-monitoring		Pre and post-monitoring			

2.3 Key Decision Points

Several decision points over the next ten years will be important for directing the development of habitat enhancement projects in Dry Creek (Figure 3). An inventory of current conditions in Dry Creek and associated feasibility assessment (Inter-Fluve 2010a) has informed the conceptual design for the demonstration project in Mile 1 (Phases I & II in Table 1; see Inter-Fluve 2010b, 2011a, 2011c). Inter-Fluve's design documents (and reviews by NMFS and CDFW) have moved the project considerably closer to actual construction of habitat enhancement projects (Phase III in Table 1 and Figure 3). Decision points following the completion of habitat enhancement within the first mile and the second and third miles (Phases III and IV, respectively; blue arrows in Figure 3) represent logical places to pause, evaluate the physical habitat response to habitat enhancement projects, and adapt/modify subsequent habitat enhancement projects based on the learning that has taken place through rigorous effectiveness monitoring. Validation (biological response) monitoring will also take place for all phases of the project. However, because of population drivers that are external to habitat conditions in Dry Creek, data from validation monitoring will be supportive to the main data gained through implementation and effectiveness monitoring as described in section 3.3.3 Validation monitoring.

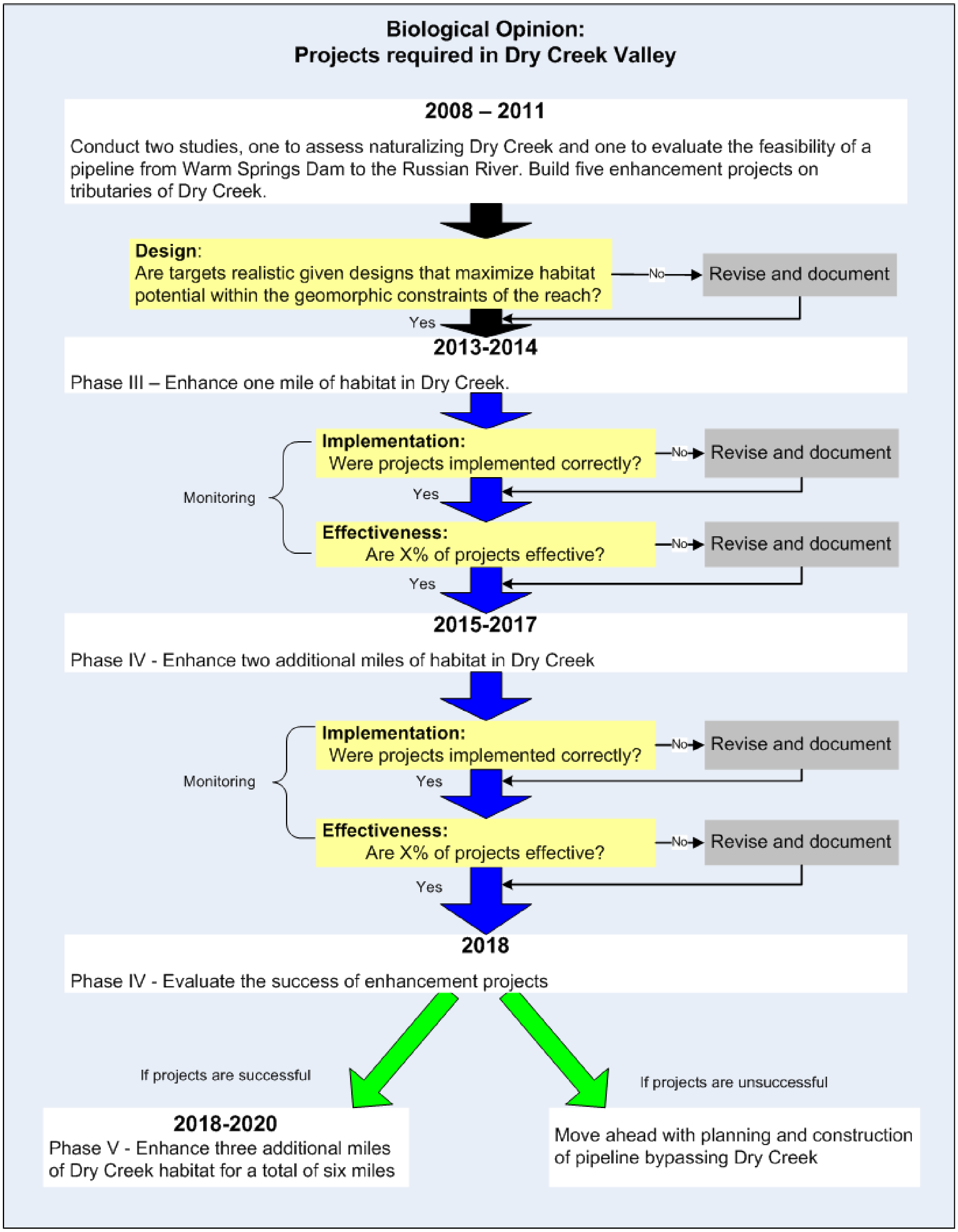

Figure 3 Straw decision process for Dry Creek habitat enhancement. The results of effectiveness and validation monitoring undertaken throughout the 5 years of project implementation from 2013-2017 will be evaluated in 2018 in order to further inform the decision of whether to design and implement future habitat enhancements.

At a higher level is a decision regarding the Water Agency's and USACE's level of compliance with the RPA for Dry Creek. This will involve examination of data from implementation, effectiveness and, to a lesser extent, validation monitoring, as well as comparisons against timelines and targets stipulated in the RPA.

2.4 Actions under consideration for enhancing fish habitat

According to the RPA (NMFS 2008, Section 3.1.1), habitat enhancement activities will focus on converting sections of stream containing marginal or poor quality habitat to near optimal quality habitats that can accommodate a range of flow releases from WSD. Habitat enhancement will create both winter and summer rearing habitat for juvenile steelhead and coho; with an emphasis on improving habitats for the survival of juvenile coho (NMFS 2008). The RPA outlines specific criteria for desired rearing habitat characteristics (see Table 13 in Inter-Fluve 2010a for summary). In considering alternative actions for enhancing fish habitat it will be important to bear in mind that Dry Creek is a fluvial system with particular physical and biological processes operating longitudinally, vertically, laterally, and temporally (Inter-Fluve 2010a). Consequently, all actions will need to be assessed individually and within the context of the system as a whole (WSD to confluence) in order to affirm the feasibility and sustainability of the enhancement work that is implemented at a project scale. Planned fish habitat enhancements (Inter-Fluve 2012) are intended to emphasize natural stream characteristics, or those which evolve through the geomorphology of a given stream reach. By using enhancement practices that emulate outcomes from natural geomorphic effects, the benefits provided to juvenile coho and steelhead will be optimized by increasing the amount of high quality rearing habitat. Because these approaches occur within a dynamic system, they should not be expected to be static through time. However, they should provide approximately similar quantities of habitat through time within an enhancement reach (Inter-Fluve 2012); the planned adaptive management approach outlined in the current document will guide the process of assessing whether this is indeed the case.

2.5 Conceptual model for Dry Creek

A conceptual model for the Dry Creek habitat enhancement is shown in Figure 5. The conceptual model indicates the expected salmonid habitat and population response as a result of management actions (yellow row, second from bottom) implemented in Dry Creek. Implementation of listed management actions will result in various fluvial geomorphologic processes (darker blue row, third from bottom) taking place which will in turn result in fish habitat creation (light blue row, third from top) and an eventual fish response (juveniles – grey row, second from top, and adults – top tan row). Habitat creation and fish response relate most clearly to the objectives outlined in the RPA. Therefore, progress towards these objectives will need to be monitored and evaluated to determine if the implemented management actions are working as intended.

The brown bottom row of Figure 5 shows factors currently outside the control of Dry Creek management actions, but which could have significant effects on the rate of recovery of habitat, fish populations and other ecosystem components. These factors operate concurrently with management actions, potentially generating cumulative effects that could make it difficult to tease out their relative importance. The AM monitoring design will attempt to account for and/or control for these factors by creating contrasts (to the extent possible) in time and space (e.g., reference sites subjected to the same external factors but not enhanced).

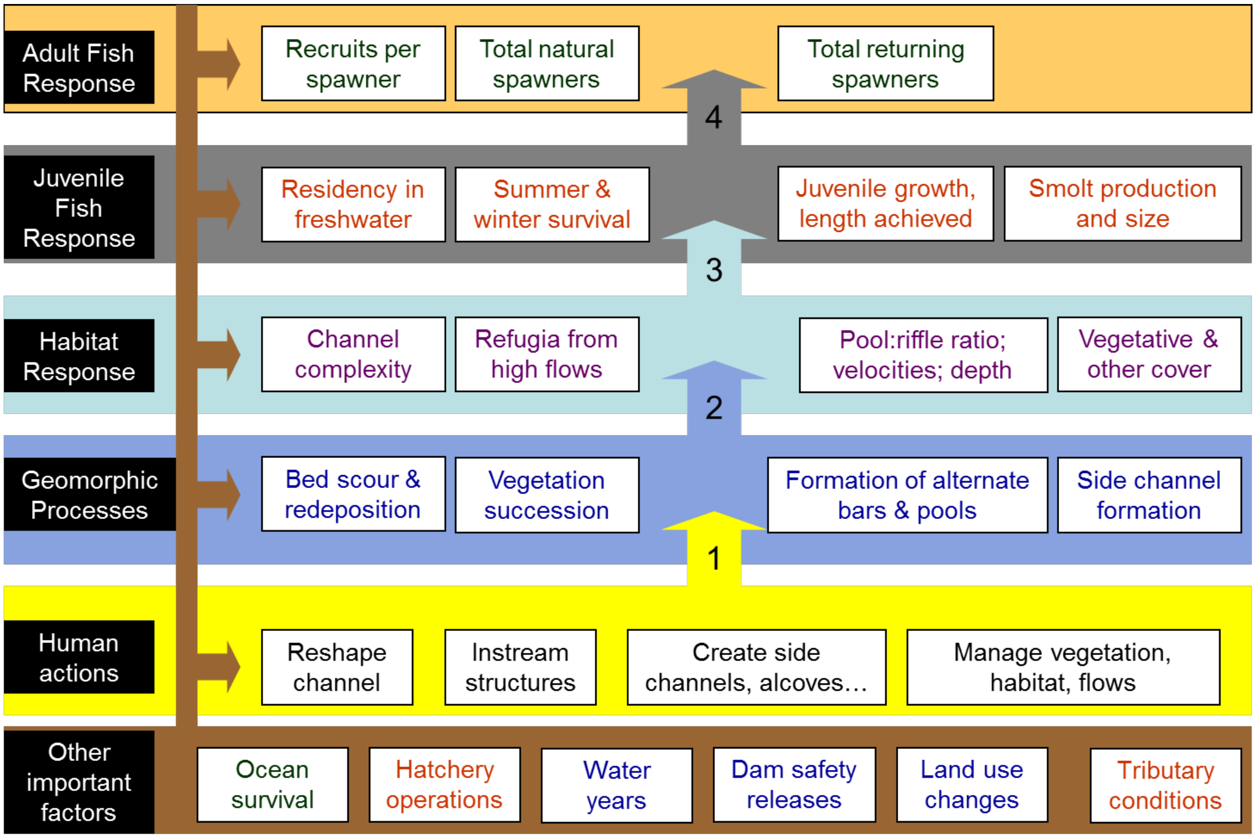

Figure 4 Conceptual model for the Dry Creek habitat enhancement activities. Color coding indicates the different types of monitoring that will be required to determine whether particular objectives are being met. The brown row at the bottom reflects important factors outside of the control of the Water Agency/USACE but that can nevertheless significantly affect each of the other rows.

2.6 Objectives

The objectives hierarchy for Dry Creek (Figure 5) provides a structured way of displaying multiple levels of objectives within the project and the relationships between these objectives. All objectives (at some level of the hierarchy) are measurable by one or more performance measures (PMs).

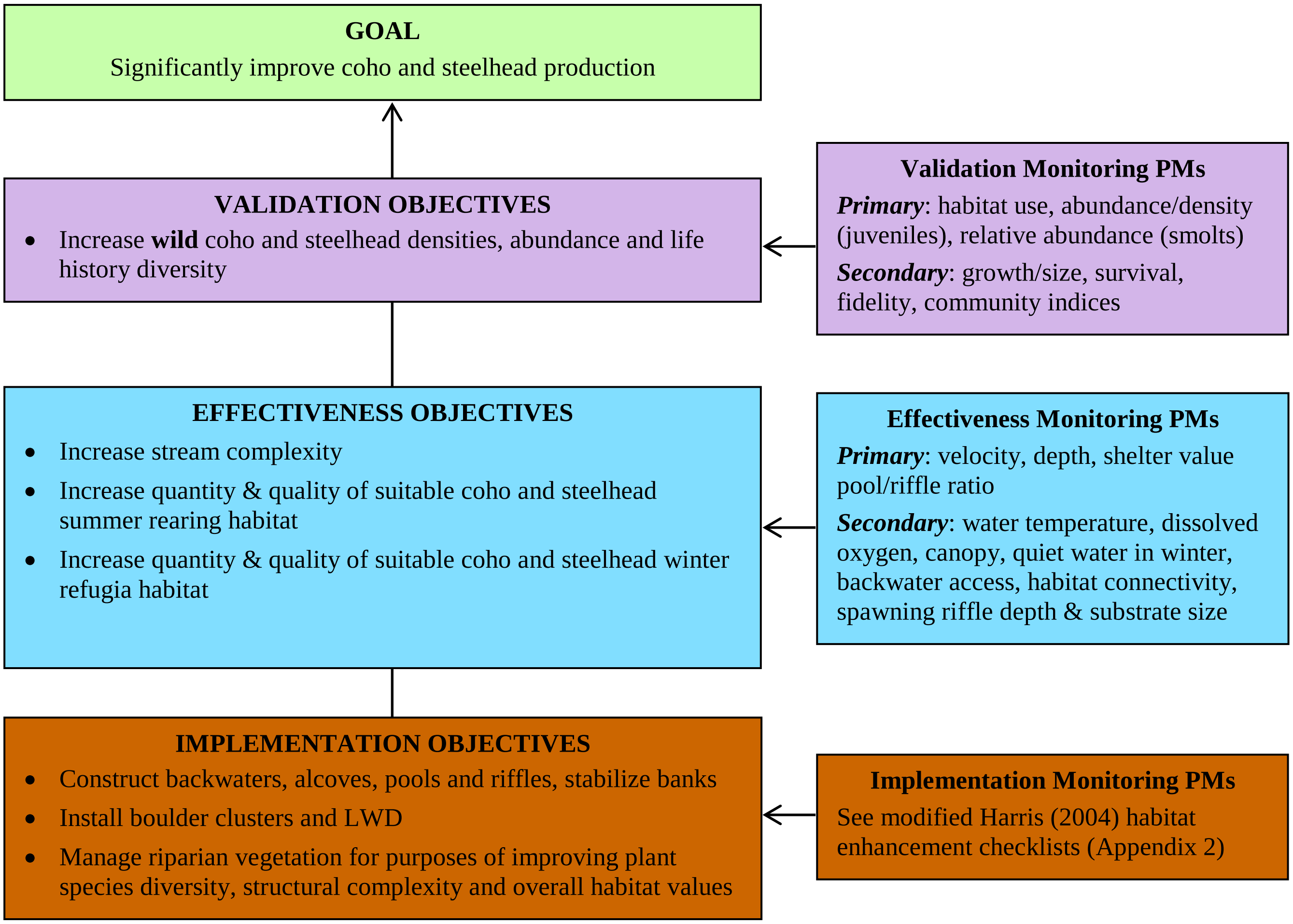

Figure 5 Objectives hierarchy for Dry Creek enhancements (organized by the causal relationships depicted in the Dry Creek conceptual model – Figure 4) with associated performance measures (PMs) to be monitored at each level of the hierarchy.

The RPA has directed the Water Agency and USACE to implement enhancements that will improve the quality of rearing habitat and appreciably increase the survival of juvenile salmonids in Dry Creek in both summer and winter months (NMFS 2008, pg. xvii). At the next level of objective specificity, the RPA lists the expected quantified habitat benefits of the RPA on Dry Creek:

- 96,500 m^2 of habitat created for steelhead (pg. 281 in RRBIOP), assuming that the 6 miles of enhanced pool-riffle habitat averages 10 m in width (i.e., 6 mi * 5280 ft/mi * 0.3048 ft/m * 10 m width) distributed over 8+ sites of Dry Creek (upper, middle, lower),
- 96,500 m^2 of high quality habitat created for coho (pg. 289 in RRBIOP, same assumptions as for steelhead) distributed over 8+ sites of Dry Creek (upper, middle, lower),
- An additional 3,000 to 6,000 m^2 of coho rearing habitat from boulder clusters (pg. 289 in RRBIOP), plus 5,000 to 10,000 m^2 of steelhead habitat from boulder clusters (pg. 282 in RRBIOP) located between enhanced reaches,

- No negative impact on Chinook.

The RPA also translates these expected habitat improvements into specific expected biological responses, while recognizing that the timing of those responses will be delayed (i.e., will not occur immediately after the habitat enhancement activities). RPA estimates of benefits to the population from fish habitat enhancements are based on assumptions outlined for juvenile steelhead and coho (pp. 281 and 289). A broader suite of detailed, measurable objectives and associated PMs have been defined that relate to successful achievement of Dry Creek RPA enhancements across different spatial (e.g. features, sites, reaches) and temporal scales.

3.0 Key questions, information and decisions

The decision that will be made in 2018 to answer the key question of whether to enhance the remaining three miles of Dry Creek will depend on the information collected and associated decisions made relative to the performance of the first three miles of habitat construction until then. For example, if the three miles enhanced by 2018 were functioning well then the decision could be made to similarly enhance additional miles. However, alternative decisions might be made (e.g., undertake additional work, re-evaluate or eliminate poorly performing enhancement techniques/reaches, build pipeline, etc.) if considerably less than a desirable amount of habitat enhancement projects were considered to be effective or a much smaller amount of enhanced coho habitat was considered near-optimal than is listed in the RPA.

This AMP incorporates the performance measures (PMs), target criteria for those PMs and the broad decision rules that will govern future actions and decisions over the 15 years encompassed by the RRBIOP (2009-2023). Decision rules adopted by the agencies will drive the design of pre- and post-construction habitat monitoring. It is expected that feedback from monitoring with regards to how the Dry Creek ecosystem actually responds to habitat enhancements, which techniques are ultimately effective, and which factors (illustrated in the conceptual model – Figure 4) are outside of management control (e.g., extreme climatic events) will allow for continued learning and innovation as well as adaptations of monitoring protocols as appropriate. In short, the results of the monitoring will answer the key questions which inform the decision process. A Joint Monitoring Team consisting of representatives from NMFS, CDFW, USACE and the Water Agency will be responsible for collecting and evaluating monitoring data.

This Adaptive Management Plan is intended to inform the subsequent phases of monitoring by incorporating feedback about the design, implementation and performance of the various techniques and features through decision rules that incorporate information collected from monitoring. Some decision rules are binary and fairly straightforward (e.g., yes or no response). For example, under implementation monitoring, the Joint Monitoring Team will evaluate whether habitat enhancement projects (e.g., pool-riffle sequencing) have been built according to their respective design plans. If the answer is yes, no action is required. If the answer is partially, the Joint Monitoring Team documents deviations from the approved designs (i.e., modifications, additions or omissions) and a course of remediating actions and/or additional monitoring is determined.

Decision rules for effectiveness monitoring are more nuanced, and require a mix of quantitative and qualitative information that involve decision rules at multiple scales to determine a suitable course of action. For example, there are decision rules which involve several possible action alternatives on a response continuum ranging from perfectly functioning habitat enhancements to habitat enhancements that do not function at all. Such a continuum necessitates management actions ranging from no action to no or reduced credit (Figure 6). Although Figure 6 pertains specifically to the first three miles enhanced between now and 2018, it could be extended (with or without modification) for additional miles of habitat enhancement after the 2018 decision point. No feature or site can receive a failed rating – in this case, some action is required to either repair, replace or accept reduced credit.

The feedback portion of the AMP comes into play through the phased approach of tracking project performance from the conceptual design and approved construction design to the overall implementation rating and effectiveness rating through time. For example, if techniques, features or sites do not perform as expected, this could be explained by a poor design, or a good design but poor implementation. The latter instance would be addressed at the implementation monitoring phase. Alternatively, if the design plans were jointly approved by NMFS and CDFW and the overall implementation rating was favorable yet the overall effectiveness rating was poor, the Joint Monitoring Team may decide to eliminate poorly performing techniques in future phases of construction. The Joint Management Team would then determine how much credit would be applied depending upon the relevant information contained in the design feasibility analysis, and the outcome of previous monitoring phases and/or future monitoring phases (eg. validation).

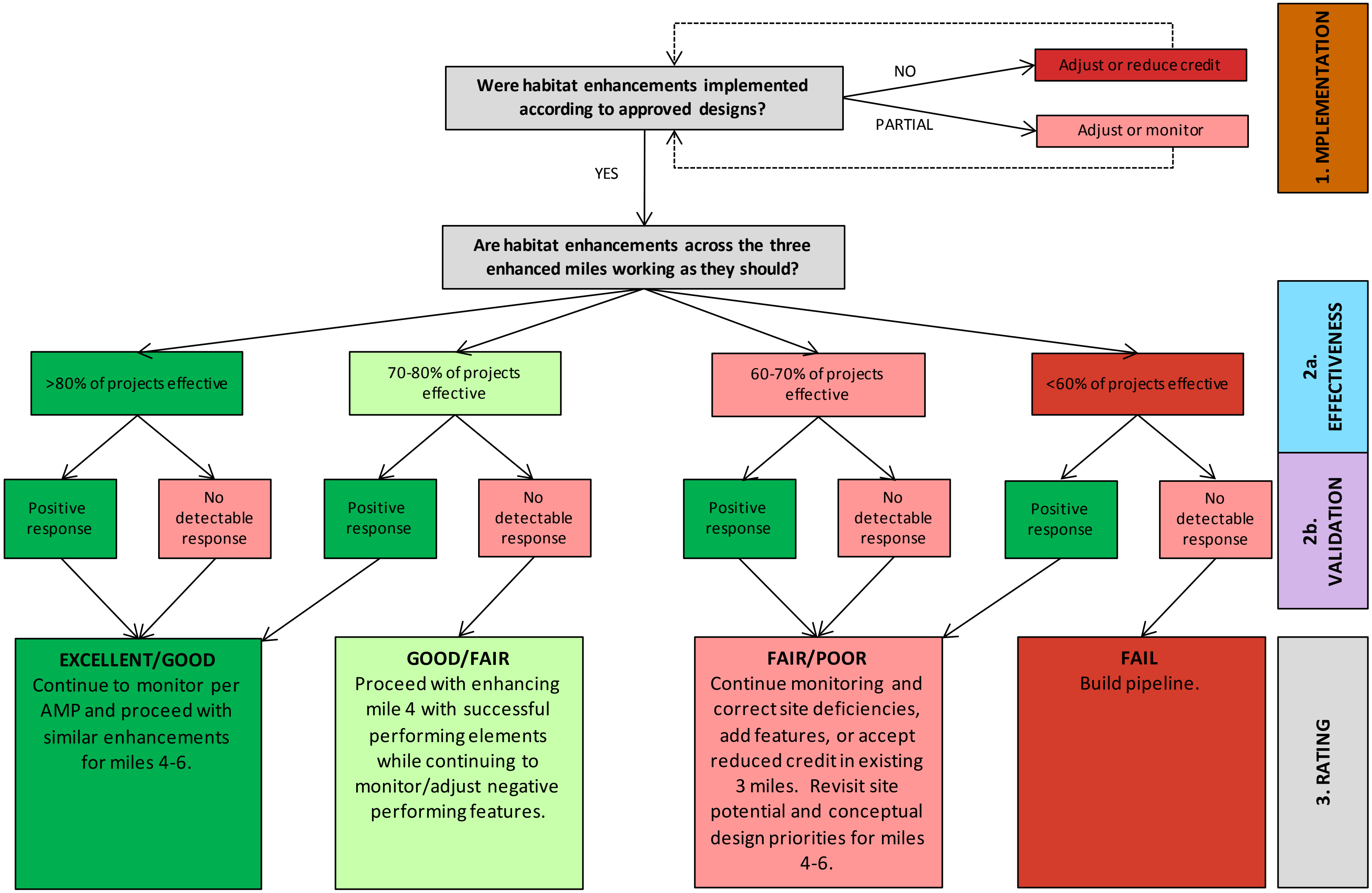

Figure 6 Process for determining course of action in 2018 after the first three miles of Dry Creek have been enhanced. Ratings will be based on an objective evaluation by the Joint Monitoring Team in a step-wise phased monitoring approach which includes phyiscal and biological quantitative measurements which lead to qualitative ratings.

3.1 Types of monitoring

Three types of monitoring (implementation, effectiveness and validation) as defined in the RPA (NMFS 2008, pg. 266) will be conducted in order to inform the decisions in Figure 6. Physical habitat responses (e.g., changes in depth, velocity, shelter) can be more directly linked to habitat enhancement actions than can biological responses which may be subject to complex factors outside of human control (e.g., seasonal rainfall patterns, ocean conditions, etc.) that will affect salmon and steelhead survival and abundance on an annual basis. Additionally, it may take a considerable length of time and a considerable amount of habitat enhancement to produce and detect a measurable biological response (Bradford et al. 2005; Roni et al 2010). For these reasons once project conditions have been documented and approved via implementation monitoring, effectiveness monitoring of improvements in physical habitat will be the primary means whereby the results of fish habitat enhancements in mainstem Dry Creek will be credited.

Implementation monitoring is "monitoring to determine if the habitat enhancement was done according to the approved design" (NMFS 2008, pg. 266). In other words, did the contractor/builder do what they said they were going to do? Implementation monitoring will occur immediately post-construction and will serve as a check-in point to determine if all the essential elements were placed according to the design as approved by NMFS/CDFW. Based on the results of post-construction implementation monitoring, The Water Agency's, USACE's or other engineering techniques and approaches will be re-visited as deemed necessary.

Effectiveness monitoring is "monitoring to determine whether habitat enhancement is having the intended effect on physical habitat quality" (NMFS 2008, pg. 266). This definition implies that protocols should facilitate a detailed comparison between baseline habitat quantity and quality data collected prior to any enhancement actions (pre-enhancement monitoring) and the habitat amounts/condition as measured over time after each implementation phase (post-enhancement monitoring). For example, pre-enhancement monitoring will occur prior to each enhancement phase, and post-enhancement monitoring will occur after the first geomorphically-effective flow (i.e., flow that deposits substantial sediment on the flood plain), or within 3 years following each enhancement phase, and then at minimum every 3 years until 2023, to assess the long term sustainability of all implemented habitat enhancement actions. Proposed timing and location of effectiveness monitoring across the 6 enhanced miles is described in Table 7.

Validation monitoring is "monitoring to determine whether habitat enhancement work is achieving the intended objective (i.e., creating habitat that is inhabited by listed salmonids and appreciably improves the production and survival of rearing steelhead and coho salmon in Dry Creek"; NMFS 2008, pg. 266). As discussed elsewhere in this document, establishing the temporal component for validation monitoring (i.e., when should validation monitoring start and for how long) will be challenging because of the inherent time lag between the physical habitat response and the expected biological response. Statistical power to detect changes in freshwater fish production depends strongly on the number of years of pre-enhancement baseline monitoring (Bradford et al. 2005; Parnell et al. 2003) and may require an extensive amount of habitat to be enhanced in order for there to be a measurable response (Roni et al. 2010). Due to serious sampling challenges given the current channel form in Dry Creek (i.e., water depths, velocities and water clarity common in Dry Creek limit efficacy of juvenile sampling techniques) there is the added complexity of how much baseline population monitoring can be effectively conducted in the time frame prior to scheduled habitat enhancements (Water Agency 2009). Proposed timing and location of validation monitoring across the 6 enhanced miles is described in Table 7.

3.2 Spatial scale and data rollup

In addition to the temporal scale (discussed above) the spatial scale at which data to evaluate PMs are collected will include four progressively broader scales: feature, site, enhancement reach, project reach (see Glossary of Terms section for definitions). Assessments at a smaller spatial scale can be viewed as the fundamental elements of habitat enhancement at a broader scale. For example, a collection of individual features can be considered the building blocks for habitat enhancement within a given site if they work together to achieve desired target conditions (Figure 7).

Depending on the type of monitoring (implementation, effectiveness or validation) and the monitoring objective, data will be used to assess the degree of success in meeting stated objectives as follows. With a few exceptions (see 3.3 Performance measures and monitoring protocols below), quantitative data collected at the feature scale will be used to inform qualitative assessments of individual features for all types of monitoring. The set of qualitative assessments for all features in a given site will then be combined in a data “rollup” to arrive at a qualitative rating (ranging from excellent to fail) for the site. For effectiveness and validation monitoring, this data rollup concept will be similarly extended to the enhancement reach and project reach scales (Figure 8).

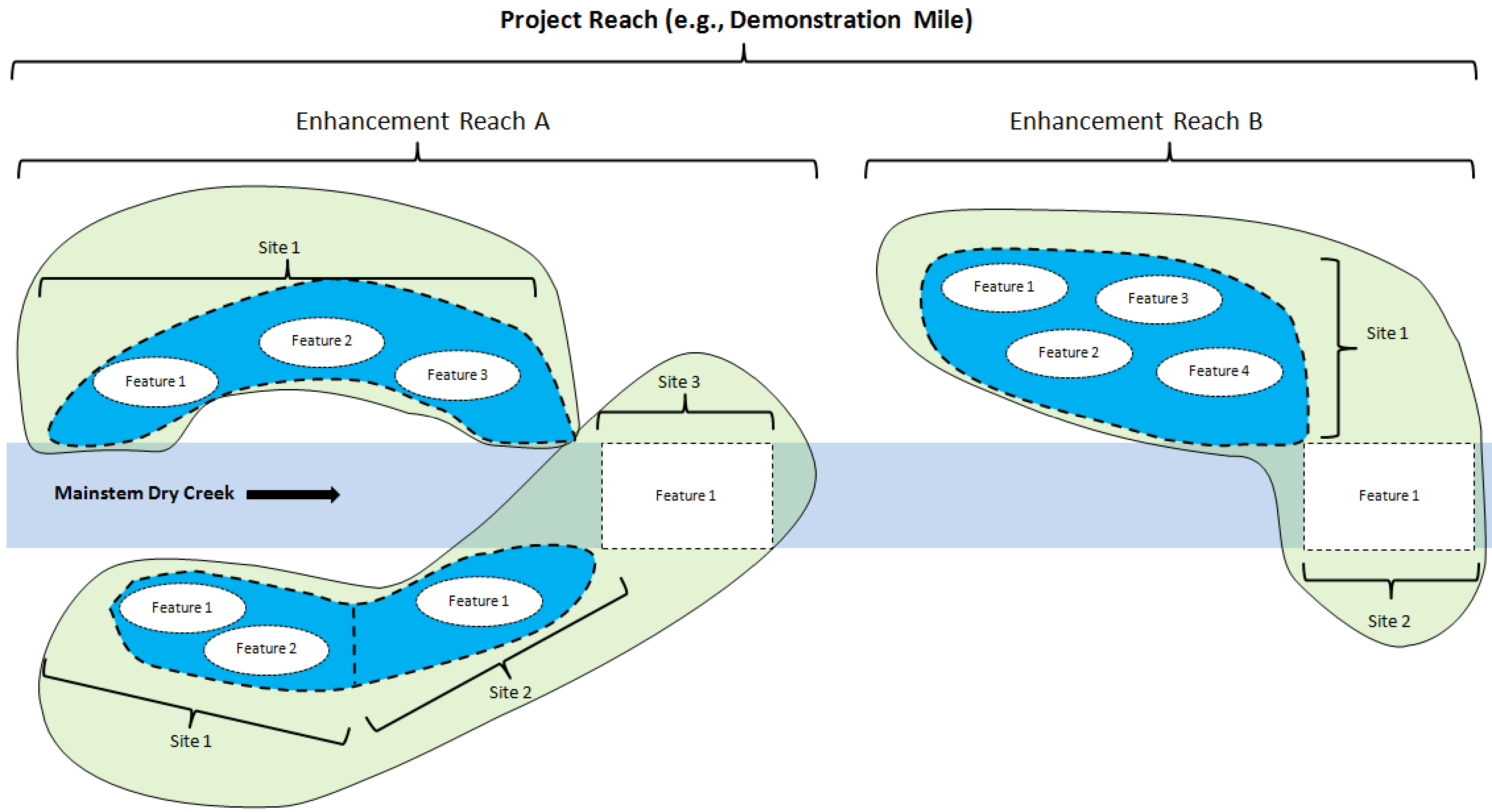

Figure 7 Hypothetical example of an enhancement reach illustrating the relationship between features, sites, enhancement reaches and project reaches. The collection of all project reaches treated represent the length of stream in Dry Creek ultimately treated and evaluated.

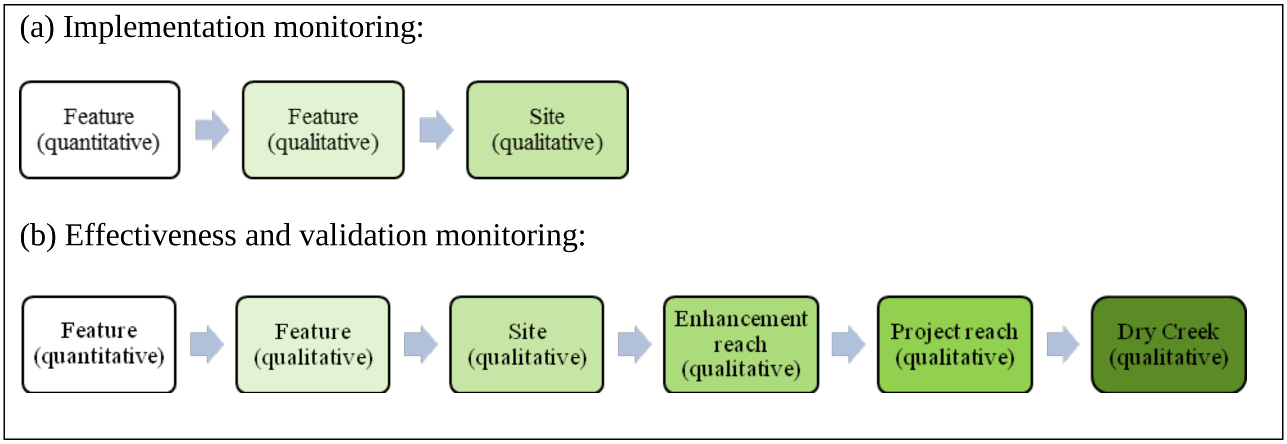

Figure 8 Illustration of the rollup concept for (a) implentation and (b) effectiveness and validation monitoring.

Because of the spatial rollup approach to monitoring described here, an important initial step prior to the commencement of post-construction effectiveness monitoring within a given enhancement reach will be an agreed-on definition of what constitutes a feature and a site within that reach. For features that will be enhanced (e.g., existing pools, placement of boulder clusters) this step could occur prior to the commencement of construction so that the degree of improvement in meeting target habitat conditions can be assessed for a given site. However, in cases where no habitat currently exists (e.g., construction of new off-channel habitat) features and sites will be defined immediately following construction (i.e., during implementation monitoring).

For purposes of the Dry Creek AMP, a site is defined as one or more engineered habitat features that have been designed to work in combination within a stream reach. The degree of hydrologic connectivity between features over a range of flows will be used as the primary criterion for determining which features comprise a given site. While hydrologic connectivity is an important consideration during the design phase, it will be necessary to confirm that all features were implemented according to the approved design (see 3.3.1 Implementation monitoring below) so that, if necessary, adjustments to which features constitute a given site can be documented.

An enhancement reach is defined as a specified collection of enhancement sites that are implemented in close proximity to one another. Most often, an enhancement reach will represent a well-defined area from which to stage construction for a particular group of features/sites. The project reach is a collection of enhancement reaches. In 2018, sufficiency of progress toward habitat enhancement in Dry Creek will be made based on how well the project reach is functioning from both a physical habitat perspective (via effectiveness monitoring) as well as a biological perspective (via validation monitoring).

3.3 Performance measures and monitoring protocols

The basis for monitoring will be performance measures (PMs) and associated protocols to assess habitat enhancement measures relative to these measures. PMs are quantitative and qualitative criteria for measuring or assessing the success of project activities that are intended to support agency management objectives. PMs will provide information on how well the Dry Creek habitat enhancements have achieved their intended benefits (in aggregate, and where appropriate and feasible, their independent benefits or unintended impacts). Consequently, PMs include explicit, pertinent and objectively verifiable results achieved at lower levels of the objectives hierarchy, leading towards the achievement of higher level project objectives and goals.

PMs are based on the expected physical and biological responses under each objective (e.g., improved rearing habitat is an example objective in the RRBIOP). Associated elements include post-project treatment mitigations which would be initiated if the expected target criteria are not met. The summary of PMs and their associated monitoring protocols in the sections that follow describe the habitat and fish response indicators, and the types of decisions they will inform. Given the nature of the AMP, the list of PMs and associated targets (i.e., success criteria) may be revised depending upon data feedback from the initial monitoring of implemented enhancement projects.

3.3.1. Implementation monitoring design and ratings

The focus of implementation monitoring is simply to determine whether actions have/have not been undertaken as intended/planned. As a matter of course, NMFS/CDFW will approve the construction plans for each phase of project construction (phases of overall project construction for habitat enhancement on mainstem Dry Creek are listed in Table 1). This approval is based on several factors including whether habitat enhancement in selected reaches is being designed in such a way to maximize the benefit to juvenile salmonids given the geomorphic opportunities and other constraints in the immediate vicinity of the enhancement reach.

The implementation monitoring design can be envisioned as a way to ensure that each feature has been constructed when, where and how intended and without any structural changes or omissions that would compromise integrity. Monitoring protocols outlined in Harris (2004) and associated implementation monitoring checklists (customized as necessary for RPA assessment) provide a useful, consistent template that will be used within the AMP for describing/documenting the implementation status of engineered enhancements in Dry Creek reaches. There is a separate checklist with respect to the three relative locations within the stream channel where habitat enhancement is being contemplated: 1) instream, 2) off-channel, 3) channel reconstruction and bank stabilization. Enhanced features will be assessed using modified Harris (2004) implementation checklists (Appendix 2). Suites of feature-level assessments will then be rolled-up into a final composite site rating (Table 2) that will be used to determine whether enhancements at a particular site are considered successful or whether further remediation will be necessary. The final overall qualitative site-scale rollup assessments of habitat enhancement implementation (i.e., excellent, good, fair, poor, fail) will be undertaken by a Joint Monitoring Team consisting of representatives from NMFS, CDFW and either the Water Agency or USACE (as appropriate). In the event that implementation was insufficient, remedial action may be recommended by the Joint Monitoring Team (Table 2).

Table 2 Qualitative rating for site-level implementation. The qualitative rating is based on a combination of qualitative and quantitative data collected using protocols as modified from Harris (2004) for each feature within the site.

Rating	**Implementation Status**	**Action**
Excellent	Exceeds all specifications and all expectations.	No action required.
Good	Meets all specifications and expectations.	No action required.
Fair	Does not meet some specifications and expectations due to site capacity or conditions beyond control, but implemented adequately.	If non-compliance is significant enough to jeopardize performance, require remedial action.
Poor	Does not meet most specifications and expectations, implemented inadequately.	Serious enough to require remedial action.
Fail	Fails to meet specifications, implemented incorrectly. Or, not implemented.	Reduce total project habitat benefit unless remedial actions are implemented.

Summary of implementation monitoring steps

- Every attempt will be made to implement habitat enhancement measures in a manner that is consistent with designs approved by NMFS and CDFW.
- Upon completion of implementation, a Joint Monitoring Team consisting of representatives from NMFS, CDFW and either the Water Agency or USACE (as appropriate) will conduct a walk-through of newly-implemented enhancement reaches in order to evaluate whether the features were implemented according to the approved designs. The outcome of this step will be a site-scale rollup (see Figure 8a and Table 2).
- Modifications to the approved designs will be documented and determination made as to whether modifications were beneficial to performance or otherwise
- If implementation did not sufficiently follow the approved design, the Joint Monitoring Team will recommend what adjustments (if any) should be made.

3.3.2. Effectiveness monitoring design and ratings

The RPA highlights high stream current velocities, inappropriate water depths, minimal instream cover, and lack of habitat complexity as serious juvenile salmonid habitat deficiencies in mainstem Dry Creek. Because of this, habitat enhancement designs are focused on improving these specific conditions. Likewise, efforts will be focused on developing performance measures that capture how those habitat conditions change as a result of habitat enhancements. Pre-treatment monitoring will occur prior to habitat enhancement implementation while post-treatment monitoring will occur after the first geomorphically-effective flow (i.e., flow that deposits substantial sediment on the flood plain), or within 3 years of completion. For some features, pre-construction monitoring may not be possible or necessary (e.g., for surfaces that are not wet prior to implementation) though as built designs/documentation is necessary for further monitoring phases.

Primary and secondary PM's have been identified and agreed to by the Joint Monitoring Team. Primary PMs (Table 3) are those metrics which: 1) will be utilized to inform enhancement effectiveness across feature/habitat unit, site and reach scales; and 2) will determine whether reach and project criteria are being met which will, in turn, influence the amount of RRBIOP habitat credit assigned as well as the future decision on whether or not to continue with an additional three miles of habitat enhancement in 2018. Secondary PMs (Table 3) will assist in determining the effectiveness of various enhancement techniques in changing non-target conditions. Secondary PMs, will not directly relate to RRBIOP crediting. Reference sources for PM targets are provided in Appendix 3.

Accounting for variation in seasonal utilization of habitat via PM's

An issue that was not explicit in the RPA but one that was recognized by the Dry Creek AMP Working Group is that juvenile coho during the spring, when they are small, tend to prefer shallower water and slower water velocities than their larger counter-parts in late summer. Coupled with the importance the RPA places on creating "near-optimal" conditions with respect to the four primary PMs listed in Table 3, the Dry Creek AMP Working Group tailored the primary PM thresholds and the associated effectiveness monitoring approach in the following ways. First, there was agreement to adjust the target velocity from a range of 0-0.2 ft/s (listed in the RPA) to a range of 0-0.5 ft/s in order to encompass the range of velocity preferences of juvenile coho when the entire size range of juveniles in freshwater is considered (see discussion in Appendix 4 and associated references in Appendix 3). Second, to the extent safe and practical we will repeat quantitative data collection for velocity, depth and shelter value at stream discharges that represent the seasonal variation critical to each life stage. Because flows in mainstem Dry Creek during the non-winter season are largely controlled by releases from Warm Springs Dam, there was agreement that stream discharge would be a good proxy for season. Therefore, Table 3 lists three PMs for each of three approximate stream discharges to reflect these differences by season: 105 cfs (currently the typical summer discharge), 200 cfs (typical spring discharge), and 1,000 cfs (typical winter discharge).

Table 3 Primary and secondary habitat performance measures and their associated "near-optimal" quantitative ranges (targets) for coho salmon at feature/habitat unit, site, enhancement reach, and project reach scales that will be directly evaluated at three different flows (spring, summer, winter) during Dry Creek effectiveness monitoring. Reference sources used to inform targeted ranges are provided in Apppendix 6.

Type of Performance Measure	Per-formance Measure	Life Stage	Biologic Function	Spatial Scale	Habitat Type	Evaluation Method	Near-Optimal Ranges (Targets)		
							Spring Flow[1]	Summer Flow[2]	Winter Flow[3]
PRIMARY	Velocity	fry	Rearing	Feature/HU/Site	Margins	Quant. & Qual.	0-0.5 ft/s	n/a	n/a
	Depth	fry	Rearing	Feature/HU/Site	Margins	Quant. & Qual.	0.5-2.0 ft	n/a	n/a
	Velocity	Summer/ winter parr	Rearing	Feature/HU/Site	Pools, off-channel	Quant. & Qual.	0-0.5 ft/s	0-0.5 ft/s	0-0.5ft/s
	Depth	Summer/ winter parr	Rearing	Feature/HU/Site	Pools, off-channel	Quant. & Qual.	2-4 ft	2-4 ft	2-4 ft
	Shelter value[4]	Juvenile	Rearing	Feature/HU	Pools, margins, off-channel	Quant. & Qual.	≥80	≥80	≥80
	Pool:Riffle ratio	Juvenile	Rearing	Project reach	Pools, riffles	Quant. & Qual.	1:2 to 2:1		
SECONDARY	Temperature	Juvenile	Rearing	Site	Off-channel	Quantitative	n/a	8-16^{o} C	n/a
	Diss. oxygen	Juvenile	Rearing	Site	Off-channel	Quantitative	n/a	6-10 mg/l	n/a
	Canopy	Juvenile	Rearing	Site	Off-channel	Quantitative	80 %		
	Quiet water (< 0.5 ft/s)	Juvenile	Rearing	Enhancement reach	Pools off-channel/ backwaters (in winter)	Quant. & Qual.	n/a	n/a	≥ 25%
	Off-channel access	Juvenile	Rearing	Project reach	Off-channel/ backwaters	Quant. & Qual.	Approx. 0.05 – 0.06 ft/s (ucrit); Approx. 3.3 ft/s (burst speed)		
	Connectivity of habitats	Juvenile	Rearing	Project reach	Pools, riffles, margins, off-channel	Qual. & GIS & Inter-Fluve modeling	Undefined		
	Substrate particle size	Adult	Spawning	Feature/Site	Riffles	Quant. & Qual.	n/a	n/a	0.25-2.5 in
	Depth	Adult	Spawning	Feature/Site	Riffles	Quant. & Qual.	n/a	n/a	0.5-1.6 ft

[1] Target coho life stage during spring is newly-emerged feeding fry which use shallower depths than would be preferred later in the summer and winter when fish would be larger. Target spring flow (discharge within the enhancement reach) is 200 cfs (approximately double the summer "base" flow).
[2] Target summer flow is 105 cfs
[3] Target winter flow is 1000 cfs
[4] See Flosi et al. (2003) for a description of how data for shelter value is collected and how shelter values are calculated.

Harris (2004) provides effectiveness monitoring protocols and associated monitoring checklists which will provide the foundation for many of the effectiveness evaluations to be utilized in Dry Creek. The standard Harris (2004) effectiveness monitoring checklists have been modified and supplemented with the addition of more quantitative PMs specific to the RPA as it pertains to Dry Creek, as well as to allow rollup of habitat feature effectiveness ratings to the site and reach scale. These include a pre-treatment and a post-treatment checklist for each of the three relative locations within the stream channel where habitat enhancement is being contemplated: 1) instream, 2) off-channel, 3) channel reconstruction and bank stabilization for a total of six checklists, see Appendix 2).

Quantitative data

As previously discussed (section 3.2 Spatial scale and data rollup), the collection of quantitative data for PMs will form the basis for evaluating overall effectiveness of habitat enhancement measures in Dry Creek (Figure 8b). Collection of quantitative data on velocity, depth and shelter (the three primary PMs that can be measured at the feature/habitat unit scale; Table 3) will take place in locations where habitat enhancement will occur (pre-treatment) or has occurred (post-treatment).

Water velocity and depth data will be collected in either of two ways depending on the type of habitat enhancement being evaluated:

- In constructed backwaters and in main channel portions of Dry Creek where constructed riffles will be placed, water depth and average water column velocity will be measured along evenly-spaced cross-sectional transects. The sampling intensity (i.e., measurement interval along each transect as well as the distance between individual transects) will be decided by the Joint Monitoring Team. To help inform that decision, various levels of sampling intensity will be evaluated in an effort to optimize the trade-off between effort and accuracy so as to inform planning for future effectiveness monitoring.
- In main channel (instream) portions of Dry Creek near selected large woody debris structures (log jams, etc.) and boulder placements, water depth and velocity gradients will be measured and mapped in relation to installed features. This “habitat feature mapping” will result in spatial (two-dimensional) depictions of various habitat features showing the area of newly created habitat meeting depth and velocity criteria (Table 3). Specific approaches and instruments for habitat feature mapping will be evaluated and decided on by the Joint Monitoring Team.

Shelter value (Flosi et al. 2003) is a primary PM that will be measured at the habitat unit-scale for both enhanced existing habitat units as well as newly-created habitat units (e.g. constructed backwaters, pools).

Pool:riffle ratio is the fourth and final primary PM. Pool:riffle ratio will be measured at the project reach scale.

In all cases, the quantitative data will be used to develop qualitative ratings for evaluation at the appropriate scale (feature, habitat unit, project reach). Qualitative ratings for features / habitat units within a site will then be rolled-up to arrive at a composite site rating (Table 4). Qualitative ratings for sites within an enhancement reach will be further rolled-up into a composite enhancement reach rating and, finally, enhancement reach ratings within a project reach will be rolled-up into a final project reach rating. For both the enhancement reach and project reach rollups, the same criteria listed in Table 5 will be used. Monitoring of secondary PMs at the appropriate scale will also occur as a way to document changes that may arise as unintended benefits or detriments due to habitat enhancements which are largely targeted at the primary PMs; however, secondary PMs will only be used as a way to guide future enhancement efforts. The final overall qualitative rollup assessments of habitat enhancement effectiveness (i.e., excellent-good, fair-poor, fail) will be undertaken by a Joint Monitoring Team consisting of representatives from NMFS, CDFW and either the Water Agency or USACE (as appropriate). In the event that effectiveness monitoring reveals less than a "good" rating for a feature, site or an enhancement reach, remedial action may be recommended by the Joint Monitoring Team (Table 4 and Table 5) depending on the circumstances. The Joint Monitoring Team will use the adaptive management feedback loop (Figure 2) as a mechanism to incorporate information regarding primary and secondary PMs when developing/reviewing plans for future habitat enhancements.

Table 4 Post treatment site-level effectiveness rating. Standard CDFW habitat ratings based on Harris (2004) have been modified to incorporate Dry Creek RPA-specific quantitative enhancement objectives.

Rating	Objectives	Criteria	Unintended Effects	Structural Condition	Future Outcome
Excellent-Good	Achieved all or most stated site design objectives.	All to most features/ habitat units achieve desired habitat response and meet targeted values for primary PMs (where relevant) **(>80% of features rated Good or Excellent)**	None or minimal negative unintended effects. Unintended positive effects may outweigh failure to achieve a targeted value.	Excellent to Good. Has the intended functional value.	Continue to monitor according to adaptive management plan.
Fair-poor	Some to many site design objectives not achieved, or objectives not achieved were beyond site capacity	Some to many features/ habitat units do not achieve desired habitat response and do not meet targeted values for primary PMs (where relevant) **(60-80% of features rated Good or Excellent)**	May have minor or major unintended negative effects that partially offset objectives or negates a targeted gain.	Poor to fair. Has some functional value	Step up monitoring on features exhibiting negative performance. Correct site or feature deficiencies as appropriate, including the option of adding sites/features or reducing total project habitat credit.
Fail	No site design objectives achieved at site due to the fault of the features; sites/feature may be completely gone.	Many features/ habitat units did not achieve desired habitat response and did not meet targeted values for primary PMs (where relevant) **(<60% of features rated Good or Excellent).**	Few positive effects and/or unintended negative effects may be degrading the habitat and outweigh achieved objectives.	Fail. Has no functional value.	Reduce site contribution from total project habitat credit. Revisit site potential and feature level design priorities. Redesign or add more sites/features. Alternatively reduce total project habitat credit.

Table 5 Post treatment enhancement reach- and project reach-level effectiveness rating.

Rating	Objectives	Criteria	Unintended Effects	Future Outcome
Excellent-Good	Achieved all or most stated reach design objectives.	All or most sites/ enhancement reaches meet or exceed targeted values.**(>80% of sites rated Good or Excellent)**	None or minimal negative unintended effects. Unintended positive effects may outweigh failure to achieve a targeted value.	Continue to monitor according to adaptive management plan.
Fair-Poor	Partially achieved most reach design objectives, or objectives not achieved were beyond reach capacity	Some sites / enhancement reaches did not meet targeted values **(60-80% of sites/ enhancement reaches rated Good or Excellent)**	May have minor or major unintended negative effects that partially offset objectives or negates a targeted gain.	Develop and implement plans to correct site or metric deficiencies, add sites/features or reduce total project habitat credit. Step up monitoring on sites and features exhibiting negative performance.
Fail	Many sites achieved no goals; objectives not achieved were the fault of the feature; sites/feature may be completely gone.	Many sites/ enhancement reaches did not meet targeted values **(<60% of sites/ enhancement reaches rated Good or Excellent).**	Few positive effects and/or unintended negative effects may be degrading the habitat and outweigh achieved objectives.	Reduce total project habitat credit, and abandon use of failed features. Revisit site potential and conceptual design priorities.

Potential use of reference sites to supplement effectiveness monitoring

As recommended in the RPA, a clearer interpretation of the benefits from habitat enhancement in Dry Creek could be gained through the use of reference/control sites (NMFS 2008). The goal of control-impact survey approaches is to assess the impact of some change, in this case the suite of Dry Creek habitat enhancement projects. A variety of impact designs with degrees of inference that increase with the level of effort (summaries in Underwood 1994 and Schwarz 2006). Mellina and Hinch (1995) provide a summary of different impact designs and describe how each might be used to assess watershed restoration. The simplest impact studies look at a single location before and after some event. Obtaining multiple observations before and after an event improves the ability to determine if an observed change is 'real' by taking into account the natural year to year variability. Because obtaining 'before' samples is often difficult, some have suggested that randomly sampling from similar but undisturbed habitats may be a suitable way to estimate variance (Underwood 1994). This approach can be considerably improved by adding a control site, where the control site is similar to the treatment site with respect to general characteristics (e.g., region, annual precipitation, size, etc.). These Before-After-Control-Impact (BACI) designs are intended to address the question of whether a particular action has resulted in a change at the treatment/impact site relative to the control site, while simultaneously adjusting for extraneous co-variables that might be similarly affecting both impact and control areas. Our ability to incorporate any of these comparative approaches in our effectiveness monitoring design will depend in large part on whether or not areas of Dry Creek currently exist that represent target conditions. Evaluations of potential reference sites are ongoing but it may be difficult to find reference conditions given dam operations and the legacy of land use in the watershed.

Summary of effectiveness monitoring steps

- Prior to implementing habitat enhancement measures (pre-construction), quantitative data on velocity, depth, shelter value and pool:riffle ratio (primary metrics) will be collected. These data will be collected in the same areas where habitat enhancement will be implemented; quantitative data will be qualitatively rated.
- Following habitat implementation (post-construction) and the first geomorphically-effective flow (i.e., flow that deposits substantial sediment on the flood plain) or within 3 years, quantitative data on velocity, depth, shelter value and pool:riffle ratio (primary metrics) will be collected at the appropriate scale (feature, habitat unit or project reach).
- Qualitative ratings of velocity, depth and shelter value at the feature- or habitat unit-scale will be developed and rolled-up to the site (Table 4) and enhancement reach (Table 5) scales in order to evaluate the project reach (Table 5). Pool:riffle ratio will be directly measured and evaluated at the project reach scale.
- Data for secondary PMs will be used as an aid in understanding unintended detriments (e.g., degraded water quality) or benefits (e.g., spawning gravel aggradation) from habitat enhancements which are primarily targeted at addressing primary PMs.
- If effectiveness monitoring reveals insufficiency (less than ‘good’ rating in either Table 4 or Table 5) in meeting primary PM targets (Table 3), the Joint Monitoring Team may recommend additional monitoring, feature or site remediation, and/or reductions in habitat crediting (Table 4 and Table 5).

3.3.3. Validation monitoring design and ratings

While biological response (validation) monitoring in mainstem Dry Creek will represent a significant effort in Dry Creek over the next several years, the utility of these data for validating the benefits of habitat enhancement is uncertain for a number of reasons inherent to the complexities of monitoring fish in open systems, and due to prevailing conditions in Dry Creek. Validation monitoring in general is often difficult to implement in a meaningful way (see Roni 2005 and references therein) and certain fisheries monitoring methods are particularly difficult to apply in Dry Creek where velocities are high (Water Agency 2009). It is also expected that a significant biological response will not occur until after appreciable suitable habitat has been created (Bradford et al. 2005; Parnell et al. 2003). As such, when crediting the amount of habitat enhanced in Dry Creek, results from validation monitoring will not be weighted as heavily as results from effectiveness monitoring. In cases where effectiveness monitoring alone leads to ambiguous results, validation monitoring will be incorporated as a modifier to aid in the final assessment of whether habitat enhancements in miles 1-3 are working as intended (this concept is reflected in the conceptual model (Figure 4) and ratings process (Figure 6)).

Validation monitoring will consist of methods to gather fish demographic/behavioral data for both primary and secondary PMs with greater emphasis placed on data that facilitate the evaluation of primary PM's (Table 6). Habitat utilization and abundance (density) will be based on snorkeling observations augmented with data from electrofishing surveys and stationary PIT antennas for juveniles. In 2012-2014 the Water Agency used continuously-operated PIT antennas to successfully document use by PIT-tagged juvenile coho and steelhead of newly-created off-channel winter habitat in the Demonstration Mile. This same approach should prove useful for other sites and, possibly, some features or reaches. Each spring since 2009 a downstream migrant trap on the lower portion of Dry Creek has been operated in order to detect changes in relative smolt abundance over time (a primary PM). Baseline (pre-habitat enhancement) growth and survival (secondary PMs) of juvenile steelhead at the reach scale have been successfully estimated with the use of PIT tags, backpack electrofishing and continuously-operated PIT antennas.

Accounting for variation due to spatial scale via PM's

Responses to habitat enhancement via validation PM's may be difficult to detect or interpret at some spatial scales given the necessary assumptions, which may be impossible or prohibitive to test. For example, each summer from 2010-2012 the Water Agency has been conducting repeated electrofishing sampling in conjunction with continuous-operation of PIT antennas to allow decoupled reach-specific survival and fidelity estimates for juvenile steelhead (Manning and Martini Lamb 2012). An important assumption when interpreting these estimates is that all individuals in the population of inference (juvenile steelhead in the reach) experience the same probability of survival regardless of habitat type, body size, behavior, etc. The consequences of violating this assumption could perhaps be partially alleviated by sampling at a small spatial scale (i.e., less habitat variability); however, that may not possible given the tradeoff between the numbers of individuals (sample size, which may be exacerbated by movement out of the reach), and available resources (the equipment and personnel needed to sample). All approaches that could be used for estimating validation PMs listed in Table 6 will require some basic assumptions that may be difficult to satisfy. Such considerations provide yet further reason to exercise caution when interpreting and applying results from validation monitoring.

Table 6 Primary and secondary biological response performance measures and their associated target ranges at feature, site, and enhancement reach scales that will be evaluated during Dry Creek validation monitoring.

Type of Performance Measure	Performance Measure	Life Stage/ Species	Spatial Scale	Evaluation Method	Target Ranges
PRIMARY	Habitat utilization	Juvenile salmonid	Feature/ Site	PIT antennas/ Snorkeling	Evidence of use (presence/absence)
	Abundance/ Density[1]	Juvenile salmonid	Site/ Enhancement reach	Electrofishing	Coho: 0.3/m^2 Steelhead: 0.5-1.5/m^2
	Relative Abundance	Smolt salmonid	Enhancement reach	Downstream migrant trap	Increasing trend
SECONDARY	Growth/ Size	Smolt salmonid	Enhancement reach	Downstream migrant trap/ PIT tags	Comparable to other Russian River coho tributaries
	Growth/ Size	Juvenile salmonid	Enhancement reach	Electrofishing/ PIT tags & antenna	Comparable to other Russian River coho tributaries
	Survival	Juvenile salmonid	Enhancement reach	Electrofishing/ PIT tags & antenna	Comparable to seasonal survival from other Russian River coho tributaries
	Fidelity	Juvenile salmonid	Enhancement reach	Electrofishing/ PIT tags & antenna	Comparable to reference sites
	Community indices	Aquatic macro-invertebrate	Site	To be determined	Comparable to reference sites

Summary of validation monitoring steps

- As with effectiveness monitoring, the focus of validation monitoring will be on evaluating primary PMs (habitat utilization, abundance/density). The methods for gathering data to evaluate primary PMs will include snorkeling observations (juveniles) and downstream migrant trapping (trend monitoring for smolts) augmented with data from electrofishing surveys and stationary PIT antennas.
- It is expected that a significant biological response will not occur until after appreciable suitable habitat has been created and that separating the effects of habitat enhancement from natural variability will be difficult.
- For these reasons, results from validation monitoring will not be weighted as heavily as results from effectiveness monitoring. In cases where effectiveness monitoring alone leads to ambiguous results, however, validation monitoring will be incorporated as a

[1] Target juvenile densities listed for juvenile coho and steelhead are from the RPA.

modifier to aid in the final assessment of whether habitat enhancements in miles 1-3 are working as they should.

3.4 Monitoring timeline

The Water Agency and NMFS have developed an initial timeline (Table 7) for comprehensive monitoring (involving spatial and temporal contrasts within a proposed BACI-based design) of fish habitat and fish population response to Dry Creek enhancements over the duration of the project (commencing with baseline and Mile 1 Demonstration Project monitoring). While the proposed monitoring timeline and crediting strategy for Dry Creek is expected to be adaptively revised based on feedback from monitoring results over time (e.g., appropriate performance metrics to apply for the different types of monitoring, adequate sample sizes, ability to carry out a full BACI-based design, etc.), Table 7 is expected to provide the initial foundation for implementation and effectiveness evaluations of Dry Creek habitat enhancements for the Mile 1 Demonstration Project and will guide at least the first 3 years of monitoring.

3.5 Reporting schedule

Results from implementation monitoring will be reported to NMFS and CDFW during the first six months following the completion of implementation monitoring for all enhancement reaches within a given project reach. Results from effectiveness and validation monitoring will be reported during the first six months following completion of effectiveness monitoring for all enhancement reaches within a given project reach.

Table 7 Initial design and timeline for implementation, effectiveness and validation monitoring in Dry Creek. The proposed BACI component of the design will be dependent on establishing concurrently monitored reference sites for comparison.

Mile	Year	Implementation	Effectiveness		Validation		
			Feature	Reach	Feature/Site	Enhancement Reach	Watershed
pilot / baseline monitoring	2009	N/A	N/A	Yes (baseline)	Yes	Yes	Yes
	2010				Yes	Yes	Yes
Reference[1]	2011	N/A	N/A	N/A	Yes	Yes	Yes
	2012				Yes	Yes	Yes
	2013			BACI for mile 1	Yes	Yes	Yes
	2014				Yes	Yes	Yes
	2015				Yes	Yes	Yes
	2016				Yes	Yes	Yes
	2017			BACI for miles 2-3	Yes	Yes	Yes
	2018				Yes	Yes	Yes
	2019				Yes	Yes	Yes
	2020			BACI for miles 4-6	Yes	Yes	Yes
	2021				Yes	Yes	Yes
	2022				Yes	Yes	Yes
	2023				Yes	Yes	Yes
pilot / baseline monitoring	2009	N/A	N/A	Yes (baseline)	N/A	Yes	Yes
	2010					Yes	Yes
1	2011	N/A	N/A	N/A	N/A	Yes (pre-project)	Yes
	2012					Yes (pre-project)	Yes
	2013-14 (year 0)	Yes	Yes (baseline)	No	Yes (pre-project)	Yes (pre-project)	Yes
	2014-15	N/A	Yes (1x within 1-3 years depending on mobility flow)	Yes (1x within 1-3 years depending on mobility flow)[2]	Yes (post-project)	Yes (post-project)	Yes
	2015-16				Yes (post-project)	Yes (post-project)	Yes
	2016-17				Yes (post-project)	Yes (post-project)	Yes
	2017-18					Yes (post-project)	Yes
	2018-19					Yes (post-project)	Yes
	2019-20					Yes (post-project)	Yes
	2020-21					Yes (post-project)	Yes
	2021-22					Yes (post-project)	Yes
	2022-23		Yes (post-project)	Yes (post-project)[3]	Yes (post-project)	Yes (post-project)	Yes
pilot / baseline monitoring	2009	N/A	N/A	Yes (baseline)	N/A	N/A	Yes
	2010						Yes
2-3	2011	N/A	N/A	N/A	N/A	As soon as reach is identified	Yes
	2012						Yes
	2013			Repeat baseline if necessary (e.g. major changes)			Yes
	2014					Yes (pre-project)	Yes
	2015					Yes (pre-project)	Yes
	2016-17 (year 0)	Yes	Yes (baseline)		Yes (pre-project)	Yes (pre-project)	Yes
	2017-18		Yes (1x within 1-3 years depending on mobility flow)	Yes (1x within 1-3 years depending on mobility flow)[2]	Yes (post-project)	Yes (post-project)	Yes
	2018-19				Yes (post-project)	Yes (post-project)	Yes
	2019-20				Yes (post-project)	Yes (post-project)	Yes
	2020-21					Yes (post-project)	Yes
	2021-22					Yes (post-project)	Yes
	2022-23					Yes (post-project)	Yes
pilot / baseline monitoring	2009	N/A	N/A	Yes (baseline)	N/A	N/A	Yes
	2010						Yes
4-6	2011	N/A	N/A	N/A	N/A	As soon as reach is identified	Yes
	2012						Yes
	2013						Yes
	2014						Yes
	2015						Yes
	2016			Repeat baseline if necessary (e.g. major changes)			Yes
	2017					Yes (pre-project)	Yes
	2018					Yes (pre-project)	Yes
	2019-20 (year 0)	Yes	Yes (baseline)		Yes (pre-project)	Yes (pre-project)	Yes
	2020-21	N/A	Yes (1x within 1-3 years depending on mobility flow)	Yes (1x within 1-3 years depending on mobility flow)	Yes (post-project)	Yes (post-project)	Yes
	2021-22				Yes (post-project)	Yes (post-project)	Yes
	2022-23				Yes (post-project)	Yes (post-project)	Yes

[1] Section of Dry Creek a few hundred meters upstream of Westside Road Bridge. On a site visit on 6/23/10, participants agreed this section of stream probably represents best example of desired habitat conditions for juvenile coho in mainstem Dry Creek. Purpose of monitoring this reference section is to compare effectiveness and validation metrics with metrics in treatment reaches

[2] Level 2 habitat survey (use modified Harris (2004) effectiveness monitoring protocols)

[3] Repeat baseline habitat survey (use protocols in Inter-Fluve's 2010 "Current Conditions" report).

4.0 Implementing an adaptive management strategy

Implementation of the adaptive management plan for Dry Creek habitat enhancements as outlined in this document will follow the adaptive management cycle shown in Figure 2 and decisions (Figure 6) will be made on the basis of relevant sources (Figure 9).

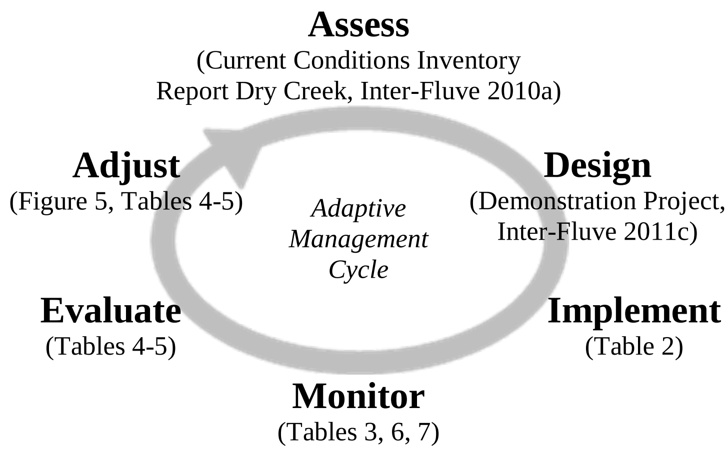

Figure 9 The adaptive management cycle (Murray and Marmorek 2003; Williams et al. 2007) including the releveant sources of information necessary to implement the AMP on Dry Creek.

Because of the period covered by this project (2009-2023), there is opportunity to learn which habitat measures are providing the greatest benefit in terms of physical habitat change to enhanced areas of Dry Creek and the associated biological responses. We will use this opportunity to learn which monitoring and sampling intensities provide the greatest benefit in terms of what we learn and can apply to later project phases.

In the spirit of adaptive monitoring and management, effectiveness monitoring in the AMP must reflect the need to understand the intended functioning of habitat enhancements of a dynamic, process-based nature (e.g., side channel location moving from time to time as dictated by geomorphologic changes) vs. enhancements that are static and fixed permanently to a specific location (e.g., boulder cluster). Questions that will guide effectiveness evaluations and allow incorporation of information learned into future designs and monitoring include:

- Did the project affect the physical, chemical and biological attributes at the appropriate scale (e.g., feature, site, or reach scale) as intended by the action?
- Has sufficient time passed for the project to be fully effective (e.g., riparian vegetation planting on newly constructed side channels would require multiple years to create shade depending on the species and local conditions)?
- Are there non-project activities in the Dry Creek watershed that are influencing the response of habitat to the enhancement projects, either positively or negatively?
- Is the extent/intensity of monitoring sufficient to assess habitat response to the project actions?

Similar to effectiveness monitoring, example questions that may guide future validation monitoring include:

- What biological response PMs are most appropriate to monitor at site, reach and watershed scales, and what are their associated targets?
- How should monitoring be conducted over space and time to assess the cause-effect linkages between habitat projects and associated fish population responses?

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Appendices

Appendix 1 Timeline of development of the Dry Creek Adaptive Management Plan (AMP).

Task	Responsibility	Timing
1. Review RRBIOP, other literature, prepare draft outline of AMP, face-to-face meetings with Water Agency, NMFS, CDFW	ESSA	May-June 2010
2. Prepare and Facilitate Workshop 1 (3 days)	ESSA	June 23-25, 2010
3. Write up results of Workshop 1 into draft AMP sections & presentation materials	ESSA	June – July, 2010
4. Iterative conference calls and revision of Workshop 1 outputs	ESSA	August, 2010
5. Prepare and Facilitate Workshop 2 (3 days)	ESSA	October 19-21, 2010
6. Send out this schedule.	ESSA	Oct 25, 2010
7. Write short technical memo summarizing Workshop 2 discussions, including summary of intended processes and description of how all the products work together.	ESSA	Dec. 2010 (this memo)
8. Water Agency, NMFS, and CDFW work together to ensure engineers and others are queued up to review the Inter-Fluve 60% design document when completed. Conduct site visit with agency engineers.	Water Agency, NMFS, CDFW	Dec. 2010
9. Inter-Fluve sends preliminary predicted habitat typing and area for demonstration reach & area	Inter-Fluve	Oct. 29, 2010.
10. NMFS, CDFW and USACE (Jane Hicks) provide biological feedback on 30% Report to Inter-Fluve – preliminary review of content. Dave Cuneo to forward doc to USACE and N. Coast Regional Water Quality Control Board.	NMFS, CDFW, USACE	Nov. 10, 2010.
11. Statistical analyses and modeling in support of design step	ESSA	Nov 2010- Dec, 2011
12. One-on-one meetings with landowners regarding 30% Design Report (after NMFS/CDFW/USACE feedback).	Water Agency	Dec 6 - 10
13. Public Meeting – Public Policy Facilitating Committee PPFC (USACE, NMFS, CDFW) – show 10% report.	Water Agency	Dec. 13
14. Write up results of Workshop 2 within draft AMP sections & presentation materials	ESSA	Jan 2011
15. ESSA to go through Harris (2004) and determine which questions are appropriate and which are not for different scales, based on Inter-Fluve's design doc for Mile 1, interacting with Inter-Fluve staff. Build this into AMP, drawing from other Harris, Flosi etc. as appropriate	ESSA	Feb 2011
16. Review literature on habitat preference curves with respect to stream velocities and depth for juvenile coho and provide summary of alternative methods for measuring suitable habitat.	ESSA with input from all parties	Feb 2011

17. 60% Design Report including design criteria, and intended evaluation method	Inter-Fluve	April 15 2011
18. NMFS, CDFW, USACE engineering and biological feedback on 60% Design Report – meeting in May	NMFS, CDFW, USACE	May 2011
19. Draft 0.8 of AMP	ESSA	July 2011
20. Prepare and Facilitate AMP Workshop 3 (1 day)	ESSA	July 19, 2011
21. Review of AMP 0.8 by Water Agency, NMFS, CDFW, USACE	Water Agency, NMFS, CDFW, USACE	July-Aug, 2011
22. 90% Design Report	Inter-Fluve	Oct 2011
23. Draft Final AMP (version 0.9)	ESSA	Sept, 2012
24. Review of AMP 0.9 by Water Agency	Water Agency,	Oct. 2012
25. Draft Final AMP (version 0.92)	ESSA	March, 2013
26. Review of AMP 0.92 by Water Agency, NMFS, CDFW, USACE	Water Agency, NMFS, CDFW, USACE	April 2013
27. Final AMP document (1.0)	ESSA	November 2013

Appendix 2 Habitat enhancement monitoring checklists and associated codes for implementation and effectiveness monitoring of instream habitat, off-channel habitat and bank stabilization projects (modified Harris (2004) protocols).

INSTREAM HABITAT ENHANCEMENT				IMPLEMENTATION
Reach #:	**Project Title:**			**page of**
Site ID:	**Site Name:**			
Date&Time:	**Evaluator:**			
	Project Feature Number			
	Feature Type Code			
Metrics	1. Was the length of channel or bank treated the same as approved?			
	a. Actual length of feature: (ft)			
	b. Width of the feature: (ft)			
	c. Area of the feature installed within bankfull channel: (ft²)			
	d. Length of aquatic habitat disturbed during implementation: (ft)			
Feature (Structure)	2. Structural condition: *Excl, Good, Fair, Poor, Fail*			
	3. Are problems with the feature visible?			
	a. Types: ANC, BBB, CRF, MAT, SHF, STR, SWA, UND, UNS, WSH, OTH			
	4. Was the feature placed in the approved location along the channel?			
	5. Was the feature placed in the approved position?			
	a. Position: LBK, MDC, RBK, SPN, OTH			
	6. Was the feature oriented as approved?			
	a. Orientation: DNS, MUL, PRL, PRP, UPS, OTH			
	7. Were approved materials used for the feature?			
	a. Materials:CON, LWD, MTL, NTR, OFR, REB, RTW, VEG, WOO, OTH			
	8. Were the sizes of materials used the same as approved?			
	9. Was the feature anchored as approved?			
	a. Anchoring: BUR, CBL, REB, STK, TIE, NON, OTH			
	10. If applicable, was the approved bank or channel excavation carried out?			
	11. Were approved erosion control measures applied to disturbed areas?			
	a. Types: FAB, NTR, NTM, OFR, PLN, SEE, SLF, STM, OTH*			
Habitat	12. If applicable, was the habitat type modification completed as approved?			
	a. Habitat created: FLT, POO, RIF, OTH			
	13. If applicable, was gravel added to the stream as approved?			
	a. Volume of gravel added to stream: (cy)			
	14. Total number of pieces of Large Woody Debris used in this feature:			
	a. Type: LWD / RTW / LWD with attached RTW: (#)			
Bank	15. If applicable, was the bank constructed to the approved angle?			
	a. As-built bank angle: (degrees)			
Implementation	16. Does the feature meet design, contract & permit specifications?			
	a. If not, were modifications beneficial to performance?			
	b. Is non-compliance significant enough to jeopardize performance?			
	c. Are corrections needed?			
	17. Would a different treatment or design have been preferable? If Y, comment.			
	18. Feature Implementation Rating: *Excellent, Good, Fair, Poor, Fail*			
FINAL SITE LEVEL RATING (feature level rollup): ***Excellent, Good, Fair, Poor, Fail***				
Comments				

□ Comment on back. Y=Yes, N=No, P=Partially, D=Don't know, A=Not Applicable.

OFFCHANNEL HABITAT ENHANCEMENT			IMPLEMENTATION		
Reach #:	**Project Title:**				**page of**
Site ID:	**Site Name:**				
Date&Time:	**Evaluator:**				
		Project Feature Number			
		Feature Type Code			
Metrics	1.	Was the length of channel or bank treated the same as approved?			
		a. Actual length of feature: (ft)			
		b. Width of the feature: (ft)			
		c. Area of the feature installed within bankfull channel: (ft²)			
		d. Length of aquatic habitat disturbed during implementation: (ft)			
Feature (Structure)	2.	Structural condition: *Excl, Good, Fair, Poor, Fail*			
	3.	Are problems with the feature visible?			
		a. Types: ANC, BBB, CRF, MAT, SHF, STR, SWA, UND, UNS, WSH, OTH			
	4.	Was the feature placed in the approved location along the channel?			
	5.	Was the feature placed in the approved position?			
		a. Position: LBK, MDC, RBK, SPN, OTH			
	6.	Was the feature oriented as approved?			
		a. Orientation: DNS, MUL, PRL, PRP, UPS, OTH			
	7.	Were approved materials used for the feature?			
		a. Materials:CON, LWD, MTL, NTR, OFR, REB, RTW, VEG, WOO, OTH			
	8.	Were the sizes of materials used the same as approved?			
	9.	Was the feature anchored as approved?			
		a. Anchoring: BUR, CBL, REB, STK, TIE, NON, OTH			
	10.	If applicable, was the approved bank or channel excavation carried out?			
	11.	Were approved erosion control measures applied to disturbed areas?			
		a. Types: FAB, NTR, NTM, OFR, PLN, SEE, SLF, STM, OTH*			
Habitat	12.	If applicable, was the habitat type modification completed as approved?			
		a. Habitat created: FLT, POO, RIF, OTH			
	13.	If applicable, was gravel added to the stream as approved?			
		a. Volume of gravel added to stream: (cy)			
	14.	Total number of pieces of Large Woody Debris used in this feature:			
		a. Type: LWD / RTW / LWD with attached RTW: (#)	/ /	/ /	/ /
Bank	15.	If applicable, was the bank constructed to the approved angle?			
		a. As-built bank angle: (degrees)			
Implementation	16.	Does the feature meet design, contract & permit specifications?			
		a. If not, were modifications beneficial to performance?			
		b. Is non-compliance significant enough to jeopardize performance?			
		c. Are corrections needed?			
	17.	Would a different treatment or design have been preferable? If Y, comment.			
	18.	Feature Implementation Rating: *Excellent, Good, Fair, Poor, Fail*			
FINAL SITE LEVEL RATING (feature level rollup): *Excellent, Good, Fair, Poor, Fail*					
Comments					

□ Comment on back. Y=Yes, N=No, P=Partially, D=Don't know, A=Not Applicable.

CHANNEL RECONSTRUCTION & BANK STABILIZATION		IMPLEMENTATION		
Reach #:	**Project Title:**			**page of**
Site ID:	**Site Name:**			
Date&Time:	**Evaluator:**			
	Project Feature Number			
	Feature Type Code			
Metrics	1. Was the length of channel or bank treated the same as approved?			
	a. Actual length of feature: (ft)			
	b. Length of bank stabilized by the feature: (ft)			
	c. Area of the feature installed within bankfull channel: (ft^2)			
	d. Length of aquatic habitat disturbed during implementation: (ft)			
	2. If applicable, was gravel added to the stream as approved?			
	a. Volume of gravel added to stream: (cy)			
	3. Was bioengineering used at this feature? If Y, use RT also.			
	4. Is feature a grade control boulder weir? If Y, use FB instead.			
Structure	5. Structural condition: *Excl, Good, Fair, Poor, Fail*			
	6. Are problems with the feature visible?			
	a. Types: ANC, BBB, CRF, MAT, SHF, STR, SWA, UND, UNS, WSH, OTH			
	7. Was the feature placed in the approved location along the channel?			
	8. Was the feature placed in the approved position?			
	a. Position: LBK, MDC, RBK, SPN, OTH			
	9. Was the feature oriented as approved?			
	a. Orientation: DNS, MUL, PRL, PRP, UPS, OTH			
	10. Were approved materials used for the feature?			
	a. Materials: CON, LWD, MTL, NTR, OFR, RTW, VEG, WOO, ROC, OTH			
	11. Were the sizes of materials used the same as approved?			
	12. Was the feature anchored as approved?			
	a. Anchoring: BUR, CBL, REB, STK, TIE, NON, OTH			
	13. Number of pieces of large wood debris used in this feature: (#)			
Reconstruction	14. If applicable, was the approved bank or channel excavation carried out?			
	15. Was the channel recontoured as approved?			
	a. Was the channel reconstructed in a new location?			
	b. Length of channel recontoured: (ft)			
	16. Were streambanks reconstructed as approved?			
	a. Were the banks reconstructed in a new location?			
	b. Length of bank reconstructed (note if length includes both banks): (ft)			
	17. Was the bank constructed or recontoured to the approved angle?			
	a. Average as-built bank angle: (degrees)			
	18. Were approved erosion control measures applied to disturbed areas?			
	a. Type: FAB, NTM, PLN, ROC, SEE, SLF, STM, OTH*			
Implementation	19. Does the feature meet design, contract & permit specifications?			
	a. If not, were modifications beneficial to performance?			
	b. Is non-compliance significant enough to jeopardize performance?			
	c. Are corrections needed?			
	20. Would a different treatment or design have been preferable? If Y, comment.			
	21. Feature Implementation Rating: Excellent, Good, Fair, Poor, Fail			
FINAL SITE LEVEL RATING (feature level rollup): ***Excellent, Good, Fair, Poor, Fail***				
Comments				
	□ Comment on back. Y=Yes, N=No, P=Partially, D=Don't know, A=Not Applicable.			

INSTREAM HABITAT ENHANCEMENT			PRE-TREATMENT	
Reach #:	**Project Title:**			**page**
Site ID:	**Site Name:**			**of**
Date&Time:	**Evaluator:**			

	Project Feature Number			
	Feature Type Code			
Metrics	1. Length of targeted treatment: (ft)			
	2. Width of targeted treatment: (ft)			
	3. Estimate area of the targeted feature: (ft^2)			
Depth / Habitat	4. Current level II habitat type: *FLT, POO, RIF, DRY, OTH*			
	5. Is change in habitat type an objective of the feature?			
	a. Targeted level II habitat type: FLT, POO, RIF, OTH			
	6. Maximum residual water depth in treatment area: *(ft)*			
	7. Is changing water depth in the treatment area an objective?			
	a. Targeted depth or range: (ft)			
Shelter	8. Instream shelter value in the targeted treatment area: *0, 1, 2, 3*			
	9. Percent of treatment area covered by shelter: *(%)*			
	10. 1st/2nd dominant: *BED, BOL, BUB, LWD, RTW, SWD, UCB, VEG, OTH*	/	/	/
	11. Is increasing instream shelter rating an objective of the feature?			
	a. Targeted minimum shelter rating: 0-300			
	12. Large woody debris count in treatment area: *D >1', L 6-20' / D >1', L >20'*	/	/	/
	13. Is increasing LWD count in the treatment area an objective of the feature?			
Other	14. Current 1st/2nd dominant substrate: *BED, BOL, COB, GRV, SND, SLC, OTH*	/	/	/
	15. Targeted 1st/2nd dominant: BED, BOL, COB, GRV, SND, SLC, OTH	/	/	/
	16. % Canopy Measurement			
	16. Photopoint data collected: yes / no			
Channel	17. Current stream channel problems: *AGG, BRD, FLO, GRC, HDC, INC, NAR,*			
	18. Is improving stream channel conditions an objective of the feature?			
	a. Targeted: AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH			
Velocity	19. Is changing velocity in the treatment area an objective?			
	a. Current avg velocity: (ft/sec)			
	b. Targeted velocity/range: (ft/sec)			
Comments				

□ Comment on back. Y=Yes, N=No, P=Partially, D=Don't know, A=Not Applicable.

OFFCHANNEL HABITAT ENHANCEMENT			PRE-TREATMENT		
Reach #:	**Project Title:**				**page of**
Site ID:	**Site Name:**				
Date&Time:	**Evaluator:**				
		Project Feature Number			
		Feature Type Code			
Metrics	1.	Length of targeted treatment: (ft)			
	2.	Width of targeted treatment: (ft)			
	3.	Estimate area of the targeted feature: (ft^2)			
Depth / Habitat	4.	Is change in habitat type an objective of the feature?			
		a. Targeted level II habitat type: FLT, POO, RIF, ALC, OTH			
	5.	Maximum residual water depth in treatment area: *(ft)*			
	6.	Is changing water depth in the treatment area an objective?			
		a. Targeted depth or range: (ft)			
Shelter	7.	Instream shelter value in the targeted treatment area: *0, 1, 2, 3*			
	8.	Percent of treatment area covered by shelter: *(%)*			
	9.	1st/2nd dominant: *BED, BOL, BUB, LWD, RTW, SWD, UCB, VEG, OTH*	/	/	/
	10.	Is increasing instream shelter rating an objective of the feature?			
		a. Targeted minimum shelter rating: (0-300)			
	11.	Large woody debris count in treatment area: *D >1', L 6-20' / D >1', L >20'*	/	/	/
	12.	Is increasing LWD count in the treatment area an objective of the feature?			
Other	13.	Current 1st/2nd dominant substrate: *BED, BOL, COB, GRV, SND, SLC, OTH*	/	/	/
	14.	Targeted 1st/2nd dominant: *BED, BOL, COB, GRV, SND, SLC, OTH*	/	/	/
	15.	% Canopy Measurement			
Velocity	16.	Photopoint data collected: yes / no			
	17.	Is changing velocity in the treatment area an objective?			
		a. Current avg velocity: (ft/sec)			
		b. Targeted velocity/range: (ft/sec)			
Comments					

□ Comment on back. Y=Yes, N=No, P=Partially, D=Don't know, A=Not Applicable.

CHANNEL RECONSTRUCTION & BANK STABILIZATION		**PRE-TREATMENT**		
Reach #:	**Project Title:**			**page**
Site ID:	**Site Name:**			**of**
Date&Time:	**Evaluator:**			
	Project Feature Number			
	Feature Type Code			
Metrics	1. Length of channel and/or bank to be treated: *(ft)*			
	2. Is feature a grade control boulder weir? If Y, use FB instead.			
	3. Will bioengineering be used at this feature? If Y, use RT also.			
Shelter	4. Is improving instream shelter and habitat an objective?			
	5. Large woody debris count in treatment area: *D >1', L 6-20' / D >1', L >20'*	/	/	/
	6. Is increasing LWD count in the treatment area an objective of the feature?			
Channel	7. Stream channel problems within the treatment area: *AGG, BRD, FLO, GRC,*			
	8. Is improving stream channel conditions an objective of the feature?			
	a. Targeted: AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH			
	9. Is reducing the active channel width within the treatment area an objective?			
	a. Average active channel width in the treatment area: (ft)			
	10. Does the stream usually go dry or sub-surface through the treatment area?			
	*a. Is decreasing the frequency and/or length of dry stream an objective?**			
	11. Is increasing residual max. water depth in the treatment area an objective?			
	a. Maximum residual water depth in treatment area: (ft)			
	12. 1st/2nd dominant substrate: *SLC, SND, GRV, COB, BOL, BED, OTH*	/	/	/
	13. Is sediment deposition at the feature an objective?			
	a. Is sediment deposition intended to narrow the stream channel?			
	b. Is sediment deposition intended to fill in a side channel?			
Streambanks	14. Is there bank erosion or instability in the vicinity of the treatment area?			
	a. Locations: UPS, DNS, WIN and LBK, RBK			
	b. Apparent causes: BAR, CNR, EMG, GRZ, HYD, RDS, UND, USG, OTH			
	15. Is stabilizing the streambank and/or reducing bank erosion an objective?			
	a. Length of targeted treatment area: (ft)			
	b. Length of unstable bank within treatment area: (ft)			
	16. Average bank angle at treatment site: (degrees)			
	17. Is reducing bank angle an objective of the feature?			
	a. Targeted bank angle: (degrees)			
Comments				

? Comment on back. Y=Yes, N=No, P=Partially, D=Don't know, A=Not Applicable.

INSTREAM HABITAT ENHANCEMENT		POST-TREATMENT		
Reach #:	**Project Title:**			page of
Site ID:	**Site Name:**			
Date&Time:	**Evaluator:**			
	Project Feature Number			
	Feature Type Code			
Feature	1. Length of targeted treatment: (ft)			
	2. Width of targeted treatment: (ft)			
	3. Estimate area of the targeted feature: (ft²)			
	4. Structural condition: *Excl, Good, Fair, Poor, Fail*			
	5. Are problems with the feature visible? Types: *ANC, BBB, CRF, MAT, SHF, STR, SWA, UND, UNS, WSH, OTH*			
	6. Is the feature still in its original location, position & orientation?			
Depth / Habitat	7. Current level II habitat type: *FLT, POO, RIF, DRY, ALC, OTH*			
	8. If an objective, did the feature create the targeted instream habitat type?			
	9. Were there any unintended effects on the habitat type? If Y, comment.			
	10. Maximum residual water depth in main channel area: *ft*			
	11. Maximum residual depth associated with the feature: *ft*			
	a. If an objective, did the feature increase/decrease water depth in the			
	12. Measure the targeted depth or range *ft*			
	a. Estimate area of feature within targeted depth or range ft²:			
	13. Were there any unintended effects on the water depth? If Y, comment.			
Shelter	14. Instream shelter value in the treatment area: *0, 1, 2, 3*			
	15. Percent of habitat unit covered by shelter: *%*			
	16. 1st/2nd dominant: *BED, BOL, BUB, LWD, RTW, SWD, UCB, VEG, OTH*	/	/	/
	17. If an objective, did the feature increase instream shelter rating?			
	a. Calculate the shelter rating: 0-300			
	18. Large woody debris count in treatment area: *D >1', L 6-20' / D >1', L >20'*	/	/	/
	19. If an objective, did the feature increase LWD count in the treatment area?			
	a. LWD recruitment methods: ANC, EXC, EXH, INT, RPR, UNA, OTH			
Channel	20. Current stream channel problems: AGG, BRD, FLO, GRC, HDC, INC, NAR, SCU, STT, WID, NON, OTH			
	21. If an objective, did the feature lead to the targeted channel conditions?			
	a. Conditions: AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH			
	22. Were there any unintended effects on the stream channel? If Y, comment.			
Velocity	23. If an objective, did the feature decrease/increase velocity in the treatment area?			
	24. Targeted velocity/range: (ft/sec)			
	25. Did the feature achieve the targeted velocity?			
	26. Measure the velocity/range: (ft/sec)			
	27. Area of habitat unit within targeted velocity: (ft²)			
	28. Percent of habitat unit within targeted velocity (see above): (%)			
	29. Were there any unintended effects on the stream channel? If Y, comment.			
Other	30. 1st/2nd dominant substrate: *BED, BOL, COB, GRV, SND, SLC, OTH*	/	/	/
	31. If an objective, did the feature achieve the targeted substrate composition?			
	32. % Canopy Measurement:			
	33. Photopoint data collected: *yes / no*			
	34. Temperature Profile: *yes / no*			
	35. Dissolved Oxygen Profile: *yes / no*			
Ratng	36. % area where targeted depth, velocity and shelter criteria overlap			
	37. Does this feature need: *DEC, ENH, MNT, REP, NON, OTH*			
	38. Are additional restoration treatments recommended at this location?			
	39. Feature Implementation Rating: *Excellent, Good, Fair, Poor, Fail*			
	FINAL SITE LEVEL RATING (feature level rollup): *Excellent, Good, Fair, Poor, Fail*			
Com-ments				

□ Comment on back. Y=Yes, N=No, P=Partially, D=Don't know, A=Not Applicable.

OFFCHANNEL HABITAT ENHANCEMENT		POST-TREATMENT		
Reach #:	**Project Title:**			**page**
Site ID:	**Site Name:**			**of**
Date&Time:	**Evaluator:**			
	Project Feature Number			
	Feature Type Code			
Feature	1. Length of targeted treatment: (ft)			
	2. Width of targeted treatment: (ft)			
	3. Area of offchannel habitat improved: ft^2			
	4. Structural condition: *Excl, Good, Fair, Poor, Fail*			
	5. Are problems with the feature visible? Types: *ANC, BBB, CRF, MAT, SHF, STR, SWA, UND, UNS, WSH, OTH*			
	6. Is the feature still in its original location, position & orientation?			
Depth / Habitat	7. Current level II habitat type: *FLT, POO, RIF, DRY, ALC, OTH*			
	8. If an objective, did the feature create the targeted instream habitat type?			
	9. Were there any unintended effects on the habitat type? If Y, comment.			
	10. Maximum residual water depth in main channel area: *ft*			
	11. Maximum residual depth associated with the feature: *ft*			
	a. If an objective, did the feature increase/decrease water depth in the			
	12. Measure the targeted depth or range *ft*			
	a. Estimate area of feature within targeted depth or range ft^2:			
	13. Were there any unintended effects on the water depth? If Y, comment.			
Shelter	14. Instream shelter value in the treatment area: *0, 1, 2, 3*			
	15. Percent of habitat unit covered by shelter: *%*			
	16. 1st/2nd dominant: *BED, BOL, BUB, LWD, RTW, SWD, UCB, VEG, OTH*	/	/	/
	17. If an objective, did the feature increase instream shelter rating?			
	a. Calculate the shelter rating: 0-300			
	18. Large woody debris count in treatment area: *D >1', L 6-20' / D >1', L >20'*	/	/	/
	19. If an objective, did the feature increase LWD count in the treatment area?			
	a. LWD recruitment methods: ANC, EXC, EXH, INT, RPR, UNA, OTH			
Channel	20. Current main channel problems: *AGG, BRD, FLO, GRC, HDC, INC, NAR, SCU, STT, WID, NON, OTH*			
	21. Did the feature lead to the targeted off channel conditions?			
	a. Overall Offchannel Condition: AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH			
	b. Outlet Conditions: AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH			
	c. Inlet Conditions: AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH			
	22. Were there any unintended effects on the main channel? If Y, comment.			
Velocity	23. If an objective, did the feature decrease/increase velocity in the treatment area?			
	a. Targeted velocity/range: ft/sec			
	b. Did the feature achieve the targeted velocity/range?			
	c. Measure the velocity/range ft/sec:			
	d. Area of habitat unit within targeted velocity: ft^2			
	24. Percent of habitat unit within targeted velocity see above: *%*			
	25. Were there any unintended effects from velocity change? If Y, comment.			
Other	26. 1st/2nd dominant substrate: *BED, BOL, COB, GRV, SND, SLC, OTH*	/	/	/
	27. % Canopy Measurement:			
	28. Photopoint data collected: *yes / no*			
	29. Temperature Profile: *yes / no*			
	30. Dissolved Oxygen Profile: *yes / no*			
Ratng	31. % area where targeted depth, velocity and shelter criteria overlap:			
	32. Does this feature need: *DEC, ENH, MNT, REP, NON, OTH*			
	33. Are additional restoration treatments recommended at this location?			
	34. Feature Effectiveness Rating: *Excl, Good, Fair, Poor, Fail*			
	FINAL SITE LEVEL RATING (feature level rollup): *Excellent, Good, Fair, Poor, Fail*			
Com-ments				

=No, P=Partially, D=Don't know, A=Not Applicable.

CHANNEL RECONSTRUCTION & BANK STABILIZATION		POST-TREATMENT		
Reach #:	**Project Title:**			page of
Site ID:	**Site Name:**			
Date&Time:	**Evaluator:**			
	Project Feature Number			
	Feature Type Code			
Metrics	1. Length of channel and/or bank to be treated: (ft)			
	2. Width of instream habitat improved: *(ft)*			
	3. Area of instream habitat improved: *(ft^2)*			
	4. Was bioengineering used at this feature? If Y, use RT also.			
	5. Is feature a grade control boulder weir? If Y, use FB instead.			
Structure	6. Feature condition: Excl, Good, Fair, Poor, Fail			
	7. Are problems with the feature visible?			
	a. Type: ANC, BBB, CRF, MAT, SHF, STR, SWA, UND, UNS, WSH, OTH			
	8. Is the feature still in its original location, position & orientation?			
Shelter	9. If an objective, was instream shelter and habitat improved?			
	a. Calculate the shelter rating: (0-300)			
	10. Large woody debris count in treatment area: *D >1', L 6-20' / D >1', L >20'*	/	/	/
	11. If an objective, did the feature increase LWD count in the treatment area?			
	a. LWD recruitment methods: ANC, EXC, EXH, INT, RPR, UNA, OTH			
Channel	12. Stream channel problems within the treatment area: *AGG, BRD, FLO, GRC, HDC,*			
	13. If an objective, did the treatment lead to the targeted channel conditions?			
	a. Conditions: AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH			
	14. If an objective, was active channel width reduced within the treatment area?			
	a. Average active channel width in the treatment area: (ft)			
	15. If an objective, was the frequency or length of dry stream decreased?*			
	16. Did the residual maximum water depth in the treatment area increase?			
	a. Maximum residual water depth in treatment area: (ft)			
	17. 1st/2nd dominant substrate: *SLC, SND, GRV, COB, BOL, BED, OTH*	/	/	/
	18. Was there sediment deposition at the feature?			
	a. Did sediment deposition at the feature narrow the stream channel?			
	b. Did sediment deposition at the feature fill in a side channel?			
	19. Were there any unintended effects on the stream channel? If Y, comment.			
Streambanks	20. Is there bank erosion or instability in the vicinity of the treatment area?			
	a. Locations: UPS, DNS, WIN and LBK, RBK			
	b. Apparent causes: BAR, CNR, EMG, GRZ, HYD, RDS, UND, USG, OTH			
	21. If an objective, was streambank instability and/or bank erosion reduced?			
	a. Length of streambank stabilized: (ft)			
	b. Length of treated bank that is still unstable: (ft)			
	22. Average bank angle at treatment site: *(degrees)*			
	22. If an objective, did the feature reduce the bank angle?			
	a. Did the feature create ≤ the targeted bank angle?			
	23. Were there any unintended effects on the banks? If Y, comment.			
Rating	24. Feature Effectiveness Rating: Excl, Good, Fair, Poor, Fail			
	25. Does this feature need: DEC, ENH, MNT, REP, NON, OTH			
	26. Are additional restoration treatments recommended at this location?			
	27. Feature Effectiveness Rating: Excl, Good, Fair, Poor, Fail			
	FINAL SITE LEVEL RATING (feature level rollup): ***Excellent, Good, Fair, Poor, Fail***			
Com-ments				

□ Comment on back. Y=Yes, N=No, P=Partially, D=Don't know, A=Not Applicable.

Codes for ***instream*** habitat enhancement checklists

Implementation - Code Key	
ANC	Anchor failure
BBB	Buried by bedload
BUR	Buried or "keyed in"
CBL	Cabled
CON	Concrete
CRF	Cable/rebar failure
DNS	Downstream
Dry	Dry
FAB	Fabric
FLT	Flatwater
LBK	Left bank
LWD	Large woody debris
MAT	Structure material failure
MDC	Mid-channel
MTL	Metal
MUL	Multiple angles
NON	None
NTM	Native mulch
NTR	Native rock
OFR	Off-site rock
OTH	Other
PLN	Planting
POO	Pool
PRL	Parallel
PRP	Perpendicular
RBK	Right bank
REB	Rebar
RIF	Riffle
RTW	Rootwad
SEE	Seeding
SHL	Shelter
SHF	Structure shifted

Implementation - Code Key	
SLF	Silt fence
SPN	Spanning
STK	Staked
STM	Straw mulch
STR	Stranded out of active channel (horizontally)
SWA	Stranded out of water (vertically)
TIE	Tied
UND	Undercut/ undermined
UNS	Undersized/ under-built
UPS	Upstream
VEG	Vegetation
WOO	Wood/wooden
WSH	Washed out

Pre-treatment - Code Key	
AGG	Aggradation
ANC	Anchor failure
BAR	Lack of stabilizing vegetation
BBB	Buried by bedload
BED	Bedrock
BOL	Boulder
BRD	Braiding
BUB	Bubble curtain
CNR	Concentrated runoff
COB	Cobble
CRF	Cable/rebar failure
DNS	Downstream
Dry	Dry
EMG	Emergent groundwater
FLO	Flow obstructions
FLT	Flatwater
FPD	Floodplain deposition
GRC	Grade control
GRV	Gravel
GRZ	Grazing/grazing animal
HDC	Headcut
HYD	Hydrologic processes
INC	Incision
LBK	Left bank
LWD	Large woody debris
MAT	Material failure
MDC	Mid-channel
MIG	Lateral migration
NAR	Narrowing
NON	None
OTH	Other

Pre-treatment - Code Key	
POO	Pool
RBK	Right bank
RIF	Riffle
RTW	Rootwad
SCU	Side cutting
SHF	Structure shifted
SIN	Sinuosity
SLC	Silt/clay
SND	Sand
SPN	Spanning
STB	Stability
STR	Stranded out of active channel (horizontally)
STT	Straightening
SWA	Stranded out of water (vertically)
SWD	Small woody debris
TOG	To grade
UCB	Undercut bank
UND	Undercut/ undermined
UNS	Undersized/ under-built
UPS	Upstream
USG	Unstable soils/ geology
VEG	Vegetation
WID	Widening
WIN	Within
WSH	Washed out

Post-treatment - Code Key	
AGG	Aggradation
ANC	Anchor failure
ANC	Anchored
BAR	Lack of stabilizing vegetation
BBB	Buried by bedload
BED	Bedrock
BOL	Boulder
BRD	Braiding
BUB	Bubble curtain
CNR	Concentrated runoff
COB	Cobble
CRF	Cable/rebar failure
DNS	Downstream
Dry	Dry
EMG	Emergent groundwater
ENH	Enhancement
EXC	Excavated
EXH	Exhumed
FLO	Flow obstructions
FLT	Flatwater
FPD	Floodplain deposition
GRC	Grade control
GRV	Gravel
GRZ	Grazing/grazing animal
HDC	Headcut
HYD	Hydrologic processes
INC	Incision
INT	Intercepted
LBK	Left bank
LWD	Large woody debris
MAT	Structure material failure

Post-treatment - Code Key	
MIG	Migration
MNT	Maintenance
NAR	Narrowing
NON	None
OTH	Other
POO	Pool
RBK	Right bank
REP	Repair
RIF	Riffle
RPR	Riparian recruitment
RTW	Rootwad
SCU	Side cutting
SHF	Structure shifted
SIN	Sinuosity
SLC	Silt/clay
SND	Sand
STB	Stability
STR	Stranded out of active channel (horizontally)
STT	Straightening
SWA	Stranded out of water (vertically)
SWD	Small woody debris
TOG	To grade
UCB	Undercut bank
UNA	Unanchored
UND	Undercut/undermined
UNS	Undersized/under-built
UPS	Upstream
USG	Unstable soils/geology
VEG	Vegetation
WID	Widening
WIN	Within

Codes for ***off-channel*** enhancement checklists

Implementation - Code Key	
ANC	Anchor failure
BBB	Buried by bedload
BUR	Buried or "keyed in"
CBL	Cabled
CON	Concrete
CRF	Cable/rebar failure
DNS	Downstream
Dry	Dry
FAB	Fabric
FLT	Flatwater
LBK	Left bank
LWD	Large woody debris
MAT	Structure material failure
MDC	Mid-channel
MTL	Metal
MUL	Multiple angles
NON	None
NTM	Native mulch
NTR	Native rock
OFR	Off-site rock
OTH	Other
PLN	Planting
POO	Pool
PRL	Parallel
PRP	Perpendicular
RBK	Right bank
REB	Rebar
RIF	Riffle
RTW	Rootwad
SEE	Seeding
SHL	Shelter
SHF	Structure shifted

Implementation - Code Key	
SLF	Silt fence
SPN	Spanning
STK	Staked
STM	Straw mulch
STR	Stranded out of active channel (horizontally)
SWA	Stranded out of water (vertically)
TIE	Tied
UND	Undercut/ undermined
UNS	Undersized/ under-built
UPS	Upstream
VEG	Vegetation
WOO	Wood/wooden
WSH	Washed out

Pre-treatment - Code Key	
AGG	Aggradation
ANC	Anchor failure
BAR	Lack of stabilizing vegetation
BBB	Buried by bedload
BED	Bedrock
BOL	Boulder
BRD	Braiding
BUB	Bubble curtain
CNR	Concentrated runoff
COB	Cobble
CRF	Cable/rebar failure
DNS	Downstream
Dry	Dry
EMG	Emergent groundwater
FLO	Flow obstructions
FLT	Flatwater
FPD	Floodplain deposition
GRC	Grade control
GRV	Gravel
GRZ	Grazing/grazing animal
HDC	Headcut
HYD	Hydrologic processes
INC	Incision
LBK	Left bank
LWD	Large woody debris
MAT	Material failure
MDC	Mid-channel
MIG	Lateral migration
NAR	Narrowing
NON	None
OTH	Other

Pre-treatment - Code Key	
POO	Pool
RBK	Right bank
RIF	Riffle
RTW	Rootwad
SCU	Side cutting
SHF	Structure shifted
SIN	Sinuosity
SLC	Silt/clay
SND	Sand
SPN	Spanning
STB	Stability
STR	Stranded out of active channel (horizontally)
STT	Straightening
SWA	Stranded out of water (vertically)
SWD	Small woody debris
TOG	To grade
UCB	Undercut bank
UND	Undercut/ undermined
UNS	Undersized/ under-built
UPS	Upstream
USG	Unstable soils/ geology
VEG	Vegetation
WID	Widening
WIN	Within
WSH	Washed out

Post-treatment – Code Key	
AGG	Aggradation
ANC	Anchor failure
ANC	Anchored
BAR	Lack of stabilizing vegetation
BBB	Buried by bedload
BED	Bedrock
BOL	Boulder
BRD	Braiding
BUB	Bubble curtain
CNR	Concentrated runoff
COB	Cobble
CRF	Cable/rebar failure
DNS	Downstream
Dry	Dry
EMG	Emergent groundwater
ENH	Enhancement
EXC	Excavated
EXH	Exhumed
FLO	Flow obstructions
FLT	Flatwater
FPD	Floodplain deposition
GRC	Grade control
GRV	Gravel
GRZ	Grazing/grazing animal
HDC	Headcut
HYD	Hydrologic processes
INC	Incision
INT	Intercepted
LBK	Left bank
LWD	Large woody debris
MAT	Structure material failure

Post-treatment – Code Key	
MIG	Migration
MNT	Maintenance
NAR	Narrowing
NON	None
OTH	Other
POO	Pool
RBK	Right bank
REP	Repair
RIF	Riffle
RPR	Riparian recruitment
RTW	Rootwad
SCU	Side cutting
SHF	Structure shifted
SIN	Sinuosity
SLC	Silt/clay
SND	Sand
STB	Stability
STR	Stranded out of active channel (horizontally)
STT	Straightening
SWA	Stranded out of water (vertically)
SWD	Small woody debris
TOG	To grade
UCB	Undercut bank
UNA	Unanchored
UND	Undercut/undermined
UNS	Undersized/under-built
UPS	Upstream
USG	Unstable soils/geology
VEG	Vegetation

Codes for ***channel reconstruction & bank stabilization*** enhancement checklists

Bank stabilization - Code Key		Bank stabilization - Code Key	
AGG	Aggradation	NAR	Narrowing
ANC	Anchor failure	NON	None
ANC	Anchored	OTH	Other
BAR	Lack of stabilizing vegetation	POO	Pool
BBB	Buried by bedload	RBK	Right bank
BED	Bedrock	REP	Repair
BOL	Boulder	RIF	Riffle
BRD	Braiding	RPR	Riparian recruitment
BUB	Bubble curtain	RTW	Rootwad
CNR	Concentrated runoff	SCU	Side cutting
COB	Cobble	SHF	Structure shifted
CRF	Cable/rebar failure	SIN	Sinuosity
DNS	Downstream	SLC	Silt/clay
DRY	Dry	SND	Sand
EMG	Emergent groundwater	STB	Stability
ENH	Enhancement	STR	Stranded out of active channel (horizontally)
EXC	Excavated	STT	Straightening
EXH	Exhumed	SWA	Stranded out of water (vertically)
FLO	Flow obstructions	SWD	Small woody debris
FLT	Flatwater	TOG	To grade
FPD	Floodplain deposition	UCB	Undercut bank
GRC	Grade control	UNA	Unanchored
GRV	Gravel	UND	Undercut/undermined
GRZ	Grazing/grazing animal	UNS	Undersized/under-built
HDC	Headcut	UPS	Upstream
HYD	Hydrologic processes	USG	Unstable soils/geology
INC	Incision	VEG	Vegetation
INT	Intercepted	WID	Widening
LBK	Left bank	WIN	Within
LWD	Large woody debris	WSH	Washed out
MAT	Structure material failure		
MNT	Maintenance		

Appendix 3 List of reference sources used to identify “near-optimal” criteria that will be used for evaluating condition of coho salmon habitat at enhanced features, sites and reaches in Dry Creek.

Preferred microhabitats for coho salmon

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Flow velocity maximums for juvenile coho (based on critical fish swimming speeds)

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Appendix 4 Assessment of engineered Dry Creek habitat enhancements in regards to desired near-optimal flows for coho salmon

There is uncertainty regarding the extent of habitat response that will be achievable in Dry Creek even when all feasible habitat enhancement techniques are undertaken, given the historical evolution of the stream channel and current land uses. Feasibility analyses undertaken (Inter-Fluve 2011b) suggest that the current width of the Dry Creek channel is insufficient to consistently meet desired RPA criteria for pool-riffle in-channel habitat (i.e., optimal pool conditions of 2 to 4 feet deep with significant areas where water column velocities are less than 0.2 ft/sec). Meeting these criteria would likely require a substantially wider channel than currently exists for Dry Creek. Attempting to widen the channel (where possible) would create a multitude of hydraulic expansions and contractions, creating discontinuities in sediment transport and other processes. Furthermore, given current hydrology and vegetation patterns, it is expected that a widened channel would ultimately evolve back towards a state similar to that currently observed in Dry Creek (Inter-Fluve 2011b). These factors suggest difficulties in engineering habitat enhancements in the mainstem which could be expected to consistently achieve average flow velocities within RPA-defined target ranges.

The velocity target defined in the RPA (NMFS 2008) was however based primarily on optima from habitat preference curves developed for juvenile coho in small streams by Beecher et al. (2002), and supported by similar velocity values from earlier studies of juvenile coho salmon (e.g., Ruggles 1966; Bovee 1978; Sheppard and Johnson 1985; Bison et al. 1988; Murphy et al. 1989; Dolloff and Reeves 1990; Bugert et al. 1991; and Shirvell 1994). More recently, however, work evaluating habitat suitability curves (i.e., Rosenfeld et al. 2005; Beecher et al. 2010) suggests that the narrow 3-6 cm/sec preference range defined for juvenile coho velocity by Beecher et al. (2002) fails to recognize the potential interactive effects of life history behaviors and food supply. Additionally, Rosenfeld et al. (2005) found that the shapes of habitat suitability curves may be sensitive to food abundance. Increased food availability can allow juvenile coho to exploit higher velocity microhabitats that might be bioenergetically unsuitable at lower food levels. Experimental studies (Rosenfeld et al. 2005) showed that increased food caused a shift to higher average focal velocities (from 6.5 to 8.4 cm/sec) with maximum growth of juvenile coho occurring in the higher velocity range of 10-12 cm/sec. The latter result is thought to relate to the territorial nature of coho and alternative feeding strategies displayed: dominant fish appear to forage first on drift in higher velocities in defended territories and grow faster, whereas more numerous subdominants forage on terrestrial drop and benthos in low-velocity habitats and grow slower.

Faster growth of juvenile coho in faster velocities is also consistent with observations by Nielsen (1992) who found that dominant fish in a natural stream had focal velocities averaging 11 cm/sec, with coho using velocities below a threshold of 6 cm/sec experiencing growth rates less than half those of fish holding at velocities greater than 6 cm/sec. In strongly territorial species, dominant fish occupying preferred habitat at low densities can force subdominant fish into lower-quality habitat at high densities. In such a scenario, effects associated with territoriality may cause suitability curves to poorly represent true habitat quality (Baker and Coon 1997; Rosenfeld et al. (2005). Consistent with the assertions of Rosenfeld et al. (2005), Beecher et al. (2010) found that PHABSIM-based results (using his defined coho habitat suitability maxima) were contrary to empirical measurement of coho smolt production in a study creek in Washington. It was determined that if flows were reduced to levels that would maximize Weighted Useable Area (WUA) then production of smolts would decline (i.e., more smolts were produced under higher flow conditions that generated an apparent decrease in the amount of suitable, velocity-based habitat for coho). Beecher et al. (2010) concluded that this apparently counter-intuitive result may have been the result of using a habitat suitability model influenced heavily by the more numerous subdominant, schooling juvenile coho salmon and less by the dominant, territorial individuals, which had higher survival and preferred higher velocities. In essence, there was a difference between the habitat occupied by most rearing coho salmon (low velocity) and that occupied by the most successful in terms of growth and survival (higher velocity).

Rosenfeld et al. (2005) suggested that traditional physical habitat-based suitability curves can provide a reasonable representation of the range of habitats that are likely to support a species (i.e., the extent of exploitable habitat) but perform poorly in discriminating habitat quality within this subset of suitable habitat. In regards to a preferred velocity for juvenile coho being 3-6 cm/sec Rosenfeld et al. (2005) suggested that Beecher et al.’s (2002) reported suitability of 0.97 for the wider velocity range of 3-12 cm/sec would more accurately reflect true habitat quality and a realistic level of confidence in the resolution of suitability curves. Recent coho habitat mapping in California’s Trinity River (Goodman et al. 2010) approaches this velocity range with an even more liberal definition of suitable velocity for coho fry: any habitats less than 15 cm/sec (0.49 ft/sec), a value based on historical fish sampling undertaken throughout the Trinity River.

Based on Inter-Fluve’s engineering work and the supporting literature that more clearly defines what should be considered “near-optimal” conditions for juvenile coho the enhancement criteria for target pool velocity that will be used within the AMP has been adjusted upwards from that defined originally in the RPA: the pool velocity target range for the AMP will be 0.0 – 0.5 ft/sec instead of the original RPA target of 0.1 - 0.2 ft/sec.

Appendix 5 Dry Creek Adaptive Management Plan (AMP) workshops.

Workshop 1 participants (June 23-24, 2010 at Water Agency offices)

Name	Affiliation
Gregg Horton	Sonoma County Water Agency (Water Agency)
David Manning	Sonoma County Water Agency (Water Agency)
Erik Brown	Sonoma County Water Agency (Water Agency)
Bob Coey	National Marine Fisheries Service (NMFS)
Bill Hearn	National Marine Fisheries Service (NMFS)
Rick Rogers	National Marine Fisheries Service (NMFS)
Eric Larson	California Department of Fish and Wildlife (CDFW)
Adam McKannay	California Department of Fish and Wildlife (CDFW)
Joel Pliskin	Army Corp of Engineers (USACE)
Mike Burke	Inter-Fluve
Greg Koonce	Inter-Fluve
David Marmorek	ESSA Technologies Ltd.
Darcy Pickard	ESSA Technologies Ltd.
Marc Porter	ESSA Technologies Ltd.
Katherine Wieckowski	ESSA Technologies Ltd.

Workshop 2 participants (Oct 19-21, 2010 at Water Agency offices)

Name	Affiliation
Gregg Horton	Sonoma County Water Agency (Water Agency)
David Manning	Sonoma County Water Agency (Water Agency)
Erik Brown	Sonoma County Water Agency (Water Agency)
Dave Cuneo	Sonoma County Water Agency (Water Agency)
Grant Davis	Sonoma County Water Agency (Water Agency)
Renee Webber	Sonoma County Water Agency (Water Agency)
Pam Jeane	Sonoma County Water Agency (Water Agency)
Bob Coey	National Marine Fisheries Service (NMFS)
Bill Hearn	National Marine Fisheries Service (NMFS)
Rick Rogers	National Marine Fisheries Service (NMFS)
Adam McKannay	California Department of Fish and Wildlife (CDFW)
Joel Pliskin	Army Corp of Engineers (USACE)
Daria Mazey	Army Corp of Engineers (USACE)
Merle Griffin	Army Corp of Engineers (USACE)
Mike Burke	Inter-Fluve
Greg Koonce	Inter-Fluve
David Marmorek	ESSA Technologies Ltd.
Darcy Pickard	ESSA Technologies Ltd.
Marc Porter	ESSA Technologies Ltd.

Workshop 3 participants (July 19, 2011 at Water Agency offices)

Name	Affiliation
Gregg Horton	Sonoma County Water Agency (Water Agency)
David Manning	Sonoma County Water Agency (Water Agency)
Erik Brown	Sonoma County Water Agency (Water Agency)
Dave Cuneo	Sonoma County Water Agency (Water Agency)
Bob Coey	National Marine Fisheries Service (NMFS)
Bill Hearn	National Marine Fisheries Service (NMFS)
Rick Rogers	National Marine Fisheries Service (NMFS)
Brian Cluer	National Marine Fisheries Service (NMFS)
Adam McKannay	California Department of Fish and Wildlife (CDFW)
Ryan Wantanabe	California Department of Fish and Wildlife (CDFW)
Peter LaCivita	Army Corp of Engineers (USACE)
Mike Burke	Inter-Fluve
Greg Koonce	Inter-Fluve
David Marmorek	ESSA Technologies Ltd.
Marc Porter	ESSA Technologies Ltd.

Workshop 4 participants (May 23, 2012 at Water Agency offices)

Name	Affiliation
Gregg Horton	Sonoma County Water Agency (Water Agency)
David Manning	Sonoma County Water Agency (Water Agency)
Erik Brown	Sonoma County Water Agency (Water Agency)
Dave Cuneo	Sonoma County Water Agency (Water Agency)
Bob Coey	National Marine Fisheries Service (NMFS)
Rick Rogers	National Marine Fisheries Service (NMFS)
Adam McKannay	California Department of Fish and Wildlife (CDFW)
Peter LaCivita	Army Corp of Engineers (USACE)
Mike Burke	Inter-Fluve
Greg Koonce	Inter-Fluve
David Marmorek	ESSA Technologies Ltd.
Marc Porter	ESSA Technologies Ltd.